



This project is funded by the European Union

Annual Action Programme for Turkey for
the Year 2015 under the Instrument for
Pre-accession Assistance (IPA II)

Technical Assistance for Improvement of Performance-Based Tariff Regulation of EMRA for Turkish Energy Markets through Introducing an Enhanced Monitoring System

Project Identification No: EuropeAid /139125/IH/SER/TR

Contract No: TR2015/EN/07/A3-01/001

Task 4: Preparation of Smart Grid Road Map and Required Methodological Tariff Approaches

**Activity 4.1 - Smart Grid and Methodological Tariff
Approaches Report for Electricity Sectors (Volume II)**

Prepared: August 2020





This project is funded by the European Union



Table of Contents

Table of Contents.....	2
List of Figures.....	5
List of Tables.....	7
Abbreviations.....	8
1 Introduction to Entire Report	15
2 Electricity Distribution Sector Report	16
2.1 Introduction	16
2.2 Overview of Smart Grid Regulations in the EU	17
2.3 Overview of Smart Grid Efforts of EU Regulatory Bodies	25
2.3.1 CEER.....	25
2.3.2 EC - Smart Grid Task Force	26
2.3.3 ACER	29
2.3.4 ERGEG	29
2.3.5 ENTSO-E	30
2.3.6 NordREG	30
2.3.7 ICER.....	31
2.3.8 EDSO	31
2.4 Overview of Smart Grid Projects in EU	32
2.5 International Benchmarks: Smart Grid Regulations in Electricity Distribution	38
2.5.1 UK	38
2.5.2 Italy.....	55
2.5.3 Germany.....	70
2.5.4 Spain	80
2.5.5 Sweden	86
2.5.6 Recap of EU Countries.....	99
2.5.7 Challenges and Barriers	105
2.6 Regulatory Approaches for Selected Smart Grid Components in EU.....	106
2.6.1 Key Performance Indicators Used by Regulatory Organizations	106
2.6.2 Regulations Regarding Smart Metering.....	110
2.6.3 Legislation on Energy Storage Systems	118
2.6.4 Demand Side Management (DSM) Regulations	130
2.6.5 Interoperability and Standardization.....	148
2.6.6 Regulations on Communication Infrastructures for Smart Grids	153
2.6.7 Smart Grids Cyber Security and Data Ownership Regulations	154
2.6.8 Regulations on Renewable Energy Sources Integration.....	157



This project is funded by the European Union



2.6.9	Relationships between Distribution and Transmission System Operators	161
2.7	As-Is Policy and Regulatory Framework in Turkey for Electricity Distribution	164
2.7.1	Overview of Energy Sector Strategic Plan	164
2.7.2	Review of Secondary Legislations and Tariff Methodology	167
2.8	Gap Analysis and Regulatory Recommendations for Electricity Distribution	170
2.8.1	Barriers and Challenges	170
2.8.2	Overarching Principles	175
2.8.3	Regulatory Recommendations	178
2.8.4	Recommendations for Smart Grid Planning.....	196
2.9	Smart Grid Road Maps in Different Countries and Regions.....	200
2.9.1	Sweden - 2030 Road Map	200
2.9.2	Germany - Standardization Road Map for “E-Energy/ Smart Grids”	204
2.9.3	Germany - BDEW 2022+ Road Map	207
2.9.4	United Kingdom - Ofgem 2030+ Road Map.....	208
2.9.5	Spain - FutuRed 2030 Electricity Network Vision	213
2.10	Smart Grid Roadmap for Turkish DSOs.....	218
2.10.1	As-is Status of Smart Grids in DSOS.....	219
2.10.2	Needs Assessment	221
2.10.3	Smart Grid Roadmap for DSOs	225
2.10.4	Recommendations on Implementation Roles and Responsibilities	260
3	Electricity Transmission Sector Report	264
3.1	Introduction of Electricity Transmission Part	264
3.2	European Legislative Framework Related to Smart Grids	266
3.2.1	Energy Union Strategy	266
3.2.2	European Green Deal.....	269
3.3	Smart Grid Efforts in EU	272
3.4	Pan-European Activities on Design of Future Electricity Transmission Systems	275
3.4.1	CEER.....	275
3.4.2	Smart Grid Task Force	275
3.4.3	ENTSO-E	279
3.5	Smart Grid Regulations in Electricity Transmission: International Benchmark.....	287
3.5.1	UK	288
3.5.2	Italy	298
3.5.3	Germany	299
3.5.4	France	301
3.5.5	Sweden	302
3.5.6	Finland	303
3.5.7	Recap of EU Countries.....	305



This project is funded by the European Union



3.6	As-Is Policy and Regulatory Framework in Turkey for Electricity Transmission	315
3.7	Gap Analysis and Regulatory Recommendations for Electricity Transmission	317
3.7.1	Overarching Principles	317
3.7.2	Regulatory Recommendations to Support Smart Grid Roll-out in TEİAŞ	319
3.8	Smart Grid Roadmap for TEİAŞ	324
3.8.1	As-is Status of Smart Grids in TEİAŞ	324
3.8.2	Smart Grid Roadmap for TEİAŞ	336
3.8.3	Other Recommendations on Implementation Roles and Responsibilities	353
4	Annex	355
4.1	Annex-1: Europe 2020 Headline Indicators	355
4.2	Annex-2: Italy - Selection Process and Results: A Key Performance Indicator Approach	357





This project is funded by the European Union



List of Figures

Figure 1: Role and Relationship Between Different Elements of the Smart Grid	16
Figure 2: Smart Meter Provisions of the Directive	22
Figure 3: Map of Smart Grid Projects (as of August 2020) since 1994	33
Figure 4: Potential Roles and Relationships of the Energy Industry within a Smart Grid	40
Figure 5: Key Stages in the Development of Smart Grid	43
Figure 6: Smart Grid Enablers Programme Snapshot	48
Figure 7: National Funds for Electric System Research	52
Figure 8: Key Smart Grids Facts and Figures by the end of 2018	55
Figure 9: Focus of Pilot Smart Grid Demonstration Projects in Italy	58
Figure 10: Requirements for Demonstration Projects	60
Figure 11: Business Models	61
Figure 12: National Funds for Electric System Research	64
Figure 13: Smart Metering in Italy: System Architecture "1G"	68
Figure 14: Smart Metering in Italy: System Architecture "2G"	69
Figure 15: Key Smart Grids Facts and Figures by the end of 2018	70
Figure 16: Smart Grid Market Forecast by Segment in Germany (Cumulative)	75
Figure 17: National Programs related to Smart Grid and Renewables	78
Figure 18: Modified Replacement Plan	86
Figure 19: Key Smart Grids Facts and Figures by the end of 2018	87
Figure 20: Timeline of the Development of Smart Meters in Sweden	97
Figure 21: Development of Smart Meter Legislation in EU	110
Figure 22: Revised CBA Results Electricity Smart Meters Considering a Large-Scale Rollout to at least 80% by 2020 (as of July 2018)	111
Figure 23: Electricity Smart Meters Deployment Strategy Foreseen by the Manufacturer Landis+Gyr	114
Figure 24: Energy Storage; Flexibility Components in the Electrical System	121
Figure 25: Possible Relationships between Demand Side Management and Future Market Roles	133
Figure 26: Predicted Structure of the Flexibility System	140
Figure 27: Comparison of Business Processes in Traditional and Smart Grids	141
Figure 28: Local Administration Model under Distribution Operator's Control	146
Figure 29: Standardization of Demand Side Management Communication Architecture	150
Figure 30: Interoperability Process	151
Figure 31: Cyber Security Development Map for Smart Grids	155
Figure 32: Transition from Firefighting to Risk Elimination	155
Figure 33: Australia "Power of Choice" Summary	156
Figure 34: Overview of electricity sector regulations	164
Figure 35: Overview of Electricity Distribution and Retail Legislation	168
Figure 36: Example Smart Grid Legislation Regulations	171
Figure 37: EU Smart Grid Standardization Steps	172



This project is funded by the European Union



Figure 38: Main Objectives in the Development of Smart Grid Legislations	175
Figure 39: Sweden-2030 Road Map Stakeholders and Components	200
Figure 40: Historical Development of Smart Meter Applications in Sweden	202
Figure 41: Sweden - 2030 Smart Grid Road Map.....	204
Figure 42: IEC TR 62357 Smart Grid Integration Architecture	205
Figure 43: Sustainable Workflow of Smart Grids Standardization (DKE)	206
Figure 44: BDEW, Germany 2022+ Road Map.....	208
Figure 45: BDEW, Germany 2022+ Road Map.....	210
Figure 46: Smart Grid Components of Generation, Transmission and Distribution System Stakeholders	211
Figure 47: United Kingdom – 2030+ Road Map	212
Figure 48: Turkey's Expectations from Smart Grids	222
Figure 49: Energy Union Focus.....	267
Figure 50: Geographical Distribution of Investments and Project Categories.....	274
Figure 51: Cybersecurity in the Energy Sector	277
Figure 52: Proposed Structure for the Network Code on Cybersecurity by EG2	278
Figure 53: Role and Relationships Between Different Elements of the Smart Grid	291
Figure 54: National and Regional Control Centres (RCCs) of TEİAŞ.....	325
Figure 55: Technical Domains for TEİAŞ Smart Technologies Plan	337
Figure 56: P _{smart} : SHC at Network Level.	357



This project is funded by the European Union



List of Tables

Table 1: Regulations in EU Related to Smart Grid	17
Table 2: The Normalized SG Investments and the Three Analysed Regulatory Factors for 30 European Countries (EU- 28, Norway and Switzerland)	23
Table 3: Incentives for Innovation	24
Table 4: Smart Grid Practices and Technologies	48
Table 5: Progress within the Scope of the Program	49
Table 6: New Incentives for DSOs: Output Based, Selectivity	62
Table 7: EU Smart Grid Key Performance Indicators	106
Table 8: Key Electricity CBA Parameters	112
Table 9: Costs and Benefits per Meter	112
Table 10: Main Developments in Storage (Technology Priorities)	123
Table 11: Selected Energy Storage Projects	124
Table 12: Contribution Levels of Generator Technologies to Ancillary Services	143
Table 13: Ability to Provide Ancillary Service of Different Generator Types.....	143
Table 14: Electricity Transmission Innovation Projects: ENTSO-E Clusters	282
Table 15: Benefit Score (A_j).	358
Table 16: Selected Smart Grid Projects	359
Table 17: Impact on MV Grids (Size of the Projects)	360
Table 18: Technical Solutions of Selected Projects	361



This project is funded by the European Union



Abbreviations

€/EUR	European Euros
£/POUND	British Pound Sterling (in 2019 1 Euro costs 0.88 POUND)
₺/TL	Turkish Liras (in 2019 1 Euro costs 6.3477 TL)
\$/USD	United States Dollars (in 2019 1 Euro costs 1.12 USD)
ACER	Agency for the Cooperation of Energy Regulators
ADMS	Advanced Distribution Management Solutions
AEEG	The Italian Authority for Energy and Gas
AEEGSI	The Italian Authority for Energy and Gas
AGC	Automatic Generation Control
AGM	Active Grid Management
AMI	Advanced Manufacturing Infrastructure
ANM	Active Network Management
API	Application Programming Interface
ARERA	The Italian Regulatory Authority for Energy, Networks and Environment (former AEEGSI)
AS	Ancillary Services
ASMS	Ancillary Services Central Monitoring and Control System
BAIOP	Basic Application Interoperability Test Profile
BAP	Basic Application Profiles
BEIS	Department for Business, Energy and Industrial Strategy
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMWi	Federal Ministry for Economic Affairs and Energy
BNetzA	Bundesnetzagentur
BPL	Broadband over Power Line
BRP	Balancing Responsible Parties
CA	Contingency Analysis
CACM	Capacity Allocation and Congestion Management
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditures
CBA	Cost-Benefit Analysis
CCS	Carbon Capture and Storage
CEER	Council of European Energy Regulators
CEM	Consumer Energy Management
CEmA	Coordination of Emergency Actions
CEN	European Committee for Standardization
CENELEC	European Electrotechnical Standardization Committee
CER	Commission for Energy Regulation
CHP	Combined Heat and Power
CIM	Common Information Model
CMA	Competition and Markets Authority
CNCA	China Certification and Accreditation Agency
CNMC	The Spanish National Commission on Markets and Competition



This project is funded by the European Union



CNR	National Research Council
CPS	Cyber Physical System
CRA	Coordination of Re-Energizing Steps
CRCP	Continuously Reinforced Concrete Pavements
CRE	French Energy Regulatory Commission
CRM	Customer Relationship Management
CSP	Competitive Service Provider Model
DCA	Distribution Congestion Analysis
DCENR	Department of Communications, Energy and Natural Resources
DEA	Data Envelopment Analysis
DECC	Department of Energy and Climate Change
DENA	German Energy Agency
DER	Distributed Energy Resources
DERMS	Distributed Energy Resources Management Systems
DETI	Department of Enterprise, Trade and Investment (DETI)
DFR	Digital Fault Recorder
DISCOM	Distribution System Operator
DNO	Electricity Distribution Network Operators
DOMA	Real Time Distribution Operation Model and Analyses
DPCR5	The British Distribution Price Control Review 5 (2010-2015)
DPF	Power Flow Analysis
DPIA	Data Protection Impact Assessment
DPR	Digital Protective Relay
DRUD	Demand Response Unit Document
DSA	Dynamic Stability Assessment
DSM	Demand Side Management
DSR	Demand Side Response
DTS	Dispatcher Training Simulator
DUoS	Distribution System Usage
EA	Energy Authority
EAM	Enterprise Asset Management
EASE	European Association for Storage of Energy
EB GL	Electricity Balancing
EC	European Commission
EDCo	Electricity Distribution Company
EDISCOM	European Distribution System Operators
EDVARS	Electricity Distribution Data Warehouse and Reporting System
EEG	Renewable Energies Act
EEGI	European Electricity Grid Initiative
EHV	Extra High Voltage
EI	Swedish Energy Agency and the Energy Market Inspectorate
ELDER	the Association of Distribution System Operators of Turkey
EMR	Electricity Market Reforms
EMRA	Energy Market Regulatory Authority



This project is funded by the European Union



EMS	Energy Management Systems
ENA	The British Energy Networks Association
ENCC	Emergency National Control Centre
ENEA	National Agency for New Technologies, Energy and Sustainable Economic Development
ENTSO-E	European Network of Transmission System Operators for Electricity
EnWG	German Energy Industry Act
EPDK	Energy Market Regulatory Authority of Republic of Turkey
ERA	European Research Area
ERCOT	Texas Electrical Reliability Council
ERDF	The European Regional Development Fund
ERGEG	European Electric and Gas Regulators Group
ERP	Enterprise Resource Planning
ERRA	Energy Regulators Regional Association
ESA	Electricity Sector Law
ESO	European Standardization Organizations
ETSI	European Telecommunications Standards Institute
EU	European Union
EUR	Euro
EV	Electric Vehicle
FCA	Forward Capacity Allocation
FCC	Federal Communications Commission
FCR	Frequency Containment Reserve
FERC	Federal Energy Regulatory Commission
FLISR/FDIR	Fault Location Detection, Isolation and Re-Energization
FRA	National Defence Radio Institute
FRR	Frequency Restoration Reserve
GB	United Kingdom
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
GIS	Geographic Information System
GSE	The Energy Services Manager
GWh	1 Billion-Watt Hours
HEPP	Hydroelectric Power Plant
HES	Head End System
HPC	High Performance Computing
HV	High Voltage
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
HVRT	High Voltage Ride Through
IAP	Intelligent Alarm Processing
ICER	International Energy Regulators Confederation
ICT	Information and Communication Technology
IEA	International Energy Agency



This project is funded by the European Union



IEC	International Electrotechnical Commission
IED	Intelligent Electronic Devices
IEEE	Institute of Electrical and Electronics Engineers
IEM	Internal Energy Market
IMCG	International Management Consulting Group
IoT	Internet of Things
IPR	Intellectual Property Rights
IRM	Innovation Rollout Mechanism
ISO	Independent System Operator
ISP	Initial Screening Process
IT	Information Technologies
ITS	Interchange Transaction Schedule
JRC	Joint Research Centre
KPI	Key Performance Indicator
kV	1 thousand volts
LAR	Large Area Restoration
LCN	Low Carbon Networks
LCNF	Low Carbon Network Fund
LNAP	Local Network Access Point
LSP	Licensed Service Provider
LV	Low Voltage
LVRT	Low Voltage Ride Through
MDM	Meter Data Management
MEDREG	The Association of Mediterranean Energy Regulators
MISE	The Ministry of Economic Development
MIUR	Italian Ministry of University and Research
MS	Member States
MSB	Swedish Civil Risks Agency
MsbG	Metering Act
MSO	Metering Service Operator
MT	Medium Voltage
MV	Medium Voltage
MVA	1 million Volt-Ampere
MW	1 million watts
MWh	1 million watt-hours
NABEG	Grid Expansion Acceleration Act
NARUC	National Association of Regulatory Utility Commissioners
NC RfG	National Code Regulation for Generation
NCC	National Control Centre
NEA	Chinese National Energy Administration
NECP	National Energy and Climate Plan
NEMO	Nominated Electricity Operator
NEPP	Northern European Power Perspectives
NER	Nordic Energy Research



This project is funded by the European Union



NERC	North American Electric Reliability Corporation
NIA	Network Innovation Allowance
NIC	Network Innovation Competition
NIMBY	Not in My Back Yard
NIST	National Institute of Standards and Technology
NMS	Network Management System
NNAP	Neighbourhood Network Access Point
NRA	National Regulatory Authority
Ofgem	Office of Gas and Electricity Markets
OFR	Optimal Feeder Restructuring
OHS	Occupational Health and Safety System
OLEV	Office of Low Emission Vehicles
OMS	Outage Management System
OPEX	Operational Expenses
OPGW	Optical Ground Wire
OSOS	Automatic Meter Reading System
P2P	Peer to Peer
PCC	Point of Common Coupling
PCI	Projects of Common Interest
PI	Performance Indicator
PLC	Programmable Logic Controller
PMO	Project Management Office
PMU	Project Management Unit
PNIEC	National Energy and Climate Plan
PPC	Power Plus Communications
PTS	National Postal and Telecom Agency
PUC	Public Utilities Commission
PVPC	Voluntary Price for Small Consumer
QoS	Quality of Service
R&D	Research and Development
RAB	Regulatory Asset Base
RCC	Regional Control Centre
RdS	National Fund for Electric System Research
RES	Renewable Energy Source
RetCo	Retail Company
RIA	Regulatory Impact Analysis
RIIO	Revenue=Incentive + Innovation + Output
RITM	Wind Monitoring and Forecasting System
RM	Reserve Monitoring
RoR	Rate of Return
RPRC	Relay Protection Coordination
RTE	Electricity Transmission Network of France
RTO	Regional Transmission Operator
RTU	Remote Terminal Unit



This project is funded by the European Union



SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SE	State Estimator
SEK	Swedish Electrical Standards Organization
SEN	National Energy Strategy
SET	Strategic Energy Technology
SG	Smart Grid
SGOM	Cyber Security Operations Centre
SINTEG	Smart Energy Showcases - Digital Agenda for the Energy Transition
SME	Small and Medium Sized Enterprises
SMICoP	Smart Meter Installation Code of Practice
SNM	Smart Network Management
SPS	Special Protection System
STLF	Short Term Load Forecast
SUMS	System Usage Management System
SweGRIDS	Swedish Smart Grids and Energy Storage Centre
SWH	Stadwerke Heidelberg
TDM	Time Division Multiplexing
TEİAŞ	Turkish Electricity Transmission Corporation
TEN-E	Trans-European Networks for Energy
TEN-T	Trans-European Transport Network
TLC	Transport Layer Security
TOTEX	Total Expenditure
ToU	Time of Use
TRL	Technology Readiness Level
TSO	Transmission System Operator
TUBITAK	The Scientific and Technological Research Council of Turkey
TURPE	Tariff for the Use of Public Electricity Networks
TYNDP	Ten Year Network Development Plan
UHVAC	Ultra-High Voltage Alternating Current
UK	United Kingdom
ULEV	Ultra-Low Emission Vehicle
US	United States
USA	United States of America
V2B	Electric Vehicle to Building
V2G	Vehicle to Grid
VET	Vocational Education and Training
VPN	Virtual Private Network
VRFB	Vanadium Redox Flow Batteries
VVC/VVO	Volt/VAr Control and Optimization
WACC	Weighted Average Cost of Capital
WAMS	Web Access Management System
WFM	Work Force Management



This project is funded by the European Union



WPD	Western Power Distribution
WSA	Whole System Approach
YTBS	Load Dispatch Information Monitoring System



This project is funded by the European Union



1 Introduction to Entire Report

As part of the TARIFF Project's Task 4, "*Preparation of Smart Grid Road Map and Required Methodological Tariff Approaches for Electricity and Natural Gas Markets*", one of the deliverables is to review and assess EU and Turkey practices regarding deployment of smart grids, and deliver a report on the regulatory recommendations and roadmap for electricity and natural gas distribution and transmission sectors.

The main objective of Task 4.1 report is the elaboration of a comparative desktop analysis, so to assist to the Beneficiary to identify amendment options for secondary legislation, as well as developing a smart grid roadmap in line with best practices.

Task 4.1 report has been organized in 2 separate volumes:

- Volume-I: Smart Grid and Methodological Tariff Approaches Report for Natural Gas Sectors
- Volume-II: Smart Grid and Methodological Tariff Approaches Report for Electricity Sectors

The scope of this report (Volume-II¹) consists of the following elements:

- Electricity Distribution Sector Report
- Electricity Transmission Sector Report

Within the individual sections, practices, adopted by selected European Countries, were examined in depth to realize a gap analysis with the practises adopted by the beneficiary country and to elaborate the needed recommendations. Also, smart grid roadmap has been developed for the mentioned sectors.

¹ Relevant chapters for Natural Gas Distribution and Transmission are presented in Volume-I.

2 Electricity Distribution Sector Report

2.1 Introduction

According to the European Regulators' Group for Electric and Gas (ERGEG) Public Conclusions Paper dated June 2010²; “*Smart Grid is an electricity grid with low loss and high quality economic features that can integrate the behaviours and actions of all users (manufacturers, consumers and those assume the both roles) in a cost-effective way to ensure sustainable power systems and supply security and safety*” and both The Council of European Energy Regulators (CEER) and European Commission (EC) use this same definition. Some of the European countries such as Austria, England, Poland and Switzerland have also adapted this definition.

The following figure shows the roles and relationships between different elements of the smart grid³.

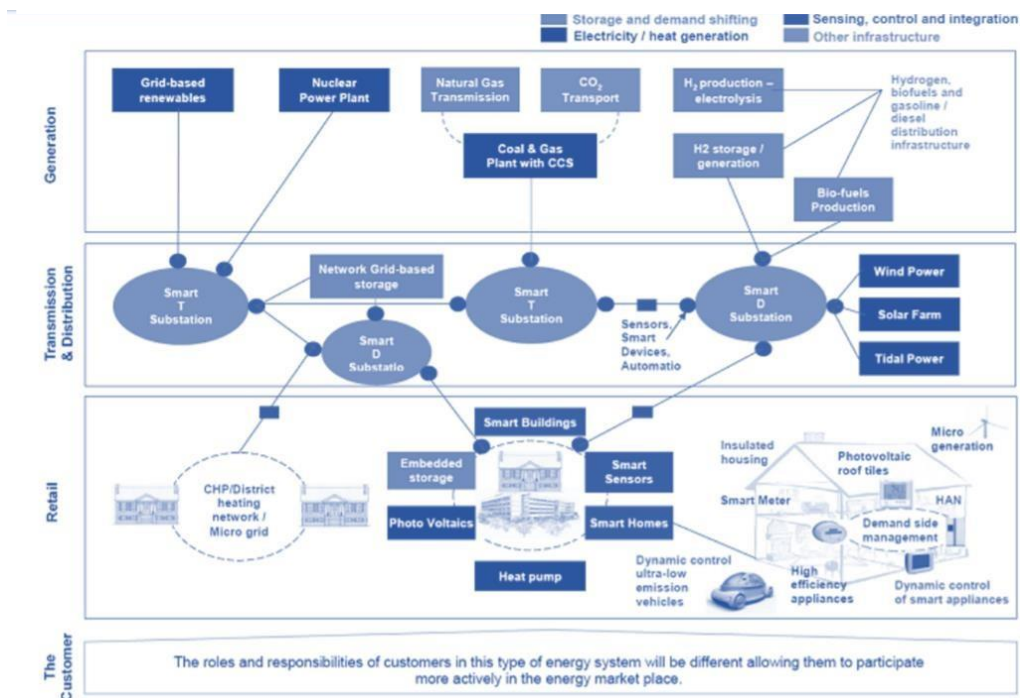


Figure 1: Role and Relationship Between Different Elements of the Smart Grid

Under this section, smart grid regulations and institutions related to electricity distribution will be analysed in more detail.

In addition;

- Smart grid regulation and regulatory authorities
- Challenges and barriers faced

² Position Paper on Smart Grids – An ERGEG Public Conclusions Paper, June 2010

³ Department of Energy and Climate Change, OFGEM, February 2014, Smart Grid Vision and Routemap



This project is funded by the European Union



- Smart grids within the scope of tariffs
- Projects awarded

will be introduced in selected countries as well as in Turkey to better understand the difference in implementation in different countries. Following gap analysis, recommendations and smart grid roadmap for electricity DSOs will be provided.

2.2 Overview of Smart Grid Regulations in the EU

European Commission emphasized that smart grids allow consumers to control and manage their own energy use, thereby contributing to build a power system that produces less carbon, and suggested that the grids shall be used in full capacity to achieve their goals related to reducing consumption of primary energy sources. Within this scope, various Articles were published related to smart grid in the EC's Directives and related Regulations. The following table shows main Regulations that consist of topics regarding smart grids⁴:

Table 1: Regulations in EU Related to Smart Grid

Directive / Regulations	Definition
Parliament and Council Directive 2004/22/EC, On Measuring Instruments, 2004 O.J. (L 135) 1.	Establishes the requirements for the deployment and use of instruments for measuring electricity
Energy Efficiency Directive 2006/32/EC	Defines the use of cost-effective technological innovations such as “electronic metering” in order to reach the energy saving targets of EU.
ThirdEnergyPackage(Parliament and Council Directive 2009/72/EC) Concerning Common Rules for the Internal Market in Electricity	Although it is not an obligation, Directive is a legal foundation on which Member States can facilitate the development and deployment of smart grids. According to the Directive a CBA shall be done to prepare a timetable regarding roll-out of smart meters. In addition, it provides a supranational legal foundation for the development of demand response in Europe.
COM (2011)202 on Smart Grids	Proposes a variety of actions aimed at smart, sustainable and inclusive growth and at developing Smart Grids to effectively contribute to the European Union's Europe 2020 Strategy.
Energy Efficiency Directive 2012/27/EC	Provides additional instructions on the deployment and the minimum common features of smart metering systems as well as on data protection and privacy of final customers. It requires Member States to ensure that network operators are incentivized to improve efficiency in infrastructure design and operation, and, within the framework of Directive 2009/72/EC, that tariffs allow suppliers to improve consumer participation in system efficiency, including demand response, depending on national circumstances. Member States shall ensure that national regulatory authorities encourage demand side resources, such as demand response, to participate alongside supply in wholesale and retail markets.
Recommendation 2012/148/EU on smart metering	Provides guidance to Member States (MS) on the design of smart metering systems to ensure the protection of personal data and recommend MS to include a data protection impact assessment in the design of smart grids and smart metering systems. Also provides guidelines on the methodology for the economic assessment of the roll-out of smart metering.

⁴ <https://ec.europa.eu/transparency/regdoc/rep/1/2014/EN/1-2014-356-EN-F1-1.Pdf>



This project is funded by the European Union



Directive / Regulations	Definition
COM(2012)663 on the Internal Energy Market	With the growing need for flexibility and energy efficiency and to accommodate distributed generation and demand-side participation, coordinated action is needed with a view to the deployment of smart grids at European, regional and municipal levels. Smart grids rely on digital infrastructure. The Commission tabled a proposal for a Regulation on "Guidelines for trans-European telecommunications networks" identifying inter alia digital services infrastructure as priorities ⁵
Energy Infrastructure Regulation (EU) 347/2013	States that smart grid is among the 12 strategic trans-European energy infrastructure priorities, the implementation of which by 2020 is essential for the achievement of the Union's energy and climate policy objectives. Smart grids deployment: adoption of smart grid technologies across the Union to efficiently integrate the behaviour and actions of all users connected to the electricity network, in particular the generation of large amounts of electricity from renewable or distributed energy sources and demand response by consumers
Electro-mobility Alternative Fuels Directive AFID; COM (2013)18	The Directive requires Member States to set targets for recharging points accessible to the public, to ensure that electric vehicles can circulate at least in urban and suburban agglomerations by 31 December 2020 as well as on the TEN-T core network by December 2025.
COM (2013)7243 on IEM and public intervention ⁶	To promote demand response deployment, Member States should accelerate the roll out of smart grids and smart metering, which will go in parallel to the Commission's work to create better conditions for smart appliances and energy management systems to develop. European standardization organizations will develop a complete set of standards for smart grids, including for demand response, by the end of 2014.
SWD (2013)442 on Demand Side Flexibility ⁷	Demand response programs should be able to rely on standardized technological solutions integrating smart metering, storage facilities. Bringing the technology into the market through the roll-out of smart metering with the appropriate functionalities
the Commission Guidelines on State aid for environmental protection and energy 2014-2020	In clarifying the conditions under which Member States are allowed to introduce capacity remuneration mechanisms, the Guideline requests Member States to consider alternatives such as demand response. The measure should be open and provide adequate incentives to both existing and future generators and to operators using substitutable technologies, such as demand-side response or storage solutions.
Recommendation 2014/724/EU Data Privacy Impact Assessment	Introduces measures for the promotion of the use of a Data Protection Impact Assessment Template (called the "DPIA Template"), developed at EU-level, with the aim of helping ensure the fundamental rights to protection of personal data and to privacy in the deployment of smart grid applications and systems and smart metering roll-out
Directive 2014/32/EU32 Measuring Instruments Directive	Harmonizes the national laws for making available measuring instruments on the market. Directive repeal the earlier Directive 2004/22/EC3.
Directive 2014/94/EU36 deployment of alternative fuels infrastructures	States that the recharging of electric vehicles at recharging points accessible to the public shall, if technically feasible and economically reasonable, make use of intelligent metering systems as defined in point (28) of Article 2 of Directive 2012/27/EU and shall comply with the requirements laid down in Article 9(2) of that Directive.

⁵ <https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0663:FIN:EN:PDF>

⁶ https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention_en_0.pdf

⁷ https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention_swd07_en.pdf



This project is funded by the European Union



Directive / Regulations	Definition
COM (2015) 339 on delivering a 'new deal' for energy consumers ⁸	States one of the targets as strengthening the link between research, innovation and industry for developing international competitiveness in smart home and smart grid technologies, in cooperation with all market players.
2016/679 General Data Protection Regulation (GDPR)	The operation of smart meters entails the processing of 'personal data' and needs to be in line with the EU's General Data Protection Regulation (GDPR).
2019/944/EU New Electricity Directive	Updates and puts forward provisions that are of direct relevance to smart metering and its use as a tool for demand-side management and flexibility.

Communication Document Smart Grids: From Innovation to Installation

Being one of the most important documents related to development of smart grids, "Communication Document Smart Grids: From Innovation to Installation" was published in 2011, proposing a variety of actions aimed at smart, sustainable and inclusive growth and developing smart grids to effectively contribute to EU-wide strategies⁹. Recently published indicators related to the Strategy are provided as Annex to this document.

According to the document, smart grids might:

- Reduce the annual primary energy consumption of the EU energy sector by about 9% by 2020;
- Create new business areas;
- Provide additional economic growth.

In addition, goals for the development and dissemination of smart grids were defined as follows;

Goal 1: Develop Common European Smart Grid Standards

Since March 2009, European Standardization Organizations (ESOs), such as the European Standardization Committee (CEN), the European Electrotechnical Standardization Committee (CENELEC) and the European Telecommunications Standards Institute (ETSI), have been responsible for the establishment of European Standards for interoperability of gas, water and heat. The results of this research partly formed the "Directive 2014/32/EU"¹⁰ principles for measuring instruments.

ESOs also have the responsibility for developing new standards for the interoperability of chargers for all types of electric vehicles and all electric supply points.

Goal 2: Guarantee Data Protection and Security

In the EU, the protection of personal data is secured by the "Directive 95/46/EC" legislation and is valid for data processing in all sectors, including smart grids.

⁸ https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8.pdf

⁹ <http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:em0028&from=EN>

¹⁰ http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:240302_0211_2&from=EN



This project is funded by the European Union



The Commission emphasized that it would make sense to adapt the directive to national legal frameworks to accommodate specific parameters of smart grids, while protecting the private life of European citizens.

While the Commission proposes to direct changes that will adapt the smart grid parameters in national legislation, ESOs have adopted the "privacy-based" approach, responsible for the development of technical standards for these networks. An expert group will evaluate the information security and network of smart grids.

Goal 3: To Promote the Dissemination of the Smart Grid

With the dissemination of smart grids, it is aimed to establish a market-oriented incentive mechanism, and also to establish incentives for investment in smart grids, such as the Electricity Directive and the Energy Services Directive, by accessing consumption information of households and companies easily, thereby reducing the energy costs.

The Commission planned to define a methodology using national smart meter implementation plans, and additionally encouraged Member States to prepare the Smart Grid Building Action Plan. It is foreseen that national Regulators and European Transmission System Network Operators for Electricity (ENTSO-E) will specifically manage the coordinated actions of all relevant market players.

Goal 4: Develop Smart Grids in a Competitive Retail Market that will Attract Consumers

The aim is that Member States establish transparent retail markets and facilitate competition between suppliers. Developing smart grids in the competitive retail market will encourage consumers to change their behaviour in energy consumption, as it will provide real-time access to energy consumption information.

The Commission has planned to review the Energy Services Directive to prepare minimum conditions on the form and content of providing information to customers. It monitors the implementation of the Third Energy Package, particularly in relation to the lifetime and flexibility management pricing.

Goal 5: Support Innovation

Smart grids require a significant investment in terms of research and development. For example, the European Electricity Grid Initiative (EEGI) was established as part of the Strategic Energy Technology Plan (SET-Plan) to accelerate the dissemination of smart grid technologies by 2020. The other two initiatives are; the Mayors Convention and the Smart Cities and Communities initiatives have the same goals.

The Commission has planned to propose new initiatives similar to those mentioned above in order to encourage the installation of smart grids.

New Electricity Directive (2019/944/EU)

Recently in 2019, new Electricity Directive (2019/944/EU) was published, updating and putting forward some provisions that are of direct relevance to smart metering and its use as a tool for demand-side management and flexibility¹¹:

¹¹ Tractebel Impact, 2019, Benchmarking smart metering deployment in the EU-28



This project is funded by the European Union



According to the Directive,

- The deployment of smart metering systems may be subject to a cost-benefit assessment, which shall be undertaken in accordance with the Commission Recommendation 2012/148/EU;
- Member States should publish the minimum functional and technical requirement for these systems which should be in accordance with those mandated in the Directive and in the spirit of the Commission Recommendation 2012/148/EU;
- Member States should ensure the interoperability of the smart metering systems and their ability to provide output for consumer energy management systems;
- Final customers should contribute to the associated cost of deployment of smart metering systems, in a transparent and non-discriminatory manner, while taking into account the long-term benefits to the whole value chain;
- When the deployment of smart metering systems is negatively assessed, Member States should revise this assessment at least every four years;
- Smart metering systems should be in accordance with applicable Union data protection rules;
- Network tariffs: as a general principle of network charges, tariffs paid by customers should fairly reflect the cost they impose on the network operator. This should also be reflected on network charges related to smart metering deployment (full or segmented roll out);
- Customers should be entitled to a smart meter in cases where the deployment has been neither negatively assessed nor systematically pursued. Then, customers should bear the associated costs of deployment, under fair, reasonable and cost-effective conditions.
- Functionalities that smart metering systems should support in order to fit their purpose and deliver benefits for the consumers and the energy system as a whole are set. It furthermore provides that Member States should ensure that the deployed smart metering systems are in accordance with European standards, the spirit of the measures under the Commission Recommendation 2012/148/EU, and in line with other specific requirements coming from Article 9 of the Energy Efficiency Directive 2012/27/EU (the type of data provided to customers, security of data and data communications, the availability of these data for the customers, the appropriate advice and information that should be given to final customers prior to or at the time of installation of smart meters.)



This project is funded by the European Union

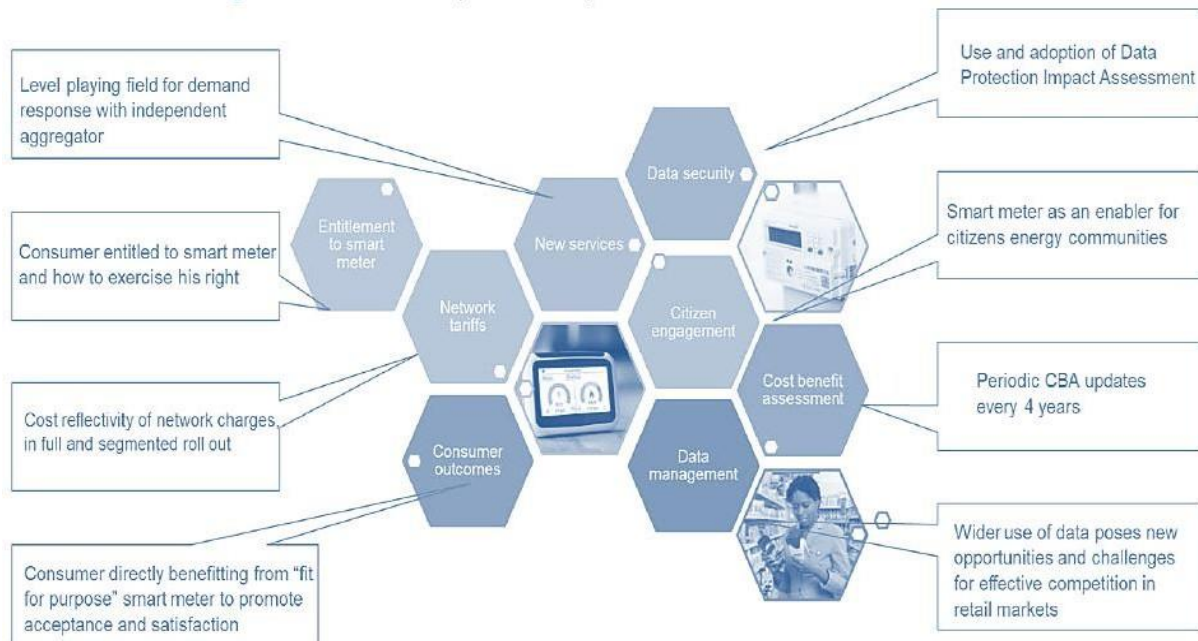


Figure 2: Smart Meter Provisions of the Directive

In addition to EU-wise regulations related to smart grid, most of the MS developed their own national regulation about deployment of smart meters and other items of smart grid. Country based regulations will be explained in the next sections.

An important and recent issue is about consumer data protection. EU has taken a series of measures to uphold data protection rules since smart grids and meters may have an impact on personal data and privacy, which is why the Smart Grids Task Force updated the impact assessment template in September 2018, and which serves as guidance on data protection and privacy for data controllers and investors in smart grids.

In addition to data protection and privacy, cybersecurity has increasingly become an issue related to smart grids and meters. The Commission is committed to mitigating any risks and enhancing resilience towards cybersecurity.¹²

In Europe, the level of smart grid investments has been low until 2007, most probably due to uncertainty related to the returns on such capital expenditures. However, following most of the NRA's introducing incentives after 2008, the investments started to increase. The smart grid investments are not uniformly distributed across Europe and the great majority of the spending is in central European countries. In the following table, investment amounts, which is normalized by dividing by the respective GDP and population data to overcome the issue of socio-economic factors, are provided.

¹² https://ec.europa.eu/energy/topics/markets-and-consumers/smart-grids-and-meters/overview_en?redir=1



This project is funded by the European Union



Table 2: The Normalized SG Investments and the Three Analysed Regulatory Factors for 30 European Countries (EU-28, Norway and Switzerland)¹³

Country	Country Code	Investment (€/M€ of GDP)	Investments (€/capita)	Distribution-Sector Concentration	Regulatory Mechanisms	Innovation-Stimulus Mechanisms
Austria	AT	193.8	7.03	Low	Incentive	Adj. Rev.
Belgium	BE	228.46	7.77	Low	Cost	None
Bulgaria	BG	56.77	0.3	Medium	Incentive	None
Switzerland	CH	26.19	1.53	Low	Cost	None
Cyprus	CY	55.49	1.27	High	Cost	None
Czechia	CZ	219.48	3.31	Medium	Hybrid	None
Germany	DE	109.19	3.54	Low	Incentive	None
Denmark	DK	566.12	24.89	Low	Hybrid	Adj. Rev.
Estonia	EE	64.73	0.8	Medium	Hybrid	None
Greece	EL	76.2	1.49	High	Cost	None
Spain	ES	174.56	4.06	Medium	Hybrid	None
Finland	FI	243.26	8.77	Low	Hybrid	Adj. Rev.
France	FR	191.15	6.18	Medium	Incentive	None
Croatia	HR	42.64	0.45	High	Cost	None
Hungary	HU	82.83	0.83	Medium	Incentive	None
Ireland	IE	88.99	3.35	High	Incentive	Adj. Rev.
Italy	IT	136.73	3.72	Medium	Hybrid	Extra WACC
Lithuania	LT	84.32	0.85	High	Incentive	None
Luxembourg	LU	68.33	5.47	Medium	Incentive	None
Latvia	LV	26.77	0.27	Medium	Hybrid	None
Malta	MT	42.8	0.7	High	Cost	None
Netherlands	NL	155.37	5.93	Medium	Incentive	None
Norway	NO	47.08	3.27	Low	Incentive	None
Poland	PL	19.21	0.18	Medium	Hybrid	None
Portugal	PT	306.46	5.11	Medium	Hybrid	Extra WACC
Romania	RO	27.55	0.18	Medium	Incentive	None
Sweden	SE	234.89	9.59	Low	Incentive	None
Slovenia	SI	337.71	6.05	High	Incentive	Adj. Rev.
Slovakia	SK	68.75	0.88	Medium	Incentive	None
UK	UK	203.18	6.1	Medium	Incentive	Adj. Rev.

- Distribution-sector concentration reflects the level of market concentration in the electric power distribution sector
- Regulatory mechanisms reflect the capacity of the regulatory scheme to provide incentives to DSOs for increasing cost efficiency or productivity

¹³ Cambini C., Meletiou A., Bompard E., Masera M., 2016, Market and regulatory factors influencing smart-grid investment in Europe: Evidence



This project is funded by the European Union
from pilot projects and implications for reform





This project is funded by the European Union



- Innovation-stimulus mechanisms refers to the mechanisms designed by regulatory authorities to stimulate the implementation of pilot projects

Although the implemented methodology changed in some of the European countries (e.g. Italy), R&D and demonstration expenses are still treated like any other cost in most of the countries; i.e. there is no specific compensation for the risks involved in testing new technologies and processes (Eurelectric, 2014). Since 2014, six Member States – France, Greece, Ireland, Italy, Portugal and Slovenia – have implemented a new specific regulatory mechanism to promote R&D and/or pilot projects.

Table 3: Incentives for Innovation¹⁴¹⁵

Country	Country code
Austria	The regulatory system provides incentives for cost reductions as companies must follow a regulatory efficient path (CEER, 2014). Additionally, E-Control (the Austrian NRA) applies an incentive factor to stimulate investments in innovation. The investment factor constitutes a cost-based element in the incentive-based regulatory system (Frontier-Economics, 2012).
Denmark	Regulator applies a public service obligation-financed mechanism (ForskEL). The ForskEL mechanism is dedicated to support R&D and demonstration of environmentally friendly technologies and provides annual funding of DKK 130 million (Energinet.dk, 2015).
Greece	From 2017 onwards, the approved budget for R&D and pilot projects will be added to the annual allowed revenues in Greece (Eurelectric, 2016)
Finland	DSOs can cover some of their investment costs through the innovation incentive system. As part of the innovation incentive system, the EMV can approve R&D related expenditures up to a maximum of 0.5% of a DSO's annual turnover (NordREG, 2011).
France	A new instrument that includes a dedicated amount for R&D and pilots was issued at the end of 2013. If the DSO spends less than the projected allowance, the remaining amount is returned to the customers benefit, while if the company overspends is at its own risk. (Eurelectric, 2014). In the current French regulatory period, R&D and pilot projects' operating costs are covered by a specific part of the distribution network tariff. These costs are excluded from efficiency requirements (Eurelectric, 2016)
Ireland	The Commission for Energy Regulation (CER) introduced an extra-allowance mechanism for incentivizing DSO to carry out research and development and sustainability activities. The total amount of the projected fund equals €18.2 million and will allow DSOs to explore technological advances in areas such as smart grids, generation integration, and adaptation of new network devices to support the integration of renewable generation into the network and improve the reliability of service (CER, 2010).
Italy	In Italy, AEEG introduced a competition-based procedure providing specific incentives for innovative demonstration projects related to the active distribution network. To generate interest by DSOs, these pilot programs allowed for a 2% premium over the cost of capital for a limited time period of 12 years. At present, output-based incentives are used.
Norway	Since 2013, the Norwegian NER has been providing extra income of up to 0.3% (book value * 1.01) on some innovative projects, that is expenditures for R&D and pilot projects are added to the allowed revenues (max. 0.3% of regulated asset base) (Eurelectric, 2016)
Portugal	The DSO will receive the minimum between a higher regulatory RoR and 50% of the system benefits. The extra rate is 0.25% in the first year and rises 0.1% each year, until it reaches 0.75% in the sixth year. Hence, projects should allow for an OPEX reduction, which will be accounted as part of the system benefits; otherwise the DSO may receive a lower incentive

¹⁴ Cambini C., Meletiou A., Bompard E., Masera M., 2016, Market and regulatory factors influencing smart-grid investment in Europe: Evidence from pilot projects and implications for reform

¹⁵ Eurelectric, 2016, Innovation incentives for DSOs - a must in the new energy market development



This project is funded by the European Union



Country	Country code
Slovenia	Regulatory framework acknowledges 3% of the book value for smart grid investments (Eurelectric, 2016)
United Kingdom	Ofgem announced a funding mechanism (Low Carbon Network Funds-LCNF) of £500 million over the period 2010 to 2015 to support competitive tenders for “large-scale trials of advanced technology including smart grids”, as part of DPCR5, and only applicable to electricity distribution companies (Crispim et al., 2014). In 2015, with the introduction of RIIO-ED1, the LCNF was replaced by a new funding scheme, called Network Innovation Competition (NIC). DSOs can now recover money for pilot projects through an innovation stimulus under the RIIO model and are incentivised to roll out innovative projects through the regulatory framework (Eurelectric, 2016).

On the other hand, the vast majority of Member States have no mechanism that takes OPEX into account. Only Finland, France, Ireland and United Kingdom have an incentive mechanism for smart grid related OPEX.

- In Finland, there are only incentives for OPEX. CAPEX for R&D and pilot projects are treated as any other costs. OPEX incentives for R&D are approved if they do not exceed 1% of the allowed revenues.
- In France, costs for R&D and pilot projects are covered within the distribution network tariff. These costs are excluded from the benchmarking.
- In Ireland, the Regulator can provide OPEX allowances for R&D projects. Separately, there is also an “Innovation OPEX Fund” for projects. If they succeed, they will strategically innovate and change how the DSO operates.
- The RIIO model in the UK does not differentiate between CAPEX and OPEX. OPEX for funded pilot projects will be recognised in the allowed revenues as well.

2.3 Overview of Smart Grid Efforts of EU Regulatory Bodies

2.3.1 CEER

The Council of European Energy Regulators (CEER) is the representative of national energy regulators in Europe at EU and international level. Through CEER, national regulators cooperate and share their experiences by exchanging information on best practices.

Currently CEER has 29 members (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, the United Kingdom and Iceland) and 6 observer members (Bosnia and Herzegovina, North Macedonia, Republic of Kosovo, Moldova, Montenegro and Switzerland).

The overall aim of CEER is to facilitate the creation of a single, competitive, efficient and sustainable domestic market for gas and electricity in Europe. CEER acts as a platform for cooperation, information exchange and assistance among European national energy regulators and is their interface at the EU and international level. CEER works closely with and supports the Energy Regulators Cooperation Agency (ACER), an EU Agency established on EU issues for cooperation with energy regulators. In addition, some of the works of the dissolved ERGEG have been passed to CEER (e.g. Customer demand) and it continues these works.

CEER is also a member of the International Energy Regulators Confederation (ICER), which brings together similar associations from around the world such as NARUC (America), ERA (Central / Eastern Europe) and MEDREG



This project is funded by the European Union



(Mediterranean region). Within the scope of CEER Smart Grid Position Paper of June 2010, it is stated that; innovation solutions (demonstration pilots) shall be incentivized, open protocols and standards for interoperability shall be adopted, the results and lessons earned from the demonstration projects shall be disseminated, societal cost-benefit assessment shall be performed and output regulation: value for money of users shall be introduced.

In 2011, CEER published CEER Status Review on European Regulatory Approaches Enabling Smart Grids Solutions ("Smart Regulation") and updated it on 18 February 2014. Objectives and contents of the document are to gather evidence and analyse information about regulatory approaches to the demonstration and deployment of smart grids. CEER applies an internal questionnaire among CEER members and observer countries (27 respondents out of 32) to gather information.

2.3.2 EC - Smart Grid Task Force

The Smart Grid Working Group was established by the European Commission in 2009 to advise on issues related to the installation and development of a smart grid. It consists of five Expert Groups that focus on specific areas. The work of these expert groups helps to shape the EU's smart grid policies.¹⁶

Expert Group 1 - Smart grid standards

It was founded in 2009 to discover the best way to offer smart grid services and operation to the benefit of the energy system and its users. The focus of attention of this group of experts has been the dissemination of successful smart grids, the determination of technical standards and provisions designed to allow interoperability of systems and technologies in the smart grid environment. Expert Group 1 provides guidance on how interoperability, connectivity and ultimately functionality of components and processes can be provided to provide smart energy grid services.

In July 2011 to work on smart grids; Smart Grid Coordination Group (SG-CG) was established. In SG-CG 2012, it produced the Sustainable Processes, First Set of Consistent Standards, Reference Architecture, Information Security and Data Privacy and Framework Document.

In 2014, the Smart Grid Coordination Group produced the Extended Standards, Review Methodology, General Market Model Development, Smart Grid Architecture Model User Guide and Demand Side Management, Smart Grid Interoperability and its Tools, Smart Grid Information Security Reports that support the spread of smart grids, and successfully completed the requirements of the M/490 instruction.

In addition, to provide an overview of some initiatives on data access and data management in the field of energy distribution, to identify possible barriers to controlled data access and data management, and to explore the potential and scope of a possible industrial enterprise in a common format for energy data exchange at EU level, on 22 April 2016, a temporary working group was established on "My Energy Data". The temporary group prepared the "My Energy Data" report in November 2016 and planned more studies for 2017.

Expert Group 1 has published the following two reports:

- Interoperability of interfaces for large-scale dissemination of smart meter systems in EU Member States
- Interoperability, standards and functions applied in large-scale deployment of smart metering applications

¹⁶https://ec.europa.eu/energy/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force_en?redir=1



This project is funded by the European Union



Based on the previous work of Expert Group 1, The European Commission has published the following tasks for European Standardization Bodies; CEN, CENELEC and ETSI to develop and update technical standards.

- M / 490 for smart grids (March 2011)
- M / 468 for electric vehicles (June 2010)
- M / 441 for smart meters (March 2009)

During the period 2017-2018, the group worked on procedures for data access and exchange for both electricity and gas, with the task of collecting information and investigating the way towards interoperable practices in the EU.

Expert Group 2 - Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment

The smart grid working group launched an initiative in October 2014 to reduce risks in the security of smart meter systems and personal data.

Under this initiative, a working group was launched in 2017 with the task to investigate for the period 2017-2018 energy-specific cybersecurity issues.

The Commission conducted a two-year evaluation process in collaboration with industry and other stakeholders and prepared a proposal package to ensure the confidentiality and cyber security of 10 minimum functional requirements in smart meter systems in accordance with the Commission Recommendation and General Data Protection Regulation at the end of November 2016.

- Work Package 1: Evaluation Metrics and Framework
- Work Package 2: Technical Clustering and Mapping, Survey Instructions, Technical Survey
- Work Package 3: Best Technical Analysis
- Work Package 4: Reference for Best Techniques (BREF)

Previously completed works;

- Proposal of Security Measures List for Smart Grids
- Basic Regulatory Requirements and Recommendations for Data Processing, Data Security and Consumer Protection
- Data Protection, Privacy and Security
- Test phase of Data Protection Impact Assessment Template for Smart Grid and Smart Meter Systems

Expert Group 3 - Regulatory recommendations for smart grid deployment

Under this initiative, a working group was launched in 2016 with the task, according to its agreed Terms of Reference, of collecting information and investigating, for the period 2017-2018, the necessary further steps for facilitating demand side flexibility in the EU. The workshops organized as well as respective findings and recommendations are:



This project is funded by the European Union



- Smart Networks Working Group, Workshop on Experiences and Conditions for the Successful Implementation of Storage Systems, including Cross-Industry Solutions, Brussels July 1, 2016
- Smart Grids Working Group, Application of Innovation Incentives Workshop, June 1, 2016 Brussels
- Smart Grids Working Group, Smart Home and Buildings Workshop, Brussels April 26, 2016
- EG3 Demand Control and Personal Consumption Workshop, Brussels March 2, 2016
- Regulatory Recommendations to Promote Flexibility
- Addendum to Regulatory Recommendations to Extend Flexibility EG3 Report
- First Year Report: Intelligent Network Data Processing Options, Document Reference List
- Energy Grid Services Concept
- Social Costs and Benefits of Smart Grids
- Introduction to Universal Smart Energy Framework, Methodology and New Applications
- Regulation of Demand Side Flexibility and Market Aspects

Expert Group 4 - Smart grid infrastructure deployment

Reports and findings are as follows:

Energy Infrastructure:

- Final Report - Evaluation of Smart Grid Projects in Expert Group 4 of the Smart Grids Working Group
- EU Smart Grid Inventory projects - 2012 update

Information request for smart grid projects aiming to be included in the common interests of the EU with the draft regulation on European Union energy infrastructure rules:

- Surveys / templates for project proposals
- Defining the evaluation framework for Common Interest Projects in the area of smart grids

Telecommunications Infrastructure:

- Telecommunications issues under Expert Group 4

Expert Group 5 - Implementation of smart grid industrial policy

- Smart Grids Project Outlook 2014 (Joint Research Centre)
- Joint Research Centre survey for the Collection of European Smart Grid Projects

Previous studies:

- Expert Group Study for 2010/2011



This project is funded by the European Union



2.3.3 ACER

Energy Regulators Cooperation Agency (ACER) was established as part of the five legislations related to the Third Energy Package, which came into force with the European Commission's decision for the liberalization of the energy market, aiming to improve the functioning of the European electricity and gas markets. It is a community body with legal personality. ACER was fully operational in Ljubljana, the capital of Slovenia, on March 3, 2011.

ACER plays a key role in the integration of the EU's electricity and gas markets and provides a framework for national regulators to cooperate at EU level and provide clarity and regulatory certainty.

ACER was led by the ERGEG, which was established in November 2003 by the European Commission's decision (November 11, 2003, 2003/796 / EC Decision). ERGEG was terminated by the Commission as of 1 July 2011, with the full commission of ACER. Some of ERGEG's works have been transferred to ACER (e.g. Regional Initiatives) and they continue these studies.

ACER completes and coordinates the work of National Regulatory Bodies at EU level. Its power includes the preparation of framework rules to form the basis of EU-wide network codes (prepared by the European Network Institutions). These are;

- Taking individual binding decisions where national regulatory authorities do not accept access to cross-border infrastructure and operational safety requirements
- Advising institutions in Europe on various energy-related issues
- Presenting their observations and reports to the European Parliament and the Council.

2.3.4 ERGEG

European Regulators' Group for Electric and Gas (ERGEG) was established by the European Commission Decision 2003/796/ EC of 11 November 2003 as the advisory body of the EU Member States' National Energy Regulatory Authorities.

Members of ERGEG are the heads of the national energy regulatory authorities in the EU's 28 Member States.

Its purpose is to ensure consistent implementation of the provisions set out in the Internal Market in Electricity Directive in all Member States. ERGEG assisted the Commission in consolidating a single EU market for electricity and natural gas.

On December 2009, ERGEG launched its "Position Paper on Smart Grids" for public consultation with the purpose of assisting regulators in understanding how smart grids can benefit network users and, potentially, other stakeholders in the European electricity supply system and exploring ways in which the development of smart grids can be encouraged, where cost effective. Together with the 50 responses gathered, on June 2010, Conclusions Paper was published to evaluate the responses received by the stakeholders and to state the final views and recommendations of ERGEG after the consultation process.¹⁷

With the ACER's becoming fully operational in March 2011, effective from 1 July 2011, ERGEG ended its activities.

¹⁷ http://www.smartgrids-cre.fr/media/documents/regulation/100610_ERGEG_Position_paper.pdf



This project is funded by the European Union



2.3.5 ENTSO-E

European Network of Transmission System Operators for Electricity (ENTSO-E), represents 42 transmission system operators (TSO) for electricity from 35 countries in Europe. Aiming to further liberalize the electricity markets in the EU, ENTSO-E was established in 2009 by the EU's Third Legislative Package for the Internal Energy Market, setting legal requirements.

The role of TSOs has evolved significantly with the Third Energy Package. Due to the unbundling of electricity generation, transmission and distribution activities and the liberalization of the energy market, TSOs have become the meeting place for various players to interact on the market.

ENTSO-E members aim to establish an internal energy market, ensure its optimum functioning and support the ambitious European energy and climate agenda. The most important issues in European energy markets today are the integration of high amounts of renewable energy in the European energy system, the development of sequential flexibility and a further customer-oriented approach compared to the past.

ENTSO-E is committed to developing the most appropriate response to the challenges of a changing power system while maintaining supply security. Innovation, market-based approach, customer orientation, interest focus, supply security, demand-side management and regional cooperation are important topics in ENTSO-E's agenda.

ENTSO-E contributes to the achievement of these goals by:

- Expressing views on policies
- Preparing grid codes and contributing to their implementation
- Development of regional cooperation with Regional Security Coordination Initiatives
- Technical cooperation between TSOs
- Publishing summer and winter electricity generation reports for an overview of short-term system capability
- Development of long-term pan-European network plans
- Coordination of research and development plans, innovation activities and participation in research programs such as Horizon 2020 or former FP7 (7th Framework Program)

ENTSO-E performs such important tasks in a strong interaction with European institutions, ACER and other stakeholders.

2.3.6 NordREG

NordREG is the organization of energy regulators of the Nordic countries (Denmark, Finland, Norway, Iceland and Sweden). It actively promotes the legal and institutional framework, the necessary conditions for developing the Scandinavian and European electricity markets.

The aim of cooperation in NordREG are:

- Opinion exchange
- Analysing energy market issues



This project is funded by the European Union



- Producing reports and papers
- Joint action to influence the development of Scandinavian countries or European energy markets

It is aimed that all Scandinavian electricity customers can freely benefit from reliable suppliers, efficient and competitive prices in the Scandinavian countries and through the European electricity market.

NordREG has mapped the national situation in the Nordic countries regarding smart metering in 2014. NordREG

has published two reports in 2016, which included survey results on the following subjects;

- Roles and responsibilities of TSO and distribution system operators (DSO) in the northern European national regulations; and
- Current market design for demand response and micro generation

2.3.7 ICER

The International Energy Regulators Confederation (ICER) is a voluntary organization for cooperation among energy regulators from around the world. Its aim is to increase knowledge and awareness of public and policymakers on the role of energy regulation and the handling of a wide range of socioeconomic, environmental and market issues.

This voluntary confederation aims to share knowledge and best practices in the field of regulation and contribute to the development of a sustainable planet, with regular and structured guides and collaboration between regulators.

In this regard, it encourages joint analysis on various regulatory issues and trade in education and training practices. It focuses in four main areas: reliability and security of supply, the role of regulators against climate change, competitiveness and affordability and independence, powers, responsibilities, best practices, and training of regulators.

Through ICER, which has more than 200 regulatory members spread across six continents, energy regulatory issues can be addressed across regional and national borders and through dialogue and collaboration on a global scale.

2.3.8 EDSO^{18 19}

European Distribution System Operators (EDSO) is the key-interface between the leading electricity DSOs and the European institutions and stakeholders. EDSO promotes the development and large-scale testing of smart grid technologies in real-life situations, new market designs and regulation.

EDSO gathers 41 leading DSOs in 24 countries, including 2 national associations, cooperating to ensure the reliability of Europe's electricity supply for consumers and enabling their active participation in energy system by shaping smarter grids.

According to the study performed by CEER, in the majority of countries (84%), DSO plays a major role in smart grid development. In addition, a smaller number of countries identified that NRAs (44%) and TSOs (40%) play a major role, with suppliers (52%), the Government (56%) and technology providers (56%) all noted as playing a supporting

¹⁸ <https://www.edsoforsmartgrids.eu/home/>

¹⁹ EDSO is not a regulatory institution but stated here because of its role related to smart grids



This project is funded by the European Union



role. Other stakeholders that were identified include local authorities, generators, technical universities, research institutes and external consultants.

The areas that NRAs are predominately involved in for smart grid development are incentivising (58%) and information provision (58%). The NRA was also identified as being involved in promoting research and development and demonstration trials, but in a lower number of countries.

Other key roles for NRAs were noted as providing input for legislation, consultation, mediation and defining the goals of smart grids. The responsibilities for smart grid development in Austria, Germany, Estonia, Luxemburg, Romania and Netherlands are mainly left to the market, without an explicit role for NRAs. In Lithuania, the NRA is involved in the CBA for smart grid development for the gas sector, but it has no specific role in smart grids in the electricity sector.²⁰

2.4 Overview of Smart Grid Projects in EU

In Europe investments related to smart grids are concentrated in 10 Member States together with Switzerland and Norway. Among them, Germany, UK, Denmark and Spain are the countries with the most initiatives. It is known that organizations in these countries are very active and have decided to start a large number of initiatives in their own countries as well as in other Member States.²¹

Especially United Kingdom, Germany and Denmark have high share of international and national projects. These countries are remarkable in terms of the positive national or regulatory environment that they create for the development of smart grids. In United Kingdom, the interaction between the national regulatory authority, Ofgem and DSOs has been a driver and funding for innovation at the heart of smart grid developments has been created. Acting as the developer of smart grid projects, DSOs have become the main source for technology transfer and sub-financing for the development of an innovative supply chain (Owaineh, Leach, Guest, and Wehrmeyer, 2015), and have created opportunities for other organizations to test, learn, implement and grow new business models.

When the number of projects per country is analysed, the projects are still concentrated in a group of EU Member States, as it can be seen from Figure 3.

²⁰ CEER, February 2014, CEER Status Review on European Regulatory Approaches Enabling Smart Grids Solutions ("Smart Regulation")

²¹ EC Smart Grid Projects Outlook 2017 "Facts, figures and trends in Europe", Flavia Gangale Julija Vasiljevska Catalin Felix Covrig Anna Mengolini Gianluca Fulli



This project is funded by the European Union

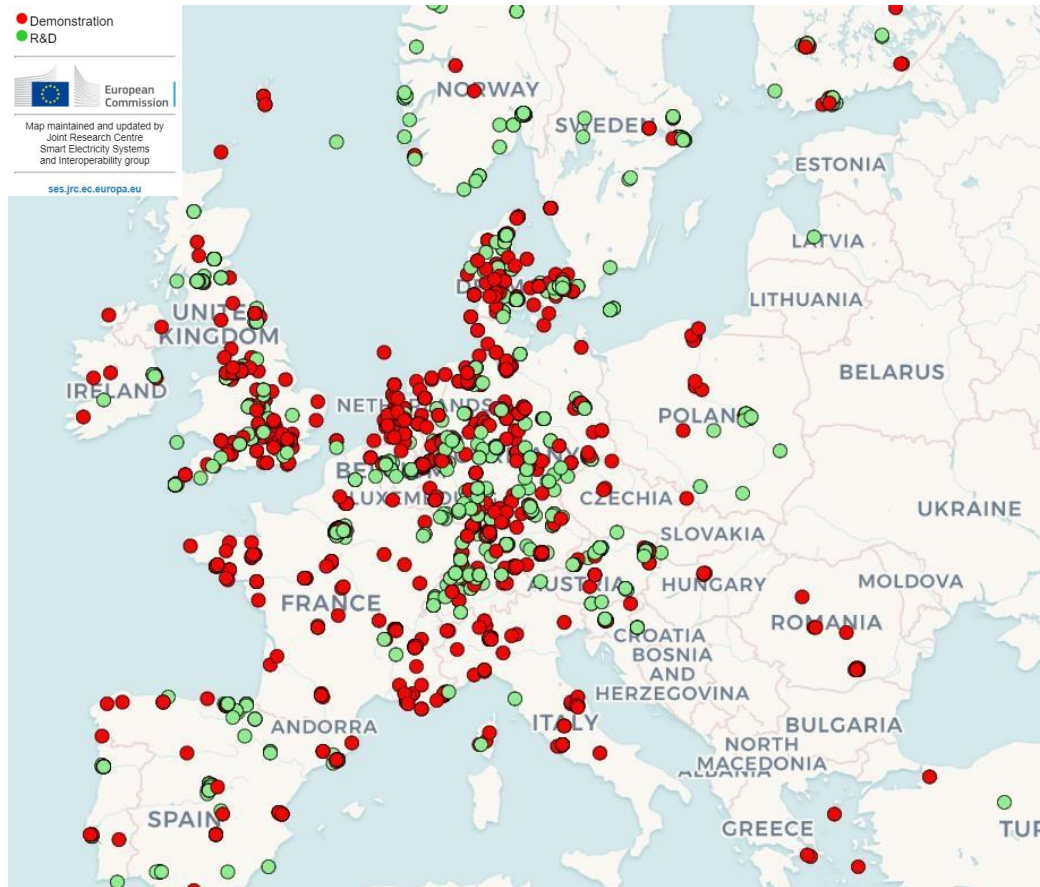


Figure 3: Map of Smart Grid Projects (as of August 2020) since 1994²²

The region located in the south of Belgium, Netherlands and west of Germany shows the highest density in smart grid projects in terms of both number and total investment.

However, Madrid the capital city of Spain and the Basque region of Spain are seen among other EU capitals, such as London, Copenhagen, Rome and Paris, and regions such as eastern Denmark and northern Italy where such organizations are condensed.

R&D projects are much more spread over many countries than pilot projects, with notable exceptions in France, Italy, Luxembourg and UK. The number of pilot implementation projects in the UK, together with France, Italy and Luxembourg, is higher than the R&D projects, due to the national policy priorities and regulatory framework that encourage the adoption of pilot implementation initiatives in different areas.

In addition to strengthening the national export potential, a positive national policy and regulatory framework are also important to make a country attractive for foreign smart grid investments. In particular, the adoption of smart grid roadmaps is a clear sign that smart grids are at high priority on the national agenda, thus attracting foreign investors to seek partnerships with local stakeholders to enter the national market. To date, only a few Member States, including the UK and Denmark, Germany, Ireland, France, Austria, Slovenia, Sweden, have adopted roadmaps for the rapid development of smart grids. The smart grid vision and roadmap in the UK was adopted by

²² <https://ses.jrc.ec.europa.eu/project-maps>



This project is funded by the European Union



the Department of Energy and Climate Change in 2014. The smart grid roadmap in Germany was prepared by the Federal Association of the Energy and Water Industry BDEW (BDEW, Bundesverband der Energie und Wasserwirtschaft eV, 2013).

Similarly, a clear sign that smart grids are of high importance in the national and international agenda is the establishment of smart grid platforms. Smart network platforms were first established in Spain (FutuRed, 2005) and followed by Slovenia (2006), Austria (SmartGrid Austria, 2008), Czechia (Česká technology platform Smart Grid, 2009), Ireland (SmartGridIreland, 2009), Flandre Regions (Smart Grids Flandre 2010), Norway (Norwegian Smartgrid Centre, 2010), Poland (Polish Consortium of Smart Power Grids, 2010), Switzerland (Smart Grid Swiss Association, 2011), Netherlands (Information Society Gifted Cities Association, Germany (SmartGrids Baden- Württemberg, 2013), Italy (Smart Grids Italia, 2014), Greece (Hellenic Technology Platform for Greece (TKI) Switch2SmartGrids, 2012), Denmark (PowerLabDK, 2012 and SmartEnergy Networks RD & D, 2013), Cyprus (Cyprus Technology Platform for Smart Grids, 2014), Latvia, (Smart Grids Latvia, 2014) and France (Think Smartgrids, 2015).

The share of general investment covered by national funding varies widely between Member States. Some Member States have developed comprehensive support plans for smart grid innovation. In most Member States, this rate is below 10%, while in Germany, Denmark, Greece, France, Austria, Poland and Finland this rate is above 20%. Along with these countries, the major points of private smart grid investment are in Spain (especially the Basque region).

Austria (mostly the region around Vienna), Greece (mostly the region around Athens) and Spain (mostly the region of Basque region) are the countries where the most important national funds created for smart grid projects are directed in Europe. Spain is also among the countries to which the most important EU funds are directed such as Belgium, France and Netherlands.

In Germany, national funds account for 47% of the total national investment. An interesting example of this funding is the 'E-Energy- ICT-based energy system of the future' and nuclear security (BMU) initiative, the co-financing program of the Federal Ministry of Economy and Technology (BMWi) and the Federal Ministry of Environment and Nature Protection. The 4-year initiative has finances of around €60 million and has supported the creation of 6 e-energy model regions in which basic technologies and business models have been developed and tested to expand the smart grid (Federal Ministry of Economy and Technology, 2009).

As another component of smart grids, the DSM domain addresses the integration of Electric Vehicles (EVs) and vehicle-network applications, including charging infrastructure for electric cars, smart charging strategies and the development and deployment of ICT services. Technology manufacturers are the most invested stakeholders in the automotive industry, charging infrastructure providers, charging and propulsion systems. DSOs also have a significant share of the investment attributed to DSOs, mostly in Germany, Spain, Italy, Netherlands and the UK. In this context, typical applications deal with smart charging strategies for electric mobility (e-mobility) and related services, new business models for public housing infrastructure and network-optimized integration of EVs and the impact of EVs on the retrofit costs of low-voltage (LV) networks, including the development of the market across Europe.

R&D applications include testing the compatibility of different systems (electrical system, charging infrastructure, etc.) to be included in the infrastructure for smart charging of EVs, interoperability and performance tests, and in 2012, national funding was observed to increase rapidly in relation to financial support. This is attributed to the ICT²³ Electric Circulation II Technology Program prepared by the German Federal Ministry of Economic Affairs and

²³<https://www.bmwi.de/redaktion/en/artikel/industry/electric-mobility-rd-funding.html>



This project is funded by the European Union



Energy. This program supports 18 projects focusing on new ideas and technologies for interaction between smart car systems within the concept of electric car (Smart car), smart power supply (smart grid) and smart mobility (Smart traffic). The biggest R&D project under this program is the "e-connect Germany" project, the research alliance between industry partners, universities and municipalities, and focuses on sustainable mobility concepts in common areas.

The limited number of countries that focus on electric roaming projects and make up about 40% of the total investment in this area are Spain, Germany, France and Austria.

In the ranking of smart grids private investment rate, Luxembourg ranks first, and UK ranks second. The ratio of total national investment to private investment is 83% in the UK and 98% in Luxembourg. In the UK, innovation incentives are considered as private funding by Ofgem. Approximately 30% of projects in the UK have received such incentives, which has increased the share of total private investment.

The investment distribution associated with stakeholder owners per participating country is €124 million in total. France, Britain and Germany are the three Member States with the highest investment from rising stakeholder owners. Most of these actors in France are energy management service providers that offer a consumption monitoring and management solution for consumption and the benefit of operators. In the UK, these organizations are mainly aggregators, housing associations and energy management service providers involved in energy community projects, while in Germany they are predominantly electric mobility (e-mobility) projects.

The current amount of EU co-financing can affect the project scope and support the development of more ambitious and expensive projects. In this context, countries with comprehensive support mechanisms such as Germany and the UK show a high level of investment.

Along with the geographical distribution of the investment targeting Smart Network Management (SNM) implementations, the majority of the investment related to the application sites comes from the UK, mostly as national projects (more than 20%), and it is followed by southwest Germany, northern Spain and France. These results are in line with existing regulatory frameworks in UK (e.g. LCNF) and national incentives in Germany (e.g. E-Energy) promoting smart grid investment. When it comes to application areas, the largest investment occurs in central and southwestern Germany, southern England and southern France. In addition, the south-eastern Greek islands and central Romania offer larger investments associated with their application areas. Approximately 75% of the total DSO investment in this area is allocated to national projects. In Demand Side Management (DSM) projects, it is emphasized that DSOs are in significant cooperation with public institutions such as city / town administrators, local energy agencies due to the national interests of some Member States (especially Germany, Spain, France, Italy and the UK) and DSOs are important in developing sustainable energy communities. In addition, there is a strong cooperation link between the ICT and telecom companies and technology manufacturers, two of the main actors that provide the digital transformation of the energy industry.

Approximately 18% of the innovative projects participated by DSOs received special incentives and made up about 35% of the total DSO investment. Italy is an interesting example of National Regulatory incentives for innovative activities. The initiative, initiated by the AEEG regulatory decision ARG / elt / 39/10, created a competitive process for selecting a series of practical pilot projects. Seven projects have been identified during the selection process, and these projects will benefit from a 2% additional weighted average cost of capital (WACC) payment in addition to ordinary returns for a 12-year period.



This project is funded by the European Union



Italy has also adopted and launched specific regulatory mechanisms to incentivize R&D and promotion projects, together with the EU 8 Member States²⁴, plus Norway, according to Eurelectric (Eurelectric, 2016).²⁵

Along with Belgium, Denmark (mostly around Copenhagen), France (mostly around Paris), Spain (especially the Basque region) and Netherlands, Italy is the main point of private investment for smart grids in Europe.

According to a study performed in 2020²⁶:

- Close to 225 million smart meters for electricity and 51 million for gas will be rolled out in the EU by 2024. This represents a potential investment of €47 billion.
- By 2024, it is expected that almost 77% of European consumers will have a smart meter for electricity. About 44% will have one for gas.
- The cost of installing a smart meter in the EU is on average between €180 and €200.
- On average, smart meters provide savings of €230 for gas and €270 for electricity per metering point (distributed amongst consumers, suppliers, distribution system operators, etc.) as well as an average energy saving of at least 2% and as high as 10% based on data coming from pilot projects.

Examples of Recent Smart Grid Projects

As mentioned before EDSO promotes the development and large-scale testing of smart grid technologies in real-life situations, new market designs and regulation. In addition to the national projects related to smart grids, there are projects that are developed by international participants. The ones to be performed by EDSO are as follows:

EUniversal: The aim of the project is to enable the transformation of the energy system into a new multi-energy and multi-consumer concept. The EUniversal will define, develop and validate a set of market-oriented flexibility management services from distributed energy resources (DER) in a real environment with a large renewable energy sources (RES) integration and high electrification. Based on this transformative concept, grids will become capable of accommodating future scenarios through the active use of grid services, fostering innovative market mechanisms, and bring additional value to society. 3 different DEMO in Portuguese, Germany and Poland will be performed. Project period is between 1 February 2020 and 30 July 2023 and project coordinator is EDP Distribuicao.



PlatOne (Platform for Operation of Distribution Networks): The project will develop and test a blockchain-based two-layer platform providing a flexible structure among energy actors accommodating seamlessly the local prosumers, as well as the increasingly less predictable consumption patterns. Project period is between 1 September 2019 and 31 August 2023. Project coordinator is RWTH Aachen.

Interconnect: Interconnect aims to the challenge regarding communication of technologies among each other by developing advanced solutions for efficient energy management, connecting digital homes and buildings with the smart energy grid. In order to roll out the project in a comprehensive manner, the objectives have been divided into 8 focus areas are big data, power grid, cloud, standardization, ontology, cybersecurity, IoT and digital platforms. In parallel, a validation of the Interconnect concept will take place in 7 different pilot sites.

²⁴ These member States are: Finland, France, Ireland, Italy, the United Kingdom, Greece, Portugal, Slovenia.

²⁵ energia elettrica e il gas del 29 Haziran 2007, n. 348/07

²⁶ Alaton, Clément; Tounquet, Frédéric, 18 March 2020, Benchmarking smart metering deployment in the EU-28 Final Report



This project is funded by the European Union



Situated in Belgium, France, Germany, Greece, Italy, Netherlands and Portugal, the pilots will work with the active involvement of citizens ensuring sustainable and efficient business models. Project period is between 1 October 2019 – 30 September 2023 and coordinator are INESC TEC.



The **IntEnSyS4EU (INTEgrated ENergy SYStem, a pathway for EUrope)** project is a coordination action which aims at paving the way for the development of a low carbon energy grid. The project runs the European Technology and Innovation Platform Smart Networks for Energy Transition (ETIP SNET) in support of the Strategic Energy Technology plan (SET-plan) issued by EU as one of the main

technology pillars to achieve the 2050 energy and climate goals. In addition to the linked third parties contributing to the INTENSYS4EU project, E.DSO members contribute with direct involvement and expertise to the 5 ETIP SNET working groups where they together with other industry experts cover the following topics

- WG1: Reliable, economic and efficient smart grid system
- WG2: Storage technologies and sector interfaces
- WG3: Flexible generation
- WG4: Digitization of the electricity system and customer participation
- WG5: Innovation implementation in the business environment

Project period is between 1 October 2017 and 30 September 2020 and coordinator is Zabala.



CoordiNET is the large-scale demonstrations of innovative network services through demand response, storage and small-scale distributed generation. Objectives of the project are to demonstrate the activation and provision of services through a TSO-DSO coordination, define and test standard products that provide services to the network operators and develop a TSO-DSO-consumer collaboration platform in demonstration areas to pave the way for the interoperable development of a pan-European market.

Project duration is between 1 January 2019 and 30 June 2022. Project include 23 partners and 10 linked third parties.



The main objective of the EDDIE Project is to develop a long-driven Blueprint for the digitalization of the European energy sector to enable the matching between the current and future demand of skills necessary for the digitalization of the energy sector and the supply of improved Vocational Education and Training (VET). This will be executed from Partners of 10 different EU Member States. Project period is between 1 January 2020 and 31 December 2023 and the coordinator is Comillas.

On the other hand, there are other smart grid projects that are identified as Projects of Common Interest (PCI) and are considered key for implementing cross-border energy infrastructure in the EU. Joint Research Centre (JRC) developed and published a report regarding Assessment Framework for Projects of Common Interest in the Field of Smart Grids — 2017 update (Vasiljevskaa and Gras, 2017)²⁷. The PCI list 2019 includes 6 smart grids projects that are²⁸:

²⁷ Vasiljevskaa, J., Flego, G., JRC, 2019, Identification of projects of common interest in the priority thematic area of smart grids deployment, Evaluation of candidate projects under EU Regulation 347/2013 on trans-European energy infrastructure

²⁸ https://ec.europa.eu/energy/topics/markets-and-consumers/smart-grids-and-meters/overview_en#smart-grid-projects-in-europe



This project is funded by the European Union



- **SINCRO.GRID (Slovenia, Croatia):** An innovative integration of synergetic, mature technology-based solutions in order to increase the security of operations of the Slovenian and Croatian electricity systems simultaneously.
- **ACON (Czechia, Slovakia):** The main goal of ACON (Again CONnected Networks) is to foster the integration of the Czech and the Slovak electricity markets.
- **Smart Border Initiative (France, Germany):** The Smart Border Initiative will connect policies designed by France and Germany in order to support their cities and territories in their energy transition strategies and European market integration.
- **Danube InGrid (Hungary, Slovakia):** The project enhances cross-border coordination of electricity network management, with focus on smartening data collection and exchange.
- **Data Bridge (Estonia, Latvia, Lithuania, Denmark, Finland, France):** The project aims to build a common European Data bridge Platform, to enable integration of different data types (smart metering data, network operational data, market data), with a view to develop scalable and replicable solutions for the EU.
- **Cross-border flexibility project (Estonia, Finland):** The project aims to support renewable energy sources (RES) integration and increase security of supply by cross-border provision of flexibility services to Estonia, Finland and Aaland provided by distributed generation.

2.5 International Benchmarks: Smart Grid Regulations in Electricity Distribution

The analysis of international experiences aims to extract relevant information necessary to understand the smart grid regulations that are implemented in selected European countries. In this section, the regulatory schemes used in selected countries are analysed in more detail.

Consolidated descriptions serve as a benchmark on international practices related to regulations and tariff methodologies for smart grid activities in the electricity distribution sector. The following countries are considered in the analysis: UK, Italy, Germany, Spain and Sweden.

2.5.1 UK

Similar to many other countries, United Kingdom is also seeing the impacts of the transition to a low carbon economy. Electricity generation mix is changing with the increasing level of RES and other low carbon generation. Share of distributed generation including solar PV and onshore wind farms are increasing while creating technical challenges such as variations in system voltages in some parts of Britain particularly overnight and creating operational challenges in managing the transmission network.

On the other hand, due to the increasing electrification of heat and transport, electrical demand increases too. In this regard, continued development of a smart grid seems essential.

At distribution level, Distribution Network Operators (DNOs) in local electricity networks are transitioning to a Distribution System Operator (DSO) role, which involves more active management of networks, including procurement of market solutions to network issues and greater coordination between the transmission and



This project is funded by the European Union



distribution boundary. DNOs have started to open up the delivery of network requirements to market-based smart solutions (storage and DSR, for example), to reduce network cost and deliver savings for consumers.²⁹

2.5.1.1 *Regulatory Institutions*

Department of Energy and Climate Change (DECC) is the main institution that has the responsibility of making decisions, policy making and legislation implementation that affect the industry. It is accountable and reports to Parliament on supply security and sustainability in the UK energy sector. DECC is a ministry unit, supported by other agencies and public institutions, including Ofgem, and works in close collaboration with them.

The relevant Government Ministry in Northern Ireland is the **Department of Enterprise, Trade and Investment (DETI)**.

Ofgem is an independent national regulatory agency recognized by the EU directives, regulating gas and electricity markets to protect the interests of current and future electricity and gas consumers in the UK and to provide appropriate regulations by encouraging competition (Utilities Act 2000). It operates within the legal framework determined by the UK Government and the European Union. It also has an additional task, in accordance with the Third Energy Package (IME3), to promote the internal energy market and to remove trade restrictions between EU Member States. Ofgem has a wide range of powers to regulate the industry.

Ofgem and the DECC established the **Smart Grid Forum** in 2011 in order to support the UK's transition to a secure, safe, low carbon, affordable energy system through considering the full range of technical, commercial and regulatory issues associated with developing smart grids.

The Forum aims to:

- Identify future challenges for electricity networks and system balancing, including current and potential barriers to efficient deployment of smart grids.
- Guide the actions that Ofgem is taking with DECC to address future challenges, remove barriers and aid efficient deployment.
- Identify actions that DECC, the industry, other parties and Ofgem could be taking to facilitate the deployment of smart grids.
- Facilitate the exchange of information and knowledge between key parties, including those outside the energy sector.
- Help all stakeholders better understand future developments in the industry that they need to prepare for.
- Track smart grid developments and their drivers.
- Track smart grid initiatives in Europe and elsewhere.

The Forum brings together representatives from electricity network companies, consumer groups, energy suppliers and wider industry.

²⁹ MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids



This project is funded by the European Union



In February 2014, Smart Grid Forum published **Smart Grid Vision and Routemap**, which will be defined in more detail in Regulatory Structure section.

2.5.1.2 New Roles after the Smart Grid

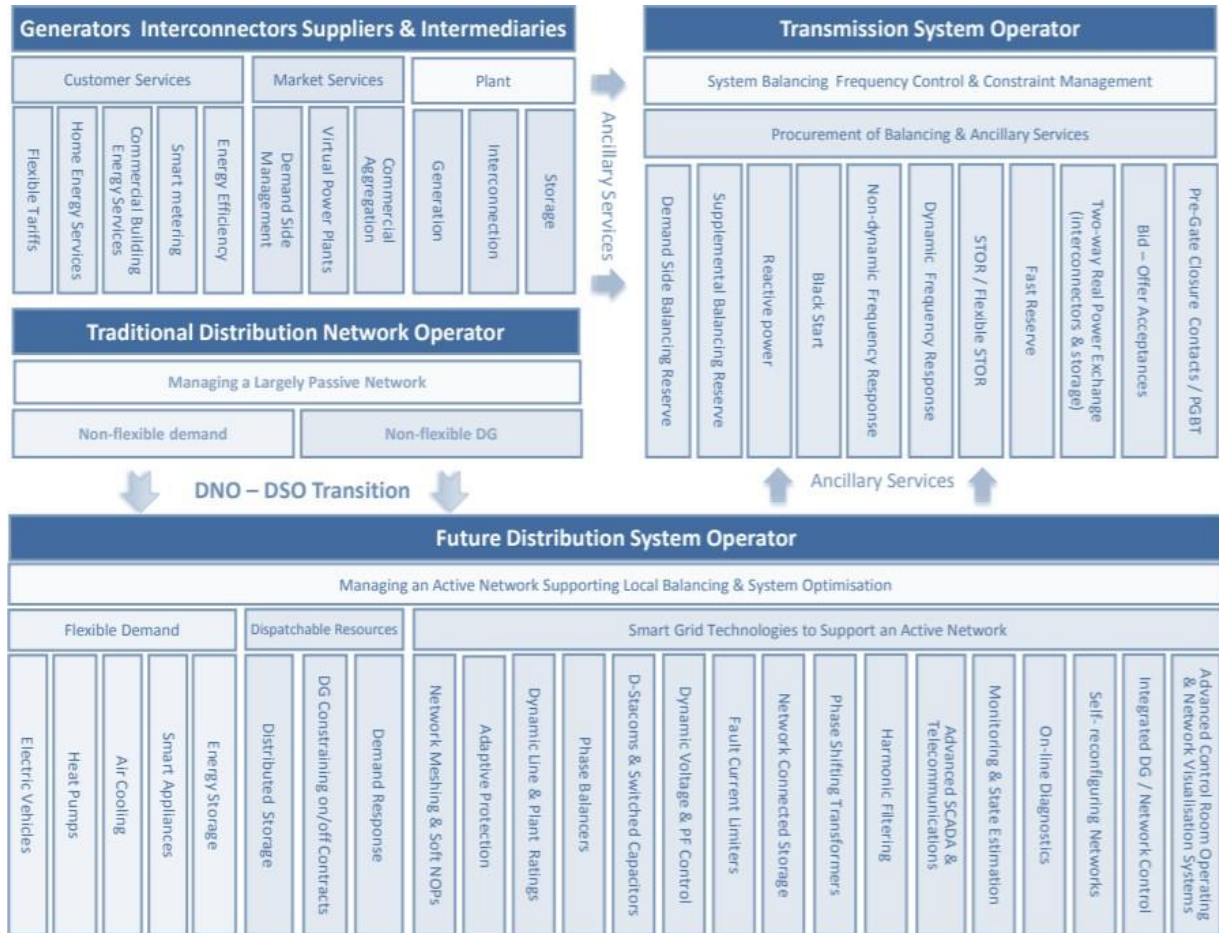


Figure 4: Potential Roles and Relationships of the Energy Industry within a Smart Grid³⁰

Together with the development of smart grids, new roles, and relationships for all the stakeholders acting in the electricity system such as suppliers, consumers, generators and network operators were defined as stated by UK Power Networks and shown in the above figure. As it can be seen, the traditional network operators will evolve from their current role to operating as a DSO supporting local balancing and system optimization. In UK;

- Suppliers will be responsible for installing smart meters across and they may introduce new time of use tariffs that reward consumers for shifting demand away from peak times
- Distributed generators will play more active role in meeting local energy demand.
- Consumers, through demand management, will play a more active role in helping to balance supply and demand.

³⁰ UK Power Networks, Smart Grid Vision and Routemap



This project is funded by the European Union



- DNOs will also have a more active role since they need to deploy the technology necessary for better managing supply and demand at the local level (as a result of developments in flexible demand, distributed generation and energy storage).
- DNO will need to be ready to find new solutions in case of situations like take-up of low carbon technologies (e.g. electric vehicles, heat pumps, solar PV) exceed expectations. The level of response will depend on development of standards for innovative solutions, supply chain capacities, skills, and thought-through systems engineering that accommodates critical aspects such as data management-at-scale, control centre integration, and commercial and consumer interfaces.
- DNOs has also challenges related to the investment decisions that they made. Investment decisions shall be made in the short-term, but they shall reflect longer term needs while avoiding the risk of stranded assets and inevitably some first-generation smart technologies may be superseded by superior and more advanced technologies over time.
- DNOs address all these issues in their business plans and innovation strategies.

2.5.1.3 *Regulatory Structure*

In UK, various papers, reports and strategy documents have been published related to the development of smart grid systems³¹.

- The **Innovation Funding Incentive** and **Registered Power Zone** incentives introduced in 2005 by Ofgem have been instrumental in catalysing innovation in the management of electricity distribution networks and development of smart solutions.
- **UK Carbon Plan (2011)** outlined different pathways (scenarios) to meet the 4th Carbon Budget and 2050 emissions target. This has provided a starting point to assess the potential impact of the low carbon transition on electricity distribution networks.
- As part of the electricity distribution price control arrangements, the **Low Carbon Networks Fund (LCNF)** was established between April 1, 2010 and March 31, 2015. The LCNF has provided £500 million to cover the costs of projects supported by distribution network operators (DNO). The projects covered new technology, business and trade arrangements.
- **Renewable Energy Roadmap (2011)**, which was updated in November 2013, presented a framework and set of actions for the delivery of renewable energy deployment. Roadmap was published by DECC and it set out 6 key areas where activity was needed to tackle cross-cutting barriers including facilitating access to the grid.
- According to the **Electricity System Assessment of Future Challenges document** published in 2012, balancing technologies and smarter networks will be crucial to the cost-effective matching of electricity supply and demand. In this document, it is also stated that the Government will have a key role to ensure that market frameworks and networks develop in a way that is fit for purpose, and in removing barriers to widespread deployment of balancing technologies.
- **Community Energy Strategy (2014)** recognizes that as the country move towards smarter energy management, communities can help pilot new approaches to balancing supply and demand, providing valuable learning that can be applied elsewhere.

³¹ Smart Grid Forum, February 2014, Smart Grid Vision and Routemap



This project is funded by the European Union



- The **Smart Energy Code** is the legal framework which sets out the day-to-day rules, rights and obligations regarding smart metering equipment and the information it provides. Given the key role of smart metering in enabling the development of a smart grid, network operators are working closely with the Government in the development of preparations for the smart meter roll-out.
- **Driving the future today - a strategy for ultra-low emission vehicles in the UK (2013)** set out the Government's strategy to drive forward the ultra-low emission vehicles (ULEVs) industry. It announced a call for evidence on how best to invest £500 million of funding for the period 2015 - 2020 to drive the revolution and establish the UK as a premier market.
- **Future of Heating: A strategic framework for low carbon heating in the UK (2012)** set out the challenge of decarbonizing the UK's heat demand and identified key enabling activities DECC will undertake in order to deliver the step-change in heating necessary to meet it. This includes looking at the most effective ways to bring about a large-scale transition to low carbon heating over the coming decades, to meet the country's carbon budgets whilst putting them on a pathway to achieve their 2050 carbon targets.
- Ofgem has developed the new **RIIO Regulatory Framework** in order to incentivize network operators to rise to the challenge of delivering a low carbon UK. RIIO is a significant departure from the previous regulatory approach to regulation (RPI-X), which was largely aimed at reducing costs and getting efficiencies out of the existing assets. RIIO requires companies to plan earlier for different scenarios and to engage more with stakeholders when preparing business plans and throughout the price control period. RIIO will be explained in more detail in the next paragraphs.
- The Smart Grid Forum developed a parametric model, the **Transform Model** to assess the costs and benefits of smart grid deployment in terms of deferred or avoided reinforcement costs under different low carbon transition pathways and investment strategies. The Transform Model provides DNOs with a robust evidence base for assessing the investment needs of accommodating low carbon technologies across any scenario for the next price control period. These estimates have informed the DNO investment proposals set out in their RIIO-ED1 Business Plans.
- **The Smart Cities' initiative** was launched by the Department for Business Innovation and Skills.
- In 2014, **Smart Energy UK** was launched and the public-facing campaign to communicate the benefits of smart meters began.
- According to **Smart Grid Vision and Routemap** of Ofgem, there are three phases to achieve their vision that are stated in Figure 5 where the first phase of the deployment is focused on capturing the short-term benefits of deploying smart technologies and solutions, and preparing for the accelerated deployment of distributed generation and increasing electrification of heating and transport projected to take place in the 2020s. The second phase of smart grid deployment sees a much greater role for the consumer, following the successful roll-out of smart meters across United Kingdom. The third phase will see UK achieve its vision objectives, where a smart grid enables UK to develop a fully integrated smart energy system and a platform for the further development of technologies to support the increasing electrification of the heating and transport sector as well as smarter homes and businesses



This project is funded by the European Union



Figure 5: Key Stages in the Development of Smart Grid

- DECC introduced in 2014, **Electricity Market Reforms (EMR)**, that consist of Contracts for Difference as the central means for incentivizing the deployment of large-scale low carbon electricity generation and a Capacity Market, which will ensure sufficient capacity margin exists in the UK power market through a series of capacity auctions.
- In 2014, **UK Solar PV Strategy document** was published by DECC to set out guiding principles, which form the basis of Government's strategy for solar PV.
- DECC has commissioned Frontier Economics, with support from Sustainability First, to review the potential for demand side response (DSR) in the electricity sector to 2035. In 2015, **Future Potential for DSR in UK** was published with the aim of creating an initial framework to capture which drivers affect the capacity and costs of all types of DSR in the long-run.
- In 2016 DECC published a **Guideline on Smart Meters and Demand Side Response** to explain how the smart metering system can support load control mechanisms to facilitate domestic demand side response.
- In February 2017, BEIS published a toolkit and factsheets on energy efficiency to enable meter installers to give tailored energy efficiency advice during smart meter installation visits, making it easier for householders to adopt energy efficient behaviours.
- **Smart Systems and Flexibility Plan of July 2017** sets out the policy direction to guide innovation and the wider smart transition. Three key areas of focus are mentioned in the plan that are to deliver a smarter and more flexible energy system, removing barriers to smart technologies including storage, enabling smart homes and businesses and making markets work for flexibility.
- In October 2018 Government and Ofgem published a **progress update to the plan**, announcing that half of the original actions had now been implemented and identifying nine new actions they are undertaking.
- The transition to second-generation smart meters began in 2018 and in May 2019, over 1 million of these meters were connected to the national smart metering communications infrastructure. In May 2018, the **Smart Meters Act 2018** received Royal Assent, extending the Government's right to exercise powers over the roll-out to November 2023.
- Towards the end of 2018, the DCC began progressing work to move first generation smart meters onto the national smart metering communications infrastructure.



This project is funded by the European Union



- In June 2019, the **New and Replacement Obligation** was activated, mandating energy suppliers to take all reasonable steps to install a compliant smart meter where a meter is installed for the first time (for example in new-build properties) or where a meter is replaced.³²
- Energy Networks Association (ENA) made studies on the benefits and development of new data management and analytics technologies, consistent with security and privacy requirements. In 2019, ENA published a **manifesto for a net zero energy system**, where it is stated that transformation to a smarter energy system shall continue. In this regard, more green energy needs to be connected to the grid to achieve net zero and support shall be provided for emerging local energy markets, the use of new forms of flexibility to manage the grid and the shift to 'distribution system operators' – to manage local electricity networks more actively than ever before.
- The Government offers grants to support the wider use of electric and hybrid vehicles via the Office of Low Emission Vehicles (OLEV). The schemes offered are³³
 - ElectricVehicleHome-chargeScheme
 - Workplace Charging Scheme
 - ChargePoint authorization
 - On-street Residential ChargePoint Scheme
 - Ultra-Low Emission Taxi InfrastructureScheme

2.5.1.4 *Investment Incentives for DSOs*

RIIO (Revenue = Incentives + Innovation + Outputs) is Ofgem's price control regulatory framework for network companies. Over the next decade, DNOs are expected to face unprecedented challenges in making significant investments to deal with demand and production changes that will occur in the low carbon future and to maintain a reliable and secure network.

As a Regulator, these investments need to be affordable, and considering these, a new performance-based model RIIO has been developed to determine the price controls of network companies that will take eight years.

RIIO is designed to encourage network companies to:

- Put stakeholders at the heart of the decision-making process
- Invest efficiently to ensure safe and reliable services
- Innovate to reduce network costs for current and future consumers
- Play a full role in achieving low carbon economy and wider environmental targets.

In early 2013, the first price control reviews were completed to use the RIIO framework. In addition to RIIO-T1 (gas and electricity transmission) and RIIO-GD1 (gas distribution), final decisions for the RIIO-ED1 price control review for electricity distribution have also been published.

Every year in July, DNOs deliver the information showing the actual expenditure they made until March 31 of the relevant year to the regulatory authority. Using this data and as a result of meetings with DNOs, Ofgem reports how

³² Department for Business, Energy and Industrial Strategy, 2019, Smart meter roll-out Cost-Benefit Analysis (2019)

³³ <https://www.gov.uk/government/collections/government-grants-for-low-emission-vehicles>



This project is funded by the European Union



the DNOs perform according to the outputs and allowances that have been issued in accordance with the RIIO price control each year. Ofgem thus conducts the monitoring process and evaluates the amount spent and the amount obtained from consumer invoices.

RIIO focuses on what the network company can offer during the price control period and minimizes total expenditure (OPEX + CAPEX). Output categories are reliability and availability, safety, customer satisfaction, timely connectivity, environmental impacts and social obligations. Performance-related rewards and fines are a combination of financial and dignity incentives. Together with RIIO, regulation periods increased from 5 to 8 years to create a safer environment for investors³⁴.

The RIIO model includes incentives to drive the innovation needed for a smarter energy network at value for money for existing and future energy customers. Under this model, network companies are expected to adopt smart solutions where they are cost-effective in comparison to conventional solutions.

The package of incentives contained in RIIO-ED1 is designed to ensure that network companies consider these solutions upfront, while also delivering these during the RIIO-ED1 period. The interruptions incentive puts a strong motivation on companies to anticipate the increased loads from low carbon technologies and ensure that they do not overload network assets. The efficiency incentive ensures that the DNOs do not over-invest to avoid interruptions. It incentivizes the companies to look for the most cost-efficient solution, which will drive the DNOs to adopt smart solutions, including Demand Side Response, in many cases.

The package of connections incentives (time to connect incentive, customer satisfaction and connection engagement) are designed to encourage the DNOs to consider the needs of customers connecting low carbon technologies and distributed generation. Network companies are also expected to maximize the benefits they can achieve from all forms of data, including but not limited to, data from smart meters.

The innovation incentive in RIIO-ED1 consists of three components:

- Network Innovation Competition (NIC) - This replaces the Low Carbon Network (LCN) Fund and applies to electricity transmission and distribution companies. For the first two years of ED1, the NIC fund for electricity has been £90M annually (adding £60m to £30m previously processed in RIIO-T1).
- Network Innovation Allowance (NIA) - aims to fund small-scale innovation projects. Its values are set by default, 0.5% of allowed income as good thinking is showed with an innovation plan of 1% of allowed income
- Innovation Roll-out Mechanisms (IRM) - a mechanism that allows companies to apply for additional funding to deliver a proven innovation that meets defined criteria.

Distribution Network Operators submit their Business Plans as part of the RIIO-ED1 process, where they consider their smart grid related investments too.

³⁴<https://publications.parliament.uk/pa/cm201415/cmselect/cmenergy/386/38604.html>



This project is funded by the European Union



RIIO-ED1 Business Plans Examples:

For ED1, Ofgem requested DNOs to include smart grid solutions in their business plans, as well as the roll-out of innovation trailed in the current price control, and the impacts of the roll-out of smart meters.

Western Power Distribution (WPD) is a DNO and distributes electricity to 7.8 million customers across the Midlands, South Wales and the South West. In Supplementary Annex of the Business Plan (SA-03) Innovation, Smart Grids, Smart Meters, Losses and Climate Change Adaptation topics are mentioned. The section of the business plan describes WPD's approach to innovation and describes how they continue to innovate within their business to improve efficiency and set the foundations for smart grids. The following 5 topics are included in SA-03 of the plan:

- Innovation Strategy: A description of WPD's Innovation Strategy, including the initiatives they have already adopted, their plans for adoption of LCNF project outputs and steps they could take to prepare for the Carbon Plan
- Smart Grid Strategy: An explanation of how WPD's network will evolve into a Smart Grid, and the interactions that they will have with customers to make more flexible use of capacity.
- Smart Meters: A description of WPD's involvement in the smart meter roll out and an explanation of how they will make use of smart meter data to manage our network.
- Losses Strategy: An explanation of how losses occur and the actions that they can take to reduce losses on their network in the future.
- Climate Change Adaptation: A description of the effects that Climate Change will have on WPD, an assessment of the key priorities for them and the work they are undertaking to prepare for changes to climate

In the business plan, WPD grouped smart grid innovation projects into three main categories. Those are:

- **Networks**: Projects in this category collect data from the network to enhance modelling. They also test alternative investment strategies that can postpone expensive investments.
- **Customers**: These projects develop new solutions to enable customers to connect low carbon technologies. For example, the application of battery storage devices to provide additional capacity at peak times.
- **Performance**: This category of projects demonstrates direct benefits to network performance from the application of technology. For example, the use of phasor measurement units to maintain supplies using local generation in the event of a fault.

In addition to the strategies related to smart grid, accommodating load on the network, smart grid connection agreements, flexibility – application of different solutions, templates and modelling, network automation, demand side management (DSM) and demand side response (DSR) are the issues defined in the business plan³⁵

For RIIO-ED1 WPD requested the minimum proposed Network Innovation Allowance (NIA) of 0.5% of total regulated revenue, around £67m throughout the period. They stated also that they will work with partners to provide innovative proposals for larger projects to be funded through the Network Innovation Competition (NIC). Together these projects will lead to investment of over £130m in innovation. In addition to NIA and NIC projects they planned

³⁵ WPD, RIIO-ED1 BUSINESS PLAN June 2013 (Updated April 2014)



This project is funded by the European Union



to continue to support R&D in partnership with other DNOs. These include continuing to support academic research through Hubnet, the IET Power Network Research Academy (PNRA) and Centre for Doctoral Training (CDT).

To ensure knowledge is effectively shared with this sector they also stated to continue to make use of the Knowledge Transfer Programme (KTP) initiative.

On the other hand, in business plan evaluation made by Ofgem, it is stated that the WPD's plan gives confidence that these savings have been reflected in its forecast costs. However, WPD's plan lacked in detail on how smart grid solutions would be used, and how they have been embedded into its business. Regarding smart meters in WPD's business plan, the calculation of the fixed DCC costs is well justified using the latest figures released by DECC. WPD's plan aims to deliver a moderate level of benefits through the use of smart meter data and a reasonable strategy for delivering these benefits is demonstrated. WPD's total costs of IT and DCC data associated with smart metering has been £24.3m. These costs are not fully justified in comparison to the £12m identified in benefits from using the data. WPD's plan includes a number of claimed innovations. For the vast majority of identified innovations there is no detail on the result savings, or impact on output targets, or explanation of how these have been built into the plan. It is stated that this makes it difficult to assess the impact of the innovation and its scale across the business.³⁶

As the second example; **Northern Power Grid**³⁷ has Customer-Led Distribution System programme that explores the future potential for their network to operate a more flexible energy system and avoid unnecessary investment in their infrastructure or new generation. They are now rolling out the initial phase of customer flexibility, using commercial solutions to resolve network issues.

Their Smart Grid Enablers programme is preparing their network for the rapid growth of electric vehicles and they have set out the steps we are taking to be ready for the electrification of transport. The project cost is £83 million, and the project is the UK's most comprehensive network upgrade programme. It gives the ability to monitor, control and communicate with more than 860 substations and to respond to real-time information about power flows on their network and enable them to roll out smart grid solutions that could generate up to £350 million of benefits by 2031.

³⁶ <https://www.ofgem.gov.uk/ofgem-publications/84945/assessmentoftherio-ed1businessplanspdf>

³⁷ Northern Power Grid, Distribution System Operator Development Plan, October 2019



This project is funded by the European Union

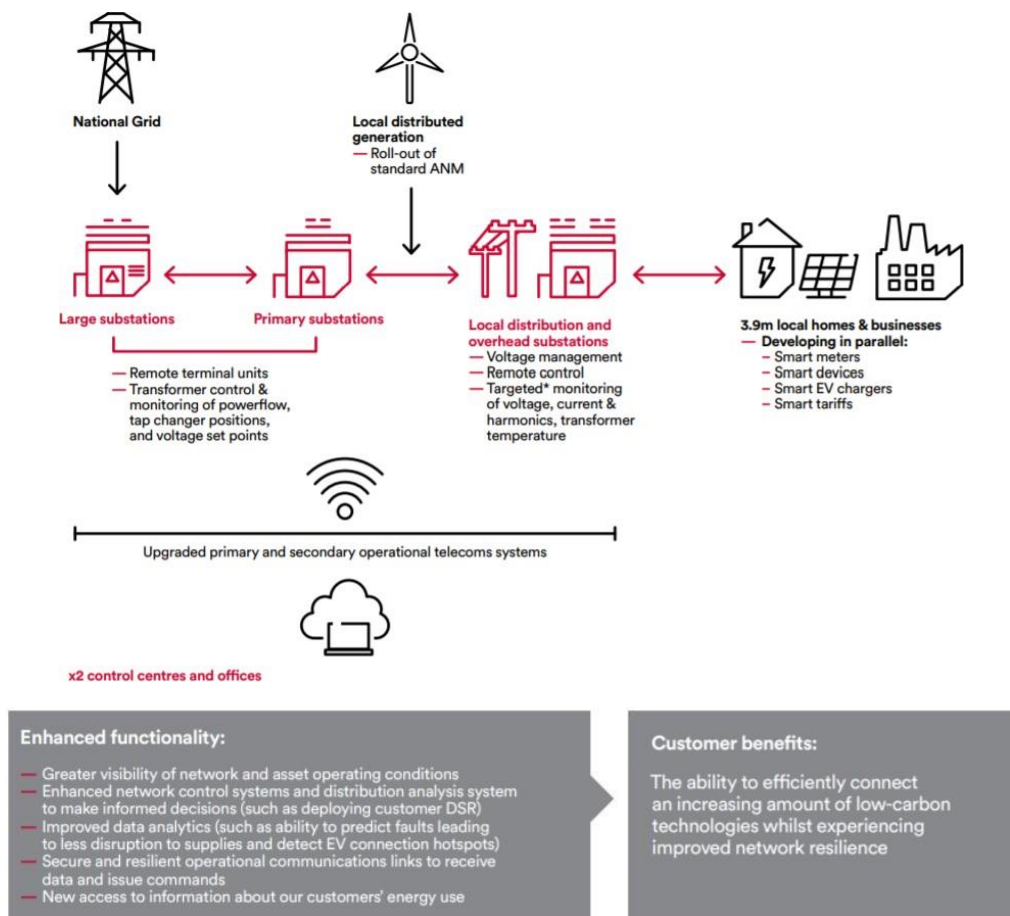


Figure 6: Smart Grid Enablers Programme Snapshot

This Smart Grid Enablers programme has been a key pillar of Northern Power Grid's ED1 business plan (2015-23) and remains a key enabler for their transition to the role of DSO. They have 433 MW of contracted flexibility in their four existing Active Network Management (ANM) zones, with Driffield having gone live in 2019. The company reviewed their network design policies to incorporate new technologies, release capacity and incorporate learning from their innovation projects. The company's major substation voltage reduction initiative has released over 1.65 GW of capacity on local networks.

Ultimately, the programme introduces network flexibility, by allowing to operate it with smarter, more efficient and cost-effective practices and technologies.

Table 4: Smart Grid Practices and Technologies

Primary Network	Local Network
Self-healing networks	Time-of-use demand data
Real-time capacity management	Remote monitoring of LV circuit power flow
Two-way power flow monitoring	Automated control of voltage



This project is funded by the European Union



Primary Network	Local Network
Advanced substation control devices	Fault prediction and smart 'fuses'
Wideband flexible communications (IP-based)	Wideband communications
	Harvesting network data from existing HV devices

The progress in the roll-out of the program is shown in the table and the company is on track to reach its objectives by the end of the price control period.

Table 5: Progress within the Scope of the Program

	Investment description	Budget	Status as of Q3 2019
Voltage Control and Monitoring	Replacement of all 132kV and EHV transformer automatic voltage control relays Installation of control equipment at HV regulators Functionality for creating network flexibility and improving network visibility	£34m	Widespread delivery across region and in year 3 of 6
Primary substation Remote Terminal Units (RTUs)	Upgrading or replacement of all remote terminal units with programmable & IP based units. Conversion to modern digital communication protocol Creates a platform for local substation control and ability to communicate more information	£18m	Widespread delivery across region and in year 4 of 7
Primary telecoms system	Upgrading core infrastructure and replacement of wide area network to all primary substations Provides IP based network with additional bandwidth & resilience	£10m	Core infrastructure upgrades in year 2 of 2 Delivery of proof of concept followed by 2-year rollout 2020-21
Distribution monitoring	Rollout of low voltage monitoring to local substations Harvesting of data from existing HV remotely controlled assets Additional visibility of network operation and provision of LV platform for advanced network management	£3m	Widespread delivery across region focusing on highly utilized networks and low-carbon technology connection hotspots
Secondary telecoms system	Replacement of existing radio system to over 9,500 sites for remote control of assets Provides scalable IP based network for grid edge control & monitoring	£14m	Procuring new system with proof of concept & rollout from 2020 to 2023
Control and operational systems	Rollout of standard ANM systems, changes to existing network control system and distribution system analysis New databases for monitoring data and platform for data analytics	£5m	Various projects in progress
Total		£83m	

Low Carbon Network Fund (LCNF): As part of the electricity distribution price control that ran until 31 March 2015, Ofgem established the Low Carbon Networks (LCN) Fund. The LCN Fund allowed up to £500 million to support



This project is funded by the European Union



projects sponsored by the DNOs to try out new technology, operating and commercial arrangements. The aim of the projects is to help all DNOs understand how they can provide security of supply at value for money as Britain moves to a low carboneconomy.

There are two tiers of funding under the LCN Fund. The First Tier allowed DNOs to recover a proportion of expenditure incurred on small scale projects. Under the Second Tier of the LCN Fund, Ofgem ran an annual competition for an allocation of up to £64 million to help fund a small number of flagship projects.

DNOs explore how networks can facilitate the take up of low carbon and energy saving initiatives such as electric vehicles, heat pumps, micro and local generation and demand side management. They also investigate the opportunities that smart meter roll-out provides to network companies.

In 2019/20, ENWL and LPN were awarded £1.59 million under the LCN Fund's Successful Delivery Reward (SDR). Licensees are also returning £4.73 million to customers as the Authority determines, that revenues received under the Second Tier and Discretionary Funding Mechanism have not been spent. The net effect is that Licensees will return £3.14 million of the LCN Fund to customers through their 2020/21 charges. As the potential learning from the LCN Fund Projects provides benefits to all Licensees, the projects were funded by all Licensees through Distribution Use of System Charges (DUoS). Therefore, Ofgem is amending the allowed revenues of all Licensees for the Regulatory Year 2020/21 and setting out the amount each needs to transfer to the other Licensees.³⁸

Network Innovation Competitions (NICs): As part of the RIIO price controls Ofgem introduced a Network Innovation Stimulus. The Stimulus includes two annual Network Innovation Competitions (NICs); one for electricity network companies and one for gas network companies.

The Electricity NIC is an annual opportunity for electricity network companies to compete for funding for the development and demonstration of new technologies, operating and commercial arrangements. Funding will be provided for the best innovation projects which help all network operators understand what they need to do to provide environmental benefits, reduce costs, and maintain security as United Kingdom (UK) moves to a low carbon economy. Up to £70m per annum is available through the Electricity NIC.

The objective of the NICs and the LCN Fund is to help network companies understand what they need to do to provide security of supply at value for money as United Kingdom moves to a low carbon economy.

The Initial Screening Process for the 2020 NIC has now concluded and the following projects have passed the ISP and will proceed to the Full Submission stage that is on 31 July.

National Funding³⁹: Between 2015 and 2021, the UK Government expects to invest more than £2.5 billion in research, development and demonstration of low carbon energy, transport, agriculture and waste. This includes the following:

- Up to £505m from BEIS's Energy Innovation Programme, where £70m of this is for smart systems innovation and has already funded multiple innovation programmes. The program aims to accelerate the commercialization of innovative clean energy technologies and processes. Smart system studies include:

³⁸ https://www.ofgem.gov.uk/system/files/docs/2020/01/lcnf_funding_direction_2019_final_for_signature.pdf

³⁹ MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids



This project is funded by the European Union



- Feasibility studies on first-of-a-kind large scale energy storage, and approaches to valuing and trading flexibility at a local level.
- Feasibility studies on domestic and commercial demand side response.
- A competition focused on energy storage cost reduction, including technologies such as flow batteries, power-to-gas systems and novel battery chemistries.
- Jointly with OLEV (the Office for Low Emission Vehicles), a £30m innovation competition supporting the development and demonstration of a range of innovative vehicle-to-grid (V2G) technologies and business models, through more than 20 projects, making the UK one of the first markets to explore V2G at scale.
- In January 2019 BEIS also launched the Storage at Scale competition and the Flex competition.
 - The Storage at Scale competition, up to £20m funding for innovative, replicable solutions which could provide a market competitive alternative to conventional commercial large-scale energy storage technologies.
 - The Flex competition which will support the development and demonstration of innovative solutions to value and trade flexibility.
- UK Research and Innovation (UKRI) will also provide up to £1.2 billion of funding, where £265m is expected to be invested in smart systems research, development, and demonstrations.
- Up to £246m for the Faraday Battery Challenge, on electric batteries will be provided. To date the Faraday Battery Challenge has supported the creation of the £78m Faraday Institution to speed up research into battery technologies, through which £42m has already been invested in four 'fast-start' projects on extending battery life, battery system modelling, recycling and reuse and next generation solid state batteries.
- Up to £620m of funding from a range of Departments, including BEIS, DfT, DfID and Defra and additional Industrial Strategy Challenge Fund support. This includes the £102m Prospering from the Energy Revolution Challenge. This programme will research, develop and demonstrate integrated smart local energy solutions across power, heat and transport to provide cleaner and cheaper energy for consumers, while building more prosperous and resilient communities.
- The devolved Governments for Scotland, Wales and Northern Ireland also fund and support low carbon innovation.



This project is funded by the European Union

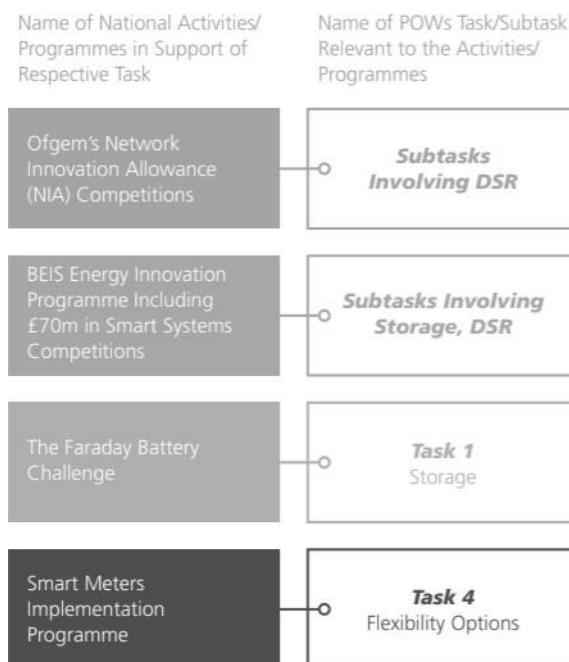


Figure 7: National Funds for Electric System Research

International Position⁴⁰: The UK plays an active role in Mission Innovation's work through roles as vice-chair of the Steering Committee and Head of the MI secretariat. The Country is running two bilateral international competitions in smart energy with Mission Innovation partners from 2018 to 2021. The UK and South Korean Governments have committed up to £6m, to deliver a bilateral competition on smart energy innovation. Projects supported by this competition include a pilot energy flexibility trading platform, gamification of EV charging/ V2G charging/ discharging and a liquid air production and storage system. In addition, the UK and Canada are running the Power Forward Challenge, offering over £11m to develop the best smart energy systems, including grids and storage, for the needs of the 21st Century.

Sample Projects:

Constellation (UK Power Networks): The project aims to develop an interoperable local intelligence platform in substations to perform network optimization, control and protection functions in software, in order to improve network resilience and resolve constraints.

Flexr (Northern Powergrid): The project proposes a system to translate data from the electricity distribution network operators' (DNO) systems into common language through a data sharing service to enable the development of flexibility market services and its integration to DNO business practice.

Proteus (National Grid Electricity Transmission): Project aims to develop and demonstrate a transmission-connected 50MVA virtual synchronous machine (VSM) STATCOM controller in partnership with a supplier, building on recent research and development and bridging the current technology gaps.

⁴⁰ MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids



This project is funded by the European Union



QUEST (Electricity North West): The project aims develop and demonstrate a holistic voltage control methodology to co-ordinate and optimize the operation of network innovations such as active network management and voltage optimization solutions.

Re-Heat (Scottish Power Distribution): The project aims to demonstrate the use of electric heating systems to smooth peak demand by interfacing networks constraint requirements to in-home control systems. The project also intends to trial commercial arrangements and develop decision-making tools.

RICA (National Grid Electricity Transmission): The project aims to develop and demonstrate a lower cost reinforcement solution by retrofitting insulated cross-arms to overhead lines, allowing an increase in voltage rating on existing towers.

2.5.1.5 *Smart Meters*⁴¹

Smart meters installed in the UK are next-generation gas and electricity meters and offer a variety of smart functions that can communicate directly with the energy supplier, telling how much energy used via a display in your home, so no one needs to come and read your meter.

The smart meter rollout in UK is underway and aims to have around 53 million smart gas and electricity meters fitted in over 30 million premises (households and businesses) in United Kingdom by the end of 2020. As of September 2018, there are around 12.8 million smart and advanced meters operating across homes and businesses in United Kingdom, by both large and small energy suppliers.

When DECC granted the DCC license to Smart DCC Ltd, a subsidiary of Capita plc. in 2013, phase 1 of the Smart Energy Code (**Smart Energy Code-SEC**) came into effect. SEC is a new industry regulation, setting requirements for the provision of DCC's services, and setting other provisions for end-to-end management of smart metering. The DCC is responsible for linking smart meters in homes and small businesses with energy suppliers, network operators and energy service companies. As with other industry regulations, Ofgem is responsible for approving any changes to protect consumers' interests.

With the Smart Meter Installation Code of Practice (SMICoP)⁴², rules and standards are determined for suppliers who undertake the supply and installation of smart meters, and consumer protection is secured. The main goals of SMICoP are to make sure that the customer receives a high standard of service throughout the installation process and knows how to use and utilize smart metering devices to improve the energy efficiency of their home.

The rollout is being led by energy suppliers, who are responsible for installing smart metering equipment, consisting of a smart electricity meter, a smart gas meter, a communications hub and an in-home display at no upfront cost. Gas and electricity suppliers are required by their license to take all reasonable steps to roll out smart meters to all of their domestic and small business customers by the end of 2020.

⁴¹www.ofgem.gov.uk ⁴²<http://www.smicop.co.uk/sitepages/home.aspx>



This project is funded by the European Union



Smart Markets Program

It is anticipated that smart meters can reform existing market regulations that can make the market better for consumers, such as changing supplier processes. The Smart Markets Program aims to proactively identify these regulations and see the changes applied to enable smarter markets to be developed.

The Government asked all consumers to buy smart energy meters by the end of 2020. Thus, it has been envisaged that it can benefit consumers by helping them manage their energy better. In addition, consumers will get back the estimated invoices by recording precise energy use and sending it directly to their suppliers.

Smart meters results in greater customer participation in the energy market, with changes in industry processes. In this way, a more dynamic and competitive market can be obtained. This paves the way for more efficient energy use and more innovative tariffs and services to consumers.

Ofgem is leading the way to ensure that the smarter market takes place over the next few years. Projects include:

Switching Program - Fast, reliable switching: Ofgem pioneering efforts to improve the change of supplier processes in order to provide fast, reliable switching for consumers.

Electricity Reconciliation Regulations: Today, half-hour consumption of most consumers is estimated. This data can be used for reconciliation since real half-hour consumption can be recorded with smart meters. This will encourage suppliers to offer tariffs that lower the prices of consumers who use cheaper electricity.

An industry proposal has recently been approved to reconcile large businesses with half an hour's consumption data, and how the same can be achieved for small businesses and households is being studied.

Flexibility on Demand Side: Within the scope of the project on demand side flexibility, the benefits of the changes in the settlement arrangements are monitored. It covers demand-side response aspects such as flexibility, energy storage and interconnection capacity. A strategy is being developed to ensure and develop efficient supply and use of flexible resources throughout the supply chain.

Consumer Empowerment and Protection: Efforts are being made to ensure that all consumers, especially vulnerable consumers, are properly protected in a smarter market.

Retail Market Review: Reforms are underway to make the retail market simpler, clearer and fairer for consumers. Energy markets have been referred to the Competition and Markets Authority (CMA) for last year's investigation, while the CMA review continues, it continues to assess the progress of reforms.

In addition to those projects two projects that are about using smart meters to automate charging of electric vehicles, which commenced in April 2019 and will be completed in March 2021, have been awarded a total of £2.7 million.⁴³

The 2 projects each include design, build, testing and trialling of demand management devices in over 100 households with electric vehicles.

⁴³ <https://www.gov.uk/guidance/electric-vehicle-smart-charging-smart-meter-demonstration-project>



This project is funded by the European Union



EDMI-led consortium: Bulb Energy will use EDMi's technical solution which integrates a SMETS2 meter with an electric vehicle charge point. An Auxiliary Load Control Switch (ALCS) will be used for load control. ALCS is a switch within a smart meter, designed to manage an appliance within a property.

EDF-led consortium: The consortium includes ITRON, Nuvve and SLS, and is developing a home area network-connected auxiliary load control switch (HCALCS). HCALCS offer similar functionality to ALCS, although rather than being integrated with the smart meter directly, the switch sits in a separate device and is remotely connected to the smart meter. This project proposes to integrate HCALCS with an electric vehicle charge point.

2.5.2 Italy

The electricity network is a strategic asset for the Italian economy and its efficiency, reliability, modernization and continuous development are considered as key. Demonstration projects of smart grids solution are ongoing all over Italy, with special reference to advanced network management solutions and storage. Figure 8 indicates the figures as end of 2018.

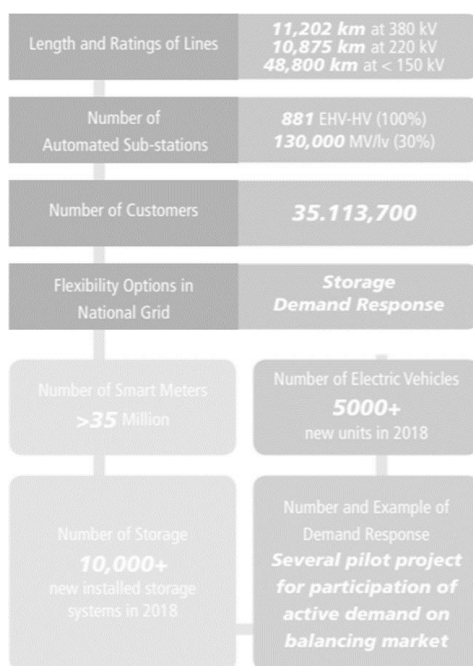


Figure 8: Key Smart Grids Facts and Figures by the end of 2018 ⁴⁴

2.5.2.1 Regulatory Institutions

The **Electricity and Gas Regulatory Authority** (Autorita per l'energia elettrica il gas ed il sistema idrico, AEEGSI)⁴⁵ was established on December 4th, 1996. AEEGSI (or AEEG) is responsible for maintaining continuous availability and distribution of services across the country by creating a transparent and reliable tariff system based on predefined criteria and promoting the interests of users and consumers. AEEG establishes and updates the base electricity tariffs, the related parameters and the reference elements, proposes schemes for the renewal and the variation of licenses, supervises the compliance to competitiveness rules and acts to protect the final user. The

⁴⁴ MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids

⁴⁵ <http://www.autorita.energia.it>



This project is funded by the European Union



Authority is fully funded through a tax on regulated entities and is completely independent of the State budget. The Authority regularly involves stakeholders of the regulatory sectors (consumer, system operators, market participants, unions and associations) in the decision-making process through the most relevant consultation documents and public hearings, as well as the Regulatory Impact Analysis (RIA). The annual reporting tasks against the Parliament and the Government are in the form of accountability to the Court of Accounts, completing the objection procedures against its decision and overview of Court of Accounts and the liability framework.

AEEGSI has a significant role in development of smart grids in Italy and devoted a lot of effort in promoting innovation since 2011 in 4 main areas related to smart grids that are smart metering, smart grids, e-mobility and storage. The Energy Regulator has recently launched a competition-based procedure to incentivize smart grid/demand response projects, which will be explained in detail in the following sections.

In summary, AEEGSI:

- Is in charge for deciding the remuneration of network investments
- Details regulations individually or in accordance with the principles set by MSE.
- Is a completely independent Regulator that has the authority to set tariffs independently.
- Employs decision-making commission members appointed directly by the President upon the recommendation of the MSE and the Government's approval.

The Ministry of Economic Development (Ministero dello Sviluppo Economico - MISE) issues provisions that affect the overall framework of the electrical industry and deals with production, economic activities, energy and mineral resources, telecommunications, consumers, tourism, internationalisation and business incentives.

MISE defines the strategic lines and sets out general principles for the organisation and functioning of the electricity and gas markets (e.g., new capacity generation, energy efficiency measures and security of supply). It also defines certification systems for energy efficiency and promotes agreements with the Italian regions with the aim of granting minimum quality levels for the supply of electricity and gas within the entire national territory. In March 2013, the Ministry published the National Energy Strategy, a very long document discussing the objectives for 2020 and 2050. MISE also publishes the call for smart grid distribution projects and takes part in evaluation of the projects.⁴⁶

The Energy Services Manager (GSE) is a state-owned company that promotes the use of renewable energy sources, mainly through incentives and information campaigns aimed at spreading the culture of environmental protection in the energy field. GES setup The Energy Research Body (RSE) as a subsidiary which carries out publicly funded national and international programmes in the fields of electrical power, energy and the environment.

2.5.2.2 *Regulatory Structure*

The first EU Electricity Directive (96/92/EC) was implemented by the Legislative Decree No. 79 of **16 March 1999 (Bersani Decree)**. The Bersani Decree introduced the first steps for the liberalization of the electricity market by reviewing the entire electricity sector, reorganizing its legal framework and setting the basic principles, including:

⁴⁶<https://www.clearygottlieb.com/~media/organize-archive/cgsh/files/italy-chapter-the-energy-regulation-and-markets-review-5th-edition.pdf>



This project is funded by the European Union



- Complete liberalization of electricity generation and import as of 1999.
- Complete liberalization of wholesale markets as of 2004.
- The liberalization of retail markets as of 2007.
- The provision of third-party access the grid includes:
 - Fair and non-discriminatory terms and conditions for new connections to the grid,
 - Regulated and non-discriminatory tariffs, and
 - Fair and indiscriminate distribution activity.
- Unbundling of generation, trade activities and transmission and distribution activities as of 2005.
- Since 2000, an anti-monopoly threshold application that limits the market share of any organization to a maximum of 50% for the generation or import of electricity has been launched.
- The Law No. 239/2004 introduced the following rules in the implementation of the second EU Electricity Directive (54/2003/EC) in 2004:
- Central Government defining exclusive competence to the energy industry.
- Despite my backyard (NIMBY) syndrome, compensation to local Governments to overcome land use challenges to construct power plants.
- Exemptions from third party access regime, especially for newly established grid infrastructures, including interconnection connections and transmission lines.

Later, in addition to the Decree Law No. 79/99 and Law No. 239/04, legislation that reflects the developments and demands of EU laws in the electricity market was introduced.

In December 2006, the Italian Energy Regulatory Authority passed **Resolution 292/06** which requires all electricity distributors operating on Italian territory to install electronic electricity meters for all low-voltage (LV) users.⁴⁷ The resolution established a timeline, where the meters should be distributed to at least 25% of consumers by the end of 2008; 65% by the end of 2009; 90% by the end of 2010; and 95% by the end 2011.

Italy's smart grid development plans are integrated with the country's renewable energies policies in the **Italian National Renewable Energy Action Plan**⁴⁸. According to the Italian Ministry for Economic Development's plan released in June 2010, Italy will encourage the modernisation of distribution networks and integrating smart grid concepts.

ARERA Resolution No. ARG/elt 39/10 and the consultation paper No. 255/2015/R/eel paved the way for smart- grid pilot projects carried out by several operators in Italy since 2011. The Resolution introduced incentives to support investments related to the development of smart grids and the installation of smart meters by electricity distributors. Temporary enhanced Return on Revenue (RoR) for demonstration projects with capital expenditure (CAPEX) has been provided in Italy under this resolution. On the basis of a competitive process, the resolution provides an additional 2% extra on Weighted Average Cost of Capital (WACC) remuneration for a period of 12 years on the part of the distribution RAB associated with investments needed for the demonstration project. However, it

⁴⁷ <http://www.autorita.energia.it/it/inglese/enlex/06.htm>

⁴⁸ http://ec.europa.eu/energy/renewables/transparency_platform/doc/national_renewable_energy_action_plan_italy_en.pdf



This project is funded by the European Union



has to be noted that it only covers capital expenditure and not operation costs, which in the case of R&D projects can be substantial.⁴⁹⁵⁰

With **Resolution ARG\elt 198/11**, the Autorità per l'energia elettrica e il gas (AEEG) maintained incentives for smart grid projects granted under the aforementioned Resolution 39/2010 for the regulatory period 2012–2015.

The Italian Energy Authority also supported pilot projects aimed at testing different market models for electric vehicle charging services under **Resolution ARG\elt 242/10**. Five new pilot projects have been allowed, with an annual contribution of EUR 728/year per charging point up to 2015 for the construction and operation of charging infrastructure, according to three market models: Distribution model, competitive service provider model, sole service provider model⁵¹

In January 2011, the Italian Energy Regulatory Authority approved the **2011-2013 Strategic Plan**⁵². The Plan includes seven general objectives for the Authority, one of which is to support and promote the efficiency and cost-effectiveness of infrastructural services by developing smart grids and promoting the efficiency of metering.

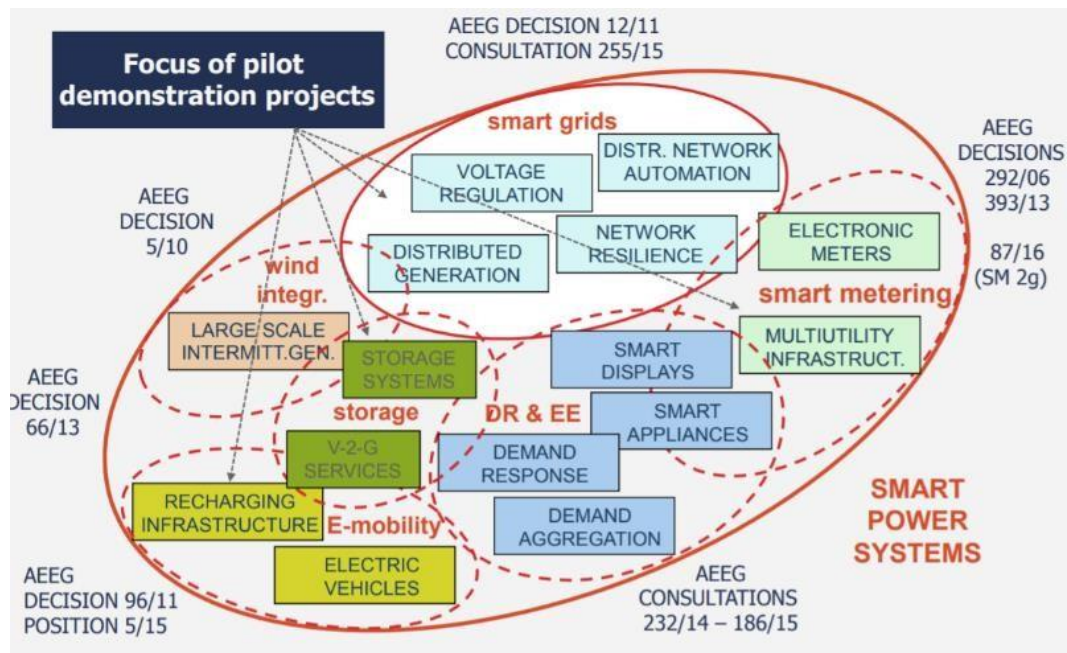


Figure 9: Focus of Pilot Smart Grid Demonstration Projects in Italy⁵³

AEEG has initiated a process for the identification of regulatory tools and criteria that could be used to incentivize DSOs to orient their own investment plans towards smart grids. Then, the regulatory authority launched a selection process for smart grid demonstration projects, focused on active Medium Voltage (MV⁵⁴) networks. This process

⁴⁹ World Energy Council, World Energy Perspective Smart grids: best practice fundamentals for a modern energy system

⁵⁰ <http://www.iea.org/textbase/pm/?mode=cc&id=4516&action=detail>

⁵¹ World Energy Council, World Energy Perspective Smart grids: best practice fundamentals for a modern energy system

⁵² http://www.autorita.energia.it/it/inglese/press_releases/11/110110.htm

⁵³ AEEGSI, 2017, Innovation in the electricity sector in the framework of cooperation between energy and telecom regulators in Italy

⁵⁴ MV is a three-phase voltage between 1 and 35 kV. Standardised voltage level in Italy are 10 and 20 kV, although in some cases different nominal voltages are still used.



This project is funded by the European Union



has been based on a comparative assessment of different proposals presented by DSOs, according to a key-performance indicator scheme that takes into account the costs and benefits.

In March 2013, the Ministry published the **National Energy Strategy**, a detailed document discussing the objectives for 2020 and 2050.

Italian Energy Efficiency Action Plan of 2014 introduced smart meters in detail within the scope of the Policy measures implementing the Energy Efficiency Directive.

Together with the **Ministerial Decree dated 19 October 2016**, the Ministry of Economic Development has established a state-aid program dedicated to investments for the construction of intelligent electricity distribution networks, where <https://thelawreviews.co.uk/edition/the-energy-regulation-and-markets-review-edition-8/1194559/italy-footnote-015> the programme is valid until 31 December 2020. The relevant ministerial decree provides a common legal and economic framework for public administrations to launch calls for tenders, in order to promote the upgrading and optimization of the electrical network in specific areas of the country. In 2017–2018, the Ministry itself launched and concluded a tender procedure for the construction of smart grids in Basilicata, Calabria, Campania, Apulia and Sicily⁵⁵.

ARERA Resolutions No. 646/2016/R/eel of 10 November 2016 and No. 222/2017/R/eel of 6 April 2017 includes the detailed rules on the recognition of costs for low-voltage electricity metering as for second generation smart metering (i.e., the remote reading and control of power consumption) with the purpose of encouraging and compelling distribution undertakings to upgrade their assets to meet the ongoing technological developments⁵⁶.

Directorial Decree 20 March 2017 – (Call for electricity distribution networks Pon I&C 2014-2020) concerns the Call for electricity infrastructures for the construction of smart energy distribution networks (smart grid) in the territories of the less developed Regions. The decree was registered by the Court of Auditors on April 4, 2017.

In 2017, the **National Energy Strategy (SEN)**, the ten-year plan was published by MiSE introducing the national energy targets to drive the energy transition toward the policy targets. The SEN is closely coordinated with the European Strategic Energy Technology Plan (SET Plan) and is complemented by the Integrated **National Energy and Climate Plan (PNEC)**.

PNEC's final draft has been submitted by MiSE to the European Commission in December 2018. The plan sets the energy scenario towards 2030, fostering a wide-ranging transformation in which the combination of decarbonisation, circular economy, efficiency and rational and fair use of natural resources represent objectives and instruments for the future of the economy.

2.5.2.3 *Investment Incentives for DSOs*

In Italy, according to the Tariff Regulation (Regulatory decision n. 348/07), some strategic investments are incentivised through an increase of the capital cost remuneration (Weighted Average Cost of Capital, WACC). This “extra-WACC” was introduced for the first time for special investment in transmission networks after the 2003

⁵⁵<https://www.mise.gov.it/index.php/it/component/content/article?id=2037857:pon-imprese-e-competitivita-2014-2020-reti-intelligenti-online-la-graduatoria-del-bando-reti-elettriche-di-distribuzione>.

⁵⁶ <https://thelawreviews.co.uk/edition/the-energy-regulation-and-markets-review-edition-8/1194559/italy>



This project is funded by the European Union



blackout and from 2008 has been extended to some classes (e.g. Demonstration projects for active grid for the regulatory period 2008-2011) of the investments in distribution networks.

In 2010, the Italian Energy Regulator has launched a selection process for smart grid demonstration projects, focused on “active MV networks”. The selection process has been based on a comparative assessment of different proposals presented by DSOs, according to a key-performance indicator scheme that takes into account costs and benefits. The selected projects are granted an extra-WACC of +2% (on top of the “ordinary” WACC equal to 7% for distribution network investments) for a period of 12 years.

The proposed selection for smart grid projects is based on tariff incentive regulation. Italy has a good experience in output-based incentive regulation, in particular for Quality of Service, however, the performance measurement require clear and fair indicators, strictly related to the pursued objectives and cleansed of external effects outside the control of network operators and this it has proven difficult so far to develop an output based regulation of the smart grids. Because of these difficulties, the existing regulatory frameworks are input-based, where incentive is applied to incurred costs (input) rather than to actual value of output for the system or for the customer.

The Italian smart regulation takes into account three complementary dimensions: grid technology innovation, new grid services, and grid user participation. The admission procedure for demonstration projects is based on the definition of minimum requirements for smart grid demonstration projects.

Figure 10: Requirements for Demonstration Projects

In addition to minimum requirements, the demonstration projects can implement further smart functionalities: providing bidirectional communication with final customers in order to develop demand response strategies, or including recharging infrastructures for electric vehicles, or other storage solutions, in order to guarantee active power modulation at TSO/DSO interface.⁵⁷ Selection process is defined in more detail in Annex 1.

Since 2011, AEEG devoted a lot of effort in promoting innovation, coping with smart metering, smart grids, e-mobility and storage. Smart distribution system functionalities that has been tested in pilots are:

- TSO-DSO integration: measurement collection, DG production forecasting and data transmission towards TSO system (better observability)

⁵⁷ Delfanti M., Schiavo L.L., Olivieri V., The Italian Regulatory Framework for Developing Smart Distribution Grids



This project is funded by the European Union



- Voltage control: participation of MV distributed generation to voltage regulation on MV feeders (higher hosting capacity)
- Active power modulation: participation of MV distributed generation to ancillary services market
- Anti-islanding: detection of possible islanding condition on MV Network – no longer needed after local solution implemented in 2012.
- Fast MV fault isolation: detection on isolation of MV fault-sections without the tripping of the breaker at the line departure (requires extra-performant tlc)
- Electricity storage: usage of electrochemical storage as a mean for improving QoS and managing RES intermittency (further evaluation needed)

Business models for **EV public recharge infrastructure** was determined with the resolution AEEG 242/11. Pilot projects aimed at demonstrating in real cases the possibility to implement different business models for the public re-charging of EVs: namely the DSO model, the LSP (Licensed Service Provider) model and the CSP (Competitive Service Provider Model). Normally, the investments for the setting up of public charging points are remunerated only based on the energy delivered including no remuneration for the investment in the RAB (remunerated asset base).

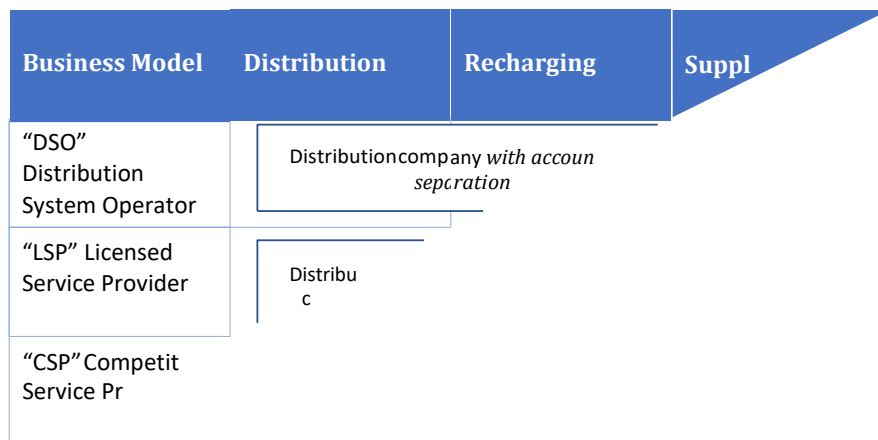


Figure 11: Business Models

In Italy, facing with the latest developments of the national electricity system, the Authority has determined that, in the tariff regulations, infrastructure projects should be developed according to selectivity and output-based logic criteria that draw attention to systemic benefits (e.g. integration of renewable resources with service quality and safety). The Electricity Market Authority has developed four consultation papers on the preparation of proposals for the selective regulation of infrastructure investments in a series of electricity transmission and distribution industries, as part of the procedure for regulating the 5th electricity tariff period.

Regarding the development of distribution grids, first and foremost about the dissemination of distributed generation, the regulations introduced by the Regulatory Authority until 2015, aims to support projects that demonstrate innovative management methods in MV grids on the one hand, and to regulate certain aspects of the accelerated development of distributed generation to ensure safety on the other. In particular, the results of the smart grid pilot project selected by the Authority have been analysed in the **255/2015/Real Consultation document** to determine the most appropriate innovative features for widespread. As a result of this consultation, selective



This project is funded by the European Union



incentive mechanisms of investments in distribution grids are defined and smart distribution systems are aimed to be developed in regions with high rates of distributed generation from renewable resources. After consultation 255/2015, **Decision 646/2016** introduced selective and output-based incentives. Output-based regulation (2016-19) was defined for 2 smart functionalities that are observability and voltage smart regulation on MV networks.

The Authority also emphasized the specific features of distribution grids in urban areas. As a matter of fact, the possible changes in consumption habits and power usage have been highlighted in the review of residential tariffs (for example, the use of heat pumps or induction cookers or charging electric vehicles at home). Taking this into consideration, the Authority recommended the promotion of incentive policies (premium/penalty) to be developed on offer from distribution companies throughout 2016 and to be implemented as part of the Improvement Plans for the period 2017-2019. Moreover, the Authority has confirmed that it is beneficial to try out technological solutions introduced to the market, but which are not widely adopted, and intent to identify appropriate incentives accordingly.

*Table 6: New Incentives for DSOs: Output Based, Selectivity*⁵⁸

As for the next developments, it is stated that the regulatory framework must adapt to the new challenges:

- Enable DSOs to take on the role of a neutral market facilitator and avoid DSO foreclose competition
- Accompany the development of new flexibility markets (on both sides: demand as well as distributed generation)
- Review distribution network tariff structure in order to develop focused incentives for smarter networks
- Clearly define DSOs' and TSOs' respective roles, establishing coordination requirements (system security)
- Enable customer awareness on his/her own energy footprint through smart metering data on consumption⁵⁹

⁵⁸ Output based incentives for smart functionalities are granted only in area with RPT > 1%

⁵⁹ Incentive Regulation of Smart Distribution Systems: from Input-based Demonstration to Output-based Deployment



This project is funded by the European Union



In Italy, the new regulation overpasses the input based incentive mechanism (extra-WACC) and the attention to the mere grid (“smart grid”), focusing on output and the smart distribution system, trying to identify the net benefit that innovation may bring at system level and not just at the network level. The incentive mechanism aims at stimulating DSOs to deploy innovative functionalities where these are mostly needed (areas with huge RES penetration) and where, without such an incentive and with the current tariff system, the DSO could have no interest in developing such innovative solutions.

As it can be seen from the table, two innovative functionalities are identified and the mechanism focused on different levels of increasing complexity which could be developed even without challenging telecommunication systems, without any direct involvement from widespread resources and, without distorting the market in the absence of competition. A CBA has been set for the valuation of the outputs, based on the examination of the performances that are actually necessary, so as to ensure, at the lowest cost, the innovative functionalities of smart distribution systems and the assessment of the costs associated with such performances, taking into account the economies of scale that might arise.

Incentive mechanism have two characteristics: that are being output-based (it is correlated to an indicator that expresses in a simple manner the level of benefit from the intervention, since this mode allows the DSO to focus on the more efficient choices for the system) and selective in nature (it is able to orient itself primarily toward those areas in which the intervention yields the greatest net benefits). The index to selectively steer the development priorities of the functionalities towards the most critical areas with the highest penetration of renewable sources, is based on the Reverse Power Flow Time Indicator that has to exceed 1% on each transformer of power station. As for the outputs, different benchmarks were chosen for the two functionalities⁶⁰

National Funding⁶¹: On the other hand, the most important program supporting R&D activities in the energy sector is the **National Fund for Electric System Research (RdS)**, that aims at the scientific and technological innovation of general interest for the electricity system for an enhancement of competitiveness, security and environmental compatibility, ensuring conditions for a sustainable development. RdS activities are financed through a levy on the consumer’s electricity bill of an order of magnitude of 0.08 €/kWh and foresee an average annual budget of €70M of which about 9.2 M€/year are devoted to smart grids and energy storage. Most of the RdS projects are implemented by public R&D institutions (Ricerca sul Sistema Energetico – RSE SpA, the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) and the National Research Council (CNR)) through agreements with MiSE. Universities and R&D labs are also involved as subcontractors. The newly launched three-year RdS program 2019-2021 (MiSE decree 16 April 2018) is in harmonization with SET-Plan and the Integrated National Energy and Climate Plan (PNIEC). The paths are;

- Technologies: monitor and develop technologies, solutions and products fundamental for the energy transition
- Electric System: foster the introduction of technologies, systems and organizational & management models for the energy transition and security

Other national supports are;

⁶⁰ CEER, 2017, Incentives Schemes for regulating DSOs, including for Innovation Consultation Paper

⁶¹ MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids



This project is funded by the European Union



Regional Operational Plans (POR) managed by Regional Governments to support smart grids research, fostering the local R&D through the involvement of local industry and research entities. This program uses regional funds also connected to European funds (e.g. European Structural and Investment Funds)

National Operational Programs (PON) By a Ministerial Decree, MISE has allocated in 2018 financial resources for PON-I&C2014-2020, which include Smart Grids Projects in the distribution network (MV/LV), focused on increasing the hosting capacity of distributed generation based on renewable sources.

The Ministry of Education and Research (MIUR) has set out the National Research Plan for 2015-2020, defining the contents and the governance of applied research. The programs include twelve “specialization areas”, among which: Energy, Technologies for life environments, Sustainable mobility, and Smart, Secure and Inclusive Communities.



Figure 12: National Funds for Electric System Research

International Position⁶²: In terms of international studies Italy is active in policy making areas such as the Clean Energy Ministerial (CEM) and in global initiatives such as Mission Innovation (MI). The Country has important leading roles within several high-level bodies of the International Energy Agency (IEA) and in particular chairs the Committee on Energy Research and Technology (CERT), owns the vice-chairmanship of the End Use Working Party (EUWP), coordinating 14 Technology Collaboration Programs (TCP). Italy actively participates in several TCPs and in particular holds important coordination roles within the International Smart Grids Action Network (ISGAN). It is also a key player in the European Energy Research Alliance (EERA) which coordinates research in the energy field across

⁶² MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids



This project is funded by the European Union



Europe and accelerate the development of innovative energy technologies by conceiving and implementing Joint Research Programmes (JPs).

Sample Projects: As introduced before, Italy is among the countries leading smart grid studies in Europe. In 2011, the country was the leader in terms of financial resources committed to research projects on smart grids (accounting for 55% of the aggregate) and was 3rd in terms of number of research projects it leads and or coordinates (5.5% of an aggregate of 219 projects). Sample smart grid projects are as follows:

- Since 2001, ENEL has been deploying a smart electronic metering system to its customer base, as well as providing other utilities capable of two-way real-time monitoring of input and consumption.
- In 2012, an advanced smart grid that consist of smart programmable and metering-capable household appliances, non-programmable renewable input prediction systems and electric car charging systems started in Isernia.⁶³
- Massive roll-out of Enel Distribuzione SpA is one of the best practices in the world. Enel has deployed a set of innovative smart grid tools in its industrial management procedures (>€2.5 billion investments) ranging from the smart metering, to the remote control and automation of the MV distribution network, the Work Force and the Asset Management. Under the Telegestore project (completed in 2006), the Automated Meter Management (AMM) System for low-voltage (LV) concentrators and remote meter management was deployed starting from 2001, before the mandatory installation program of electronic meters set by the Italian Regulatory Body in 2006. More than 32 million smart meters have been installed, allowing to periodically collect data on voltage quality and interruptions, daily consumption, active and reactive energy measurements, and to remotely manage contractual activities. Meters are able to transmit data regarding consumption, receive updates of the contractual parameters and remotely manage the supply connectivity. In 2011 more than 400 million remote readings and more than 9 million remote operations were performed, and the project resulted in approximately 500 million euro of yearly savings in customer services, company revenue protection, purchasing and logistics, filled operations. With the energy balance data from the AMM system, the success rate of the meter verification activity has increased from 5% (before the AMM) to 60%. Moreover, approximately 30,000 tons of CO2 emissions were estimated to be reduced from remote execution of customer management activities and meter readings in 2010. Enel's project aimed at improving the quality of service, reducing the operating costs and updating the technology of network components.
- Open Meter 2.0: Enel launched the meter replacement plan of first-generation electronic meters (installed in early 2000s) with the new Open Meter 2.0 (second generation electronic meter) in 2016. Open Meter involves an overall Enel investment of €4.3 billion.
- Within the scope of demonstration projects awarded by AEEG, there has been 8 projects namely: A2A Lambrate _MI, A2A Gavardo - BS, ACEA Malagrotta – RM, Enel Distribuzione CP Carpinone – IS; Deval Villeneuve – AO; ASM Terni – TR; ASSM Tolentino – MC; ASSEM San Severino Marche – MC. Some of the projects include demand response and smart electric vehicles charging management systems. The total budget for the projects is around €16.5 M. All projects consider at least one HV/MV substation and the MV system supplied, where distributed generation is present. The functionalities that will be applied included;

⁶³ Schwartz D. L., 2012, The Energy Regulation and Markets Review



This project is funded by the European Union



- Modernization of the MV network supervision system using on-line remote-controlled switching devices,
- Reliability of the generation Interface Protection System using a fail-safe remote tripping approach to avoid unwanted islanding operation,
- Advanced fault detection systems with increased logical selectivity to maintain an adequate level of system availability,
- Innovative voltage control to allow the fulfilment of all power quality parameters,
- ICT infrastructures and systems using open protocols, interaction between DSO and TSO.
- Within the scope of AEEG 242/11 on EV public recharge infrastructure, a remuneration of max 728 €/point/year (for 5 years) is awarded. 5 projects have been selected that are:
 - DSO model: ENEL Distribuzione with 310 charging points,
 - LSP model: A2A with 52 charging points, Parma with 200 charging points,
 - CSP model: ENEL Energia with 26 charging points, Class Onlus with 150 charging points.
- Within the scope of Interregional Operative Programme on renewables and energy efficiency 2007-2013 awarded by the Ministry of Economic Development (MiSE), infrastructure enhancements aimed at energy efficiency and renewable integration in four regions Calabria, Campania, Puglia and Sicilia were awarded. Funds are a combination of national resources and European resources for the development of Southern regions. Enel Distribuzione has been awarded under 3 programmes that are:
 - Enhancing MV networks to host renewables: budget is 123 M€ for the period 2009-2013, focuses on distributed generation (with attention to PV plants with peak power between 100 kW and 1 MW).
 - Intelligent MV networks: The budget is €77 M for the period 2010-2014, focuses also on distributed generation in view of maximizing the green energy produced. The aim of the project is to trial test solutions for the network management in a transition phase between passive distribution networks and passive/active networks.
 - Energy storage systems: 3 energy storage systems in HV/MV primary Substation are being installed in Sicilia, Puglia and Calabria to mitigate intermittency in renewable energy production.
- In the framework of the FP7 EU Programme, the GRID4EU project has been launched in 2011 with duration of 4 years. The project, coordinated by ERDF has technical management of Enel, will implement 6 demonstration projects in 6 EU countries (Italy, France, Germany, Sweden, Spain and Czechia). Enel demonstration project in Italy (Demo4) aims at increasing the Medium Voltage (MV) network's hosting capacity for Distributed Energy Resources (DER, in particular solar), by introducing Active Control and Demand Response of MV generators, controllable loads and storage system, which will be tested under real operating conditions.
- Smart cities projects: Many cities in Italy have initiated projects to enable the progressive transformation towards a smart city. Nearly all projects comprise, among the different chapters related to general welfare and efficiency (remote medical care, e-management, better use of soil and space, traffic control, air quality monitoring, waste and water management, telecommunication and cultural growth etc.)



This project is funded by the European Union



- Genova smart city project: includes also specific measures to electrify the harbour, thus reducing the pollution from ships diesel engines while ashore
 - Torino smart city project: focuses on a common information platform available for the integration of all the information to develop smart city applications
 - Bari smart city project: focuses on the European integration and related interoperable solutions, with special focus on the dramatic enhancement of the water supply and collection. Moreover, in Bari and Cosenza a project funded by the Italian Ministry of University and Research (MIUR) has been launched in 2012, referred as RES NOVAE, focusing on the development of smart grid technologies for LV network and innovative applications for energy management.
 - Milano smart city project: focuses on industrial reconversion, use of biomass, children care, arts and tourism
 - Other Smart City projects at a first stage have to be mentioned in Italy, such as Bologna, Pisa, Piacenza and L'Aquila Smart City.⁶⁴
- Recently, a new smart grid call has been published in the Official Gazette of the Italian Republic, where the deadline for submitting applications is set on **August 21, 2020**. Projects will be financed by the resources of the PON Enterprise and Competitiveness. Concessions are granted in the form of a **direct grant**. The amount of the concession that can be granted to each company and for each project cannot be less than €250,000 and greater than €50,000,000. According to the provisions of the Public Notice, the costs incurred starting from the date of submission of the application for aid and by 31.12.2023 are eligible. The resources allocated to the Notice amount to **€23,978,254.41**. The aim of the public notice is that the concessionaires of the public electricity distribution service operating in **Basilicata, Calabria, Campania, Puglia and Sicily** provides for the financing of construction, adaptation, efficiency and strengthening interventions of distribution infrastructures for the construction of smart grids, aimed at directly increasing the share of energy needs covered by generation distributed from renewable sources.⁶⁵
 - Enel is also one of the first movers in E-Mobility solutions globally. In its recent Italian National Plan for the installation of electric vehicle charging infrastructures: the e-Mobility Revolution, Enel envisages the installation of around 7,000 charging stations by 2020 to reach a total of 14,000 by 2022. For this, Enel will invest between 100 and 300 million euros to develop a widespread charging infrastructure network including Quick (22 kW) charging stations in urban areas and Fast (50 kW) and Ultra-Fast (150 kW) charging stations in extra-urban areas.⁶⁶
 - In 2017, Enel also launched the Electric Car Sharing Pilot Project in Italy, which is a collaboration between Enel Energia, Nissan and the Italian Institute of Technology, set up a vehicle to grid (V2G) infrastructure for an electric car sharing project in Genoa, Italy. The V2G technology turns e-cars into large mobile batteries that interact smartly with the power grid, enabling, among other things, the stabilization of power flows to promote renewable generation. Cars can accumulate energy at lower fuel consumption times and return any excess quantities. In fact, the new technology is based on bidirectional charge management: it draws energy for example from home renewable systems and feeds it into e-cars. If

⁶⁴ RSE, A Snapshot of smart grids achievements in Italy

⁶⁵ <https://www.mise.gov.it/index.php/it/incentivi/energia/nuovo-bando-smart-grid>

⁶⁶ <https://www.enel.com/media/news/d/2017/11/e-mobility-revolution-changing-gear-in-the-present>



This project is funded by the European Union



necessary, it transfers it from the car to another plug-in structure or simply to the network, guaranteeing a financial return for the EV owner.

- **I-NEXT** project, small storage on MV grid, 100 kW / 300 kWh NaNiCl₂ batteries for energy balancing of a microgrid with 100kW PV to produce, store and distribute hydrogen and electricity for a small EV and FCEV fleet.
- **CNR4CAPACITY** project, small storage on LV grid, 20 kW/40 kWh for energy balancing of a micro-grid composed of 6 houses equipped with PV and storage, where an energy service company can control contracts, loads and electricity exchange with the grid, in order to maximize the income for the users and make the demand flexible.

2.5.2.4 Smart Meters

Italy has been the first Country at global level that launched full roll-out of smart metering in 2001. As of 2017, the country has more than 35 million customers with smart meter, more than 100 distribution companies operating their own smart metering systems (even the smallest ones), more than 400 million readings per year remotely operated, 10 million operations per year for remote customer management, 28 million customers with Time-of-Use tariff, (households: 2 price-bands; small business: 3 bands) and 15 years of experience in smart metering. Initially, E-distribuzione started the replacement of traditional electromechanical meters to enhance operative costs efficiency and improve the quality of service. As a result of the remote reading, metering data and diagnostics information was collected for billing and quality of service increased. In 2006, AEEG issued the Resolution 292/2006 and it was made compulsory for all the electricity distributors in Italy to adopt smart metering systems within 2011. The number of collected measurements allowed new services for customers such as ToU tariffs, remote contract management, and network management (e.g., loss monitoring in order to identify critical LV networks where is necessary to focus on to get a commercial loss reduction). The Italian first-generation smart metering system had a strong and fast success.

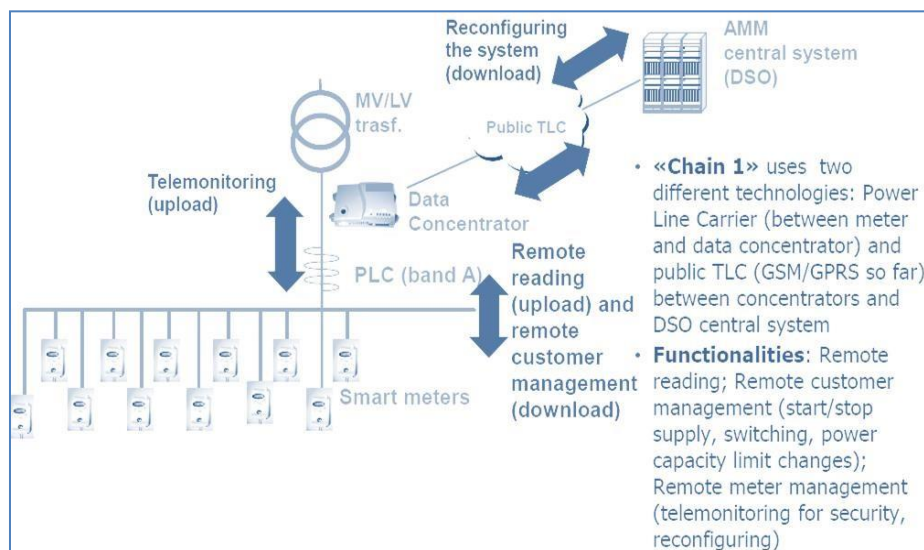


Figure 13: Smart Metering in Italy: System Architecture "1G"

Although installation of smart meters was a great success in Italy, there has been some shortcomings such as lack of a standard interface and a dedicated communication channel to inform promptly the customer about near real-



This project is funded by the European Union



time electricity consumption and production. In addition, reconfiguration process required to update the devices' firmware was slow, due to traditional architecture of the HES that was not able to assure high level of parallelization for update activities.

Considering all of these, NRA identified all the estimated benefits coming from the new smart meter generation in a consultation document and with the Decision 646/2016/R/eel, defined the methodology for cost recognition for the rollout. The traditional methodology of management of capital costs (CAPEX) and operational costs (OPEX) was substituted by a total-expenditure approach (TOTEX) that leaves the preferred technical implementation choice to the DSOs while assuring the minimum functional requirements.⁶⁷

The new mechanism encourage strong improvement in meter performance and cost reduction and the transparency of the installation plans⁶⁸ and the new regulatory framework, based on incentive approach requires the Regulatory Authority to evaluate and approve AG second generation (2G) Smart meters installation plans. The new rules confirm the current requirements for the accounting of operating costs and revenues separately for the operational activities and provide specific monitoring standards to transfer potential benefits to such business activities and customers of the electricity industry⁶⁹.

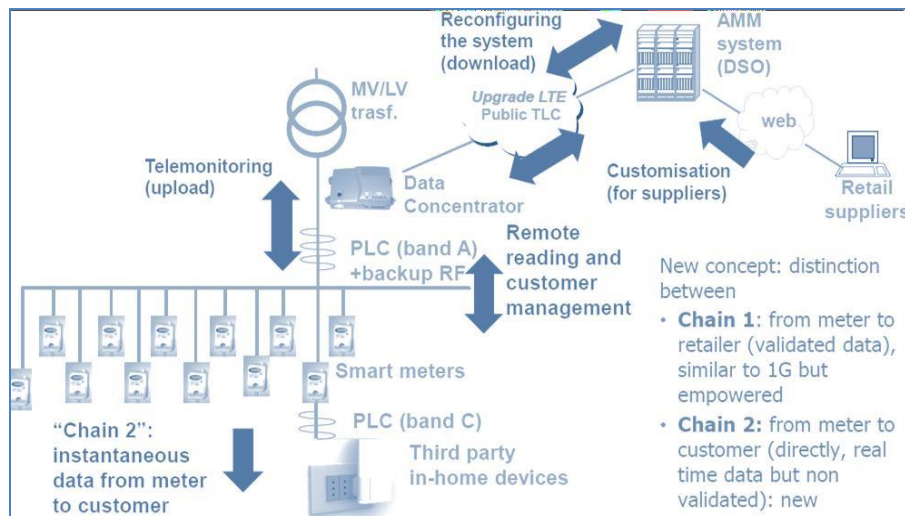


Figure 14: Smart Metering in Italy: System Architecture "2G"

(2G) Smart Meter plans are developed in detail over a period of fifteen years, including progress and expenditure estimates. When it is ensured that the measurement tariffs do not change significantly to customers (as a result of inflation) in terms of the cost tariffs of the installation and commissioning plans, a rapid approval process is applied. As a result of a comprehensive consultation process involving various stakeholders, the Regulatory Authority created rules that allow the planning flexibility of the Distribution Companies on the one hand and, on the other

⁶⁷ CIRED, 2019, SMART METERING 2G – EVOLUTION OF A SMART METERING EXPERIENCE

⁶⁸In Italy, the installation process of existing first generation (1G) meters began in 2001, and in 2006 the main distribution company changed the counters of approximately 85% of end consumers and other distribution companies in 2011. Most of these counters have completed their useful life of 15 years.

⁶⁹ www.autorita.energia.it



This project is funded by the European Union



hand, prevent the recognition of the associated costs if the Distribution Company voluntarily or intentionally causes the first generation meters to be discarded early.

The decision envisages the new 2G meters (in version 2.0) to be equipped with two communication channels. These are as follows:

- The first one will be able to use the power line carrier (PLC), RF 169 communication technology or other TLC technologies in the chain 1- and A band towards the "electrical system",
- Second one will be able to benefit from chain 2- towards user equipment and at least from carrier system in C band.

Another consultation will be made to identify incentive mechanisms for recognizing the costs of replacing first generation meters with 2G meters and analysing expected benefits associated with 2G smart metering systems. According to European regulations, this decision will be communicated to the European Commission and therefore it will come into effect at the end of the waiting period (for 3 months from the date the Commission receives communication).⁷⁰

2.5.3 Germany

Since the beginning of smart grid research funding in 2008, significant process has been achieved in various technical areas in Germany. Storage and its grid integration were supported by a large funding call (> 184M €) in 2011, in which different storage technologies are addressed, e.g. electrical, chemical and thermal storage. In addition, developments such as integration of DC links in the existing AC infrastructure and the penetration of information and communication technology (ICT) in distributions grids has been additional improvements over the recent years. Figure 15 indicates the figures as end of 2018.

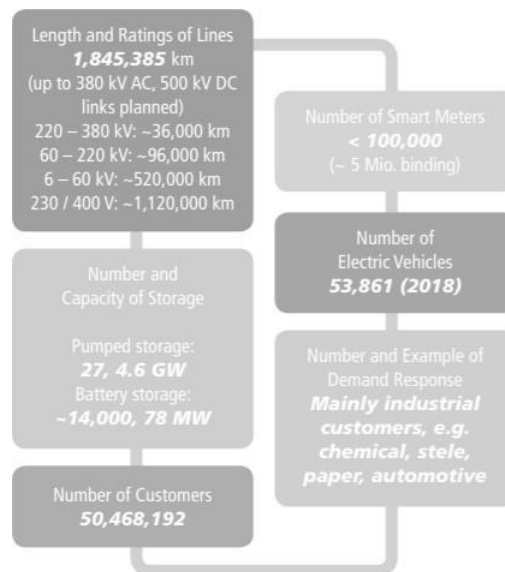


Figure 15: Key Smart Grids Facts and Figures by the end of 2018⁷¹

⁷⁰ L.L. Schiavo, 2017, Innovation in the electricity sector in the framework of cooperation between energy and telecom regulators in Italy

⁷¹ MI Smart Grids, May 2019, Smart Grids Innovation Challenge Country Report 2019 | Mission Innovation IC1: Smart Grids



This project is funded by the European Union



2.5.3.1 **Regulatory Bodies**

In Germany there are different Ministries responsible for energy⁷².

- Energy as a department lies in the **Federal Ministry of Economics and Energy (Bundesministerium für Wirtschaft und Energie, BMWi)**.
- For energy research, **the Federal Ministry of Education and Research** (Bundesministerium für Bildung und Forschung, BMBF) is responsible.
- **The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety** (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMUB) is coordinating all activities in relation to climate protection.
- **Federal Ministry of Transport** (Bundesministerium für Verkehr, BMV) is in charge for electro mobility issue.
- In addition, a department has been established for digitalization and is it embedded in the **Federal Chancellery**.

As Germany is a federally structured country, there are 16 federal states with their own Governments. They have their own budget, are independent to initiate their own projects and can prioritize different focus areas.

Other public players are the **German Energy Agency (DENA)**. The agency describes itself as “Germany’s centre of expertise for energy efficiency, renewable energy sources and intelligent energy systems”, that brings together partners from politics and industry across all sectors. There are also several agencies on state level such as the Berlin Energy Agency (Berliner Energieagentur) or the Energy Agency NRW (Energieagentur NRW).

The main regulatory authorities in the Country are as follows:

- Federal Network Agency (Bundesnetzagentur, BNetzA).
- State Regulatory Authority (Landesregulierungsbehörde).
- Federal Cartel Office (Bundeskartellamt, BKartA).
- Electricity and Gas Market Transparency Authority (Markttransparenzstelle Strom und Gas, MTS).
- Federal Environment Agency (Umweltbundesamt, UBA).
- German Emissions Trading Authority (Deutsche Emissionshandelsstelle, DEHSt).

The Bundesnetzagentur (Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway) is a separate higher federal authority within the scope of business of the Federal Ministry of Economics and Energy. BNetzA and the federal states' regulatory authorities (Bundesländer) are responsible for regulating electricity networks. **State Regulatory Authorities** are responsible for regulating energy supply companies whose networks are connected to less than 100,000 customers and whose networks do not exceed the borders of a federal state. So BNetzA is generally authorized for electrical TSOs in Germany.

Bundesnetzagentur is the regulatory body that promotes effective competition, protects consumer rights and provides non-discriminatory access to networks in the Electricity, Gas, Telecommunications, Post and Railways

⁷² http://swedishsmartgrid.se/globalassets/publikationer/marketanalysis_ger.pdf



This project is funded by the European Union



sector. In addition, Bundesnetzagentur is responsible for the implementation of the Grid Expansion Acceleration Act, the presentation of a wide variety of publications, including the Annual Report and consumer information.

The legal basis for Bundesnetzagentur's activities in the energy sector is provided by the Energy Act (EnWG) and the Grid Expansion Acceleration Act (NABEG). Energy regulation refers to the supervision of operators of energy supply grids ("network operators") by Bundesnetzagentur and federal Government regulatory agencies. Since there is only one network operator in each grid area in Germany, it is the duty of Bundesnetzagentur as the regulatory body to ensure that all network users can access and use the energy supply network without discrimination.

Bundesnetzagentur carries out the following duties as well as the energy regulation it has made to create conditions for increased competition in the markets for energy production, trade and supply:

- Providing non-discriminatory grid access.
- Checking the grid access tariffs implemented by grid operators.
- To take protection measures against grid operators' anti-competitive practices.
- Monitor the implementation of the regulatory regime.

Bundesnetzagentur has identified the energy consumer advisory service as the first point of contact for problems and complaints. Bundesnetzagentur's staff manage their consumer inquiries by phone, email or letter. The consumer advisory service on the Bundesnetzagentur website offers additional information and support and provides the opportunity to contact the authorities of the relevant institutions.

In addition to classic consumer inquiries regarding contract types and energy bills, for example, consumer advisory service addresses current issues such as smart metering systems and conversion from L-gas to H-gas. Bundesnetzagentur sees new trends and market developments, for example, as new electricity tariffs and models, providing transparency regarding energy price components.⁷³

On the other hand, **BKartA** responsibilities are merger control and protection of competition. **UBA** is the authority for environmental problems. It is also within the scope of its responsibilities to monitor the **DEHSt**, which manages the trade of emission certificates, in accordance with the Kyoto Protocol.

Germany's federal ministries fund approximately 40 federal R&D institutions. Among them, the **National Academy of Science and Engineering** has a focus on energy and resources. On the other hand, industry financed investments are also important in Germany.

As for mobility, **the Federal Ministry of Transport and digital infrastructure**, BMWi, is in charge and founded the national platform electromobility (*Nationale Plattform Elektromobilität, NPE*) which serves as advisory council to the Government. The platform aimed at making Germany a leading market within electromobility until 2020.

The office for the NPE is the common agency for electromobility (*Gemeinsame Geschäftsstelle Elektromobilität, GGEMO*), which coordinates and pools the Government activities. The Federal Ministry of Education initiated together with Fraunhofer-society a forum electro mobility (*Forum Elektromobilität*) which is supposed to be both platform and innovation network for industry, research and politics.

⁷³Bundesnetzagentur Annual Report 2016



This project is funded by the European Union



2.5.3.2 **Regulatory Structure**

The energy sector in Germany is managed with constant changes and a number of laws and regulations that are subject to changes. The main laws are the **Energy Industry Act** (Energiewirtschaftsgesetz (EnWG)) and the **Renewable Energies Act** (Erneuerbare-Energien-Gesetz (EEG)).

In accordance with the 2005 EnWG, electricity grid operators were disconnected from electricity generation or electricity sales activities and the structure of the vertical integrated energy network was abandoned. In general, it is imperative to operate electricity networks legally through separate organizations ("legal unbundling"). In addition, organizational structures guarantee the independence of the decision-makers responsible for the operation of the network ("operational unbundling"). In addition, rules on informational segregation have been introduced to ensure strict confidentiality of non-discriminatory disclosure of network-related information that potentially offers up or down economic advantages, as well as economically sensitive information obtained through network operations. Finally, internal accounting and financial reporting are required to be separated from trade-related accounting ("separation of accounts").

Since the European third energy package was converted into German laws in 2011, the revised EnWG has provided stricter separation rules for electrical transmission system operators (TSOs). The new law envisages three different models of structural operation at different levels of network operation from generation and supply activities, and these three differentiating models are:

- Full ownership unbundling.
- Independent system operator (ISO).
- Independent transmission operator (ITO).

The purpose of these three models is to ensure that vertically integrated energy companies do not subject discrimination against competitors in terms of access to the grid and investments in the grid.

The **Underground Cable-Act (Erdkabelgesetz)**, published at the end of 2015, gives priority to underground cables instead of electricity pylons for newly planned transmission paths. This prolongs the building time but meets the demands of the citizen.

The **Power Market-Act (Strommarktgesetz)** from summer 2016 opens for an increasing renewable energy share and competition. At the same time regulations for a capacity reserve as a safety net for the new power market have been created.

The **Digitizing the Energy Transition-Act** (Gesetz zur Digitalisierung der Energiewende) also from summer 2016 sets the start signal for smart grids, smart meter and smart home in Germany. Most important elements of the new act are the obligation for the smart meter rollout with a pre-defined pricing model according to consumption and regulation as regards data communication and security (see below).

Early 2017 came a reform of the **Renewable Energy Sources-Act** (Erneuerbare Energien Gesetz, EEG) into force which marks a paradigm shift: the promotion of renewable energy has become more competitive and market oriented. The EEG is the key instrument for an annual quantitative steering and for bringing renewables closer to the market. From now on the feed-in tariffs for electricity from wind, solar or biomass are no longer adopted by the state, but are instead for the most part determined through technology specific tendering in the marketplace. This shall also reduce the constant rise in prices for the end consumer. Facilities with less than 750 kW are not included



This project is funded by the European Union



in the tendering regulation. This means, that about 80% of the newly build installations will be tendered. The maximum capacity to be newly built within the different technologies is capped by so-called tendering corridors.

In addition, Federal Government introduced the vision called **Power 2030 (Strom 2030)** with the goals of a more flexible system, well expanded modern grids, integration and making the European markets further flexible, bringing production and consumption cost-efficient together and reliability of supply, digital solutions help to use decentral consumers like electric cars or heat pumps with a benefit for the system.

Smart grids are considered as integral part for the achievement of Germany's climate goals 2050. In this regard, single actors published roadmaps. For instance, the industry association BDEW has in accordance with the European industry organisation **Eurelectric** issued a **Roadmap** in 2013 that defines three phases for a smart grid in Germany:

- Preparation phase: setting the framework conditions (2012- 2014),
- Implementation phase: adaption of infrastructure and processes (2014-2018)
- Market phase: creating transparency and new products (2018-2022).

Moreover, the federal state **BadenWürttemberg** has a **Roadmap** that defines own climate goals for the state with the help of smart grids.

In 2018 the Federal Ministry for Economic Affairs and Energy presented the **Electricity Grid Action Plan** that follows a two-pronged approach: to optimise existing grids using new technologies and operating strategies, and to speed up grid expansion by simplifying planning procedures and utilising forward-looking controlling.⁷⁴

The **2019-2030 Grid Development Plan** was endorsed by the Bundesnetzagentur in December 2019. The plan outlines the grid expansion and optimisation that is necessary up to 2030 to reach the climate targets in Germany.

Germany is forecast to invest \$23.6 billion in smart grid infrastructure including 44 million smart meters by 2026. The smart metering legislation passed in July 2016 is regarded as an important next step in the country's broader transition to a low-carbon and energy efficient energy economy known as the '**Energiewende**'. According to the reports, Germany has failed to keep pace with its neighbours in terms of meeting smart metering targets.

The **Act on the Digitization of the Energy Transition** calls for the deployment of smart meters. Germany aims for full deployment of smart meters by 2032. In addition to smart metering, Germany will also invest in other smart grid infrastructure segments. Over the next decade, the country is expected to invest \$14.1 billion in advanced sensors, communications and software for its distribution grid and in battery storage. Investment will be undertaken by the country's four largest utilities: RWE, E. On, EnBW, and Vattenfall, as well as the numerous Stadtwerke, or municipal utilities.⁷⁵ Rollouts should be rapid due to an efficient power sector and popular support for Energiewende.

⁷⁴ <https://www.bmwi.de/Redaktion/EN/Dossier/grids-grid-expansion.html>

⁷⁵ <https://www.smartcitiesworld.net/news/news/germany-predicted-to-be-smart-grid-investment-hot-spot-974>



This project is funded by the European Union



Figure 16: Smart Grid Market Forecast by Segment in Germany (Cumulative)

2.5.3.3 Incentive Regulations for DSOs

As in the free market economies, the Federal Republic of Germany is working on competition to ensure that prices are affordable. There exists a balance between supply and demand, and companies are encouraged to constantly look for new products and low-cost production technologies. However, several sectors of a national economy may emerge as an exception.

Since the operation of energy networks is a capital-intensive business, Energiewende examines the investments from network operators accurately. The power and gas lines required for Energiewende cost billions of dollars. German network operators need a long-term planning horizon and reliable economic framework conditions for such investments. At the same time, it is not logical for everyone to build additional parallel power lines or gas pipelines since there is no competitor for grid operation. However, consumers and third parties (i.e., suppliers) seeking network access are of great interest in accessing the electricity grid and the gas grid and fair calculation of prices. This legal duty is carried out by Bundesnetzagentur by a specific regulatory approach known as incentive regulation.

There is no ideal regulatory approach for regulated industries. Bundesnetzagentur constantly evaluates the incentive regulation with industry associations, network operators, network users and political representatives. Moreover, Bundesnetzagentur adapts administrative procedures to new developments and proposes changes to the framework.

For consumers and commercial enterprises, fair calculation of the price of access to the electricity grid is carried out by Bundesnetzagentur with the regulation of incentive regulation.

Network operators in accordance with the German Energy Law (EnWG); provide reasonable, non-discriminatory and transparent access for;

- End customers,
- Energy supply networks and
- Generation and storage facilities.

Germany performs above the EU average in terms of research and innovation. This is particularly striking in terms of innovation, where it stands at higher levels than its main competitors.



This project is funded by the European Union



Priorities in research and development in renewable technologies (photovoltaic, wind energy), energy efficiency measures in the building industry and industry, crafts, commerce and services, and energy storage and smart grids, respectively, are the highest areas. Germany is open to increase cooperation in R&D with other EU Member States in different energy technology fields. Germany also continues to support the development of Carbon Capture and Storage (CCS) in cooperation with other EU Member States.

In German regulation, DSOs don't earn any returns for assets that are financed by public funds. Such funds (EU funds, national funds and other subsidies) are treated like interest-free capital, which are subtracted from the RAB. If a system operator conducts an R&D project, which is funded by German federal funds, he can apply to receive a part of the project costs to be granted as allowed revenues. In particular, he can receive 50% of the project costs subtracted by the federal fund money (§25a ARegV). This is only possible if the project is not already included in the system operator's allowed revenues by means of other mechanisms.⁷⁶

As part of the reformed ordinance, an efficiency bonus may be granted to eligible DSOs. It is connected to the benchmarking system, as DSOs are eligible for the efficiency bonus only if they are determined to be fully efficient as a result of the benchmarking process. Bundesnetzagentur carries out a super efficiency analysis – based on the Data Envelopment Analysis of the regular benchmarking – for eligible DSOs, both with actual costs and with standardised costs. The super efficiency value is the difference between the results of the super efficiency analysis and the efficiency values from the regular benchmarking (which is 100% since only efficient DSOs are eligible), capped at 5% for both cost bases and averaged afterwards. The bonus is then determined by multiplying the super efficiency value with the temporarily non-controllable costs and split evenly over the duration (years) of the regulatory period. The bonus is designed to enhance innovation as DSOs now have an incentive not only to be fully efficient, but to constantly try to exceed 100 % (relative) efficiency. Thus, it also rewards longer-term innovations which ensure that DSOs reach super efficiency status in future regulatory periods.⁷⁷

National Funding: National funding accounts for 47 % of the total national investment in the country. An interesting example of such funding came from the '**E-Energy — ICT based energy system of the future**' initiative (2008), a joint funding programme of the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Up to 2013 the Government provided total subsidies of about 140 million euros for six pilot projects, in which the use of ICT in the energy sector was explored and tested. In addition, cross-sectional topics, such as the legal framework (including data protection) and standardization, were also studied. With the project, it was expected to ensure more effective utilisation of the existing supply infrastructure, expand the use of renewable energy resources and reduce CO2 emissions. PPC's real-time communications platform was selected for the German smart grid beacon project 'E-Energy'. PPC's broadband powerline technology is the optimal solution for this programme.⁷⁸

The gained results and insight were continued in a follow-up programme "**Smart Energy Showcases - Digital Agenda for the Energy Transition**" (SINTEG) that aims to develop and demonstrate in showcase regions new approaches to ensure reliable and secure grid operation with high shares of RES generation on the basis of wind and solar energy. The programme places a clear focus on building smart networks linking up the energy supply and demand sides, and on the use of innovative grid technology and operating strategies. It thus addresses key challenges of the energy transition including the integration of renewables into the system, flexibility, digitisation, system security, energy

⁷⁶ European Distribution System Operators for Smart Grids, May 2017, Response to CEER consultation on incentive schemes for regulating DSOs, including for Innovation

⁷⁷ CEER, 2017, Incentives Schemes for regulating DSOs, including for Innovation Consultation Paper

⁷⁸ <https://www.ppc-ag.com/projekte/e-energy/>



This project is funded by the European Union



efficiency and the establishment of smart energy systems and market structures. The project makes an important contribution to moving forward the digital transformation and the energy transition.

The Federal Ministry for Economic Affairs and Energy is providing more than 200 M € in funding for five showcase regions. PPC is actively involved in projects in the areas of security, innovation, Broadband Powerline and Smart Meter Gateways. These are;

- C/Cellular: interconnected and regional energy systems with a cellular structure and focused on PV integration balancing each other.
- Designnetz: decentralized renewable energy flexibly supplied to urban and industrial load centres.
- Enera: Ensuring the stability of the Grid with data analysis and advanced measurement systems associated with new market mechanisms.
- NEW 4.0: Flexible demand response of the extreme productivity of regional wind energy and maximizing thereof by the effective use of interregional trade.
- WINNODE: Compliance with the integration of variable regional wind energy by the flexibility of the Electricity, Heat and Electric Circulation Sectors.

The purpose of the smart grid model regions is to show how well-designed digital technology and smart grid projects are and explain how we can use them in everyday life. The financing program launched by the Ministry of Economic affairs is in line with the Federal Government's inter-sectoral smart grid strategy.

The Federal Government promotes R&D in Germany in the field of innovative energy technologies. In September 2018, the Federal Cabinet adopted the 7th Energy Research Programme entitled “**Innovations for the Energy Transition**” that supports companies and research/academic institutions in research, development and demonstration for innovative energy technologies. The Energy Research Programme is a strategic element of the Federal Government's energy policy to support a continuous research and innovation process.

International Position: On the European level, Germany participates in strategic projects on non-nuclear energy topics within the **SET-Plan** framework and German project partners can also participate in network initiatives such as **EUREKA/EUROGIA** or **COST**. Moreover, within the framework of the **ERA (European Research Area)-Net**, topic- specific cooperation, coordination and joint calls for proposals between national funding organisations are also supported and coordinated on a European level. Within the **IEA Energy Technology Network**, Germany currently participates in 22 of the 38 current Technology Collaborations Programmes and contributes its national expertise to the international exchange. Within **Mission Innovation**, Germany has a target to double public investment in R&D for clean energies within 5 years. The Country is engaged in 6 out of 8 Innovation Challenges, in particular co- leading IC5 (Converting Sunlight Innovation Challenge) and IC8 (Hydrogen). Germany commits its active contribution in IC1 to two tasks, task 1 (storage integration) and task 4 (flexibility options). The following figure shows National Programs in Fields of Smart Grids and Renewable Energy in Germany.



This project is funded by the European Union



Name of National Activities/ Programmes in Support of Respective Task	Name of POWs Task/Subtask Relevant to the Activities/ Programmes
7th Energy Research Programme	IC1; all subtasks
SINTEG	IC1; all subtasks
KOPERNIKUS	IC1; task 4, task 5, task 2, task 1
Development of Digital Technologies	IC1; task 4, task 5

Figure 17: National Programs related to Smart Grid and Renewables⁷⁹

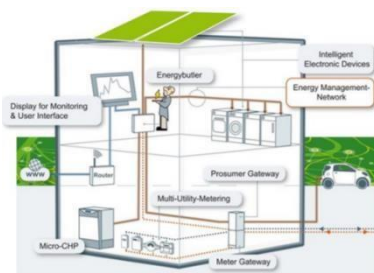
Sample Projects: In addition to the abovementioned issues, some sample smart grid projects in Germany are as follows:

Research Project in Mannheim⁸⁰: is a research project set up under E-Energy. The project has three phases and nine consortium partners putting the power grid of the future to the test in Mannheim and Dresden. The key objectives of the project are to demonstrate how renewable energy can be optimally integrated into the grid and how the city can function as an energy store. MVV Energie AG and IBM are other PPC (Power Plus Communications) partners of the project. The project involves usage of Broadband Powerline Communications across the whole network and Energy Butler home automation device connected to energy market data.

The field tests showed that customers react to price signals. Customers accepted variable tariffs and recognized their cost advantages. Depending on whether the price was high or low, energy consumption was influenced substantially. To be able to show how the customers react, price-elasticity was tested, and it is seen that customers had an average price-elasticity of between ten and eighteen percent, up to a maximum of 35% in the evenings.

To summarize, key findings have been:

- Short transport distances help to minimize grid losses.
- A powerful communication infrastructure – broadband powerline enables real-time data transmission over the power grid itself.



The Energy Butler received price signals through the BPL network and could automatically switch white goods and power generation equipment on, at the most efficient times

- Real time information about consumption and production allows intelligent network control for utilities and distribution network operators.

- The power grid can be balanced through demand side management.

Fühler im Netz (Sensors in the Grid) is another project funded by the Government. The detailed recording of the grid status plays an important role to ensure the supply security and grid stability in Germany in the future. The FiN project intends to investigate new and cost-effective ways of recording

⁷⁹ Mission innovation, May 2019, Smart Grids Innovation Challenge Country Report 2019

⁸⁰ <https://www.ppc-ag.com/projekte/moma-smart-city-mannheim/>



This project is funded by the European Union



the grid status and detecting faults, specifically the use of Broadband over Power Line (BPL) technology. BPL is used for communicatively linking different applications in the electricity grid. Power Plus Communications was the consortium leader of this project, and the participants have been Energieversorgung Leverkusen GmbH & Co. KG (EVL), Nexans Power Accessories Germany GmbH, Bergische Universität Wuppertal and Nexans S. Awhich. The support provided by the German Government has been EUR 2,5 Million.⁸¹

Within the scope of **Project Heidelberg Bahnstadt**, the city's utility operation Stadwerke Heidelberg (SWH) installed smart meters as standard in all the properties, regardless of the customers' choice of energy provider, and at no extra cost. The main challenge during the project has been that new city district with passive house standard, costs must be kept low, mobile radio communication does not work. However, smart metering with BPL in the low-voltage network with BPL headend in the transformer stations, BPL gateways in the houses and PPC's Network Management System have been used.

Mobility2Grid and **Flexible Electric Grids** are other two projects performed. Mobility2Grid involves 36 partners and is located in Berlin and the Technical University Berlin is in charge. Focus of the project is the integration of electric vehicles into decentralised energy systems. Within the project there is a special focus on acceptance and participation and smart grid infrastructures.

Electro mobility is a highly prioritised area in Germany and within the scope of the national development plan, it is stated that are supposed to be one million electric cars until 2020 and six million until 2030. It is, however, highly doubtful if Germany can reach the 2020 goal if there will not be more funding instruments and financial incentives.

In the same manner as with smart grids state support takes place in so called model regions electro mobility. One element of electro mobility which receives extra support is charging infrastructure. Until 2020 the federal Governments grasps at 15,000 charging poles at least. From 2017 till 2020 it provides €300 million for this roll out.

On the other hand, the first commercial demand response program in Germany was rolled out by the fifth largest German utility in 2011 in collaboration with a Demand Response Aggregator. Industrial and commercial businesses are offered to participate in the Demand Response program by providing their flexible load potential which is aggregated and marketed into the tertiary balancing power market in Germany.⁸²

2.5.3.4 **Smart Meters**

Germany confirmed the European objectives called "Meseberger Beschlüssen" in 2007 and implemented and adapted the changes adopted by the Energy Law.

The economic evaluation of Germany was published on July 30, 2013 in accordance with the Third Package of the EU and with recommendations for the national launch of smart meters. The economic evaluation reports completed with alternative scenarios in December 2014 are given below:

- Cost-benefit analysis for the comprehensive use of smart meters
- Calculation of variants of counter change strategies under discussion - completing cost-benefit analysis

The Metering Act (MsbG) that came into force in September 2016 triggered significant changes in Germany. The regulation requires the comprehensive rollout of modern metering equipment and smart metering systems.

⁸¹ <https://www.ppc-ag.com/projekte/fuehler-im-netz/>

⁸² https://ec.europa.eu/energy/sites/ener/files/documents/xpert_group3_first_year_report.pdf



This project is funded by the European Union



Modern metering systems do not transmit any data and they are referred to as smart metering systems when they are connected to a smart meter gateway, enabling them to transmit the data recorded by the meter.⁸³

Since the beginning of 2017, the first modern metering systems have been available in the market and have been installed by the first metering operators on a large scale. It was still not possible to start the rollout of smart metering systems in 2018, since only one smart meter gateway certified by the Federal Office for Savings based on an annual consumption between 2,500 kWh and 5,000 kWh.

Information Security (BSI) was available in the market at the end of 2018. However, in light of the statutory requirements set out in the MsbG and advances in metering technology, a large-scale rollout of modern metering equipment and smart metering systems is expected soon.

In many countries, DSOs are now responsible for smart meter installation, metering and reading. In Germany, where metering is liberalised, not many consumers choose a metering operator other than the one that belongs to their current DSO. the metering companies are owning the smart meters. Metering is done by a separate market entity, the Metering Service Operator (MSO). The cost is billed to the customers separately or through the retailer. Generally, the MSO and the DSO are in the same group of legally unbundled companies.⁸⁴

2.5.4 Spain

Like in other countries, smart grids are expected to favour the sustainable growth of the Spanish economy too. Benefits are expected 2 to 3.5 times the investment required, due to an increase in the system's reliability and efficiency and the ability to manage consumption in real time. In addition, a €10,200m estimated investment required, in grid elements and customer installations in 10 years until 2022.

2.5.4.1 Regulatory Institutions

The National Markets and Competition Board, (**Comisión Nacional de los Mercados y la Competencia - CNMC**) entered into operation on October 7, 2013 to promote and defend the proper functioning of all markets in the interests of consumers and businesses.

CNMC is a public institution with its own legal personality, independent of Government and subject to parliamentary control. Its responsibilities include monitoring the price level, the level of transparency, the market opening and the level and effectiveness of competition.

The Resolution of 2nd June 2015 of the Secretary of State for Energy approved the Operational Procedures necessary to start issuing bills to customers equipped with smart meters based on hourly consumption and hourly prices. This model provides a dynamic price signal to small customers and consequently, a way to implicitly participate in the market by shifting consumption to the hours of the day where energy is cheaper.

CNMC developed price comparison tool that aims to improve the transparency of retail markets. The tool gives consumers who have opted for PVPC and have smart meter, the ability to check their bill, besides the financial impact of their electricity consumption depending on the access costs plan chosen between the general tariff, the night tariff and the super-valley tariff (electric vehicle) and depending on the load contracted⁸⁵.

⁸³ Monitoring report 2019 - Key findings and summary

⁸⁴ Ecorys, ECN, 2014, The role of DSOs in a Smart Grid environment

⁸⁵ CNMC, 017, Spanish Energy Regulator's National report to the EC



This project is funded by the European Union



Ministry of Industry, Energy and Tourism⁸⁶ is also a member organization for the Smart Grid Regional Group in EU. The Ministry develops legislative proposal and prepared the Spanish Smart Cities National Plan, a proposal to promote technological industries, within the Smart Cities in local territory, and to help local authorities in the process of developing Smart City in Spain.

The Ministry has also the task to approve the distributors' smart meter equipment and replacement protocols within the scope of Order ITC/3860/2007 that requires utility service providers to progressively replace electricity meters under 15 kilowatts.

As the Spanish TSO, **Red Eléctrica de España** is responsible for managing some aspects of the Voluntary Price for Small Consumer (PVPC) system. This price is calculated daily by the Spanish TSO based on hourly energy prices in the spot market and applied to the average consumer profile. These prices are applied to the electricity consumption (variable energy load - kWh consumed) of the invoice calculated by the system operator using the newly approved methodology. In this way, Red Eléctrica offers consumers who prefer PVPC to see the financial impact of electricity consumption, depending on the plan of access costs selected between general tariff, overnight tariff or super valley tariff (electric vehicle). These prices can be applied to all small consumers, with or without smart meter with hourly measurement.

2.5.4.2 **Regulatory Structure** ⁸⁷

In Spain, the electricity industry has been governed for 16 years by the **Electricity Sector Law No. 54/1997** dated November 27th, which liberalizes the electricity market, and Directive 96/92/EC, which includes common rules for the EU electricity domestic market (later 2003/54 / EC and Directives 2009/72 / EC have been incorporated into Spanish law through amendments to Law No. 54/1997).

Since the previous Law has been insufficient to ensure the financial stability of the electrical system (e.g. the pricing system for the activities organized may be considered as not having the flexibility to adapt to the important developments in the electricity market or the development of the economy) **the new Electricity Sector Law (ESA)** was approved in 26 December 2013.

This law sets out provisions about specific cases of self-consumption of electricity, envisage different net metering configurations like supply with self-consumption (a consumer with a generation facility for their consumption, connected to their own grid). In this instance, production device would be deemed as part of a consumer facility and not as a producer on their own. The Law does not define a prosumer role; either one or the other role is attributed. Consumers under self-consumption are required to pay the same grid access tariffs and charges associated to the system costs as the rest of consumers. Government may nevertheless establish reductions in those tariffs and charges if self- consumption reduces overall system's costs (e.g. reducing network losses or improving generation adequacy).

In Spain, until 2007, Red Eléctrica Española and the main energy suppliers joined their efforts to transform the currently grid system to a smart grid. There was not any specific law available that regulates smart grid systems. On the other hand, there were laws that regulate the grid conditions (**Law 54/1997, Law 17/2007, RD 661/2007**) and the energy meters specifications (**RD1634/2006, RD 1110/2007, Orden ITC/3022/207, Orden ITC/3860/2007**).

⁸⁶ Later the Ministry of Industry, Tourism and Trade

⁸⁷ Electricity regulation in Spain: overview by Ignacio Borrego and Ana Calvo, Watson, Farley & Williams



This project is funded by the European Union



Order ITC/3860/2007, adopted on 28 December 2007, required utility service providers to progressively replace electricity meters under 15 kW with smart meters. During each of the four replacement periods starting from 2008 through 2018, energy distribution companies must install smart meters to replace a certain percentage of the firm's total electricity meter stock. Customers have the option of buying or renting the equipment.⁸⁸ As result of the meter replacement plan at the end of December 2017, 91% of new meters were already installed.

Smart Meter's Replacement Plan was amended in 2012 with the **ORDEN IET/290/2012** publication which modifies the previous order to adjust the Replacement Plan to the current deployment status.

Royal Decree 647/2011, of 9 May, regulating activity for charging point managers (companies allowed to buy and resell electric energy exclusively for electric vehicle charging) defined specific low access tariffs for night / off-peak recharging.

Benchmarking smart metering deployment in the EU-27 with a focus on electricity was performed with **COM (2014)356** on 17th June 2014.

Royal Decree 216/2014, of 28 March, set final prices for electricity consumers according to real metering in hourly basis.

The Resolution of 2nd June 2015 of the Secretary of State for Energy approved the Operational Procedures necessary to start issuing bills to customers equipped with smart meters based on hourly consumption and hourly prices. The first bills of this kind were issued in October 2015. This model provides a dynamic price signal to small customers and consequently, a way to implicitly participate in the market by shifting consumption to the hours of the day where energy is cheaper (PVPC Regime).⁸⁹

2.5.4.3 *Incentive Regulations for DSOs*

In Spain, there is no specific public programme to fund smart grid pilot projects. Although some basic R&D projects are partially financed with the national and European R&D programs, most of the pilots has been fully funded by the companies which are developing them and additional costs were not taken into account in the reference grid model. There are varying shares of national funding, especially mainly the Basque region area. On the other hand, being not similar to many other countries, in Spain, there is an exception for EU funding incentivising the DSO, which amounts to 10% of the regulated asset base. Investment financed by third parties don't add to RAB, but if DSOs get EU fund, 10% is added into the RAB.⁹⁰

The Spanish technological platform of electrical grids FutuRed was created in October 2015, for the purpose of integrating all of the stakeholders involved in the electricity sector behind a set of common goals. FutuRed brings together smart grid stakeholders; utilities, companies, universities, research institutions, organizations and public administration – with a total of 127 entities as members. This in order to define and promote strategies at national level to allow the realization of a more advanced power network – one capable of responding to the challenges of the future.⁹¹

⁸⁸ <http://www.iea.org/textbase/pm/?mode=cc&id=4463&action=detail>

⁸⁹ National Report submitted by CNMC to EC, July 25th, 2017

⁹⁰ European Distribution System Operators for Smart Grids, May 2017, Response to CEER consultation on incentives schemes for regulating DSOs, including for Innovation

⁹¹ <https://www.smart-energy.com/magazine-article/smart-grid-development-spain/>



This project is funded by the European Union



Important smart grid projects in Spain are as follows:

IHSMAG: IHSMAG explores the integration of households in the smart grid and develops design recommendations. Based on some case studies in the participating countries (Norway, Spain and Denmark), the project provides new information on developing a comprehensive home-smart grid solutions design that integrates the specific features of the three cross-cutting areas in the European Union. These are:

- In-house technologies,
- Daily practices of household members in electricity consumption and
- The electrical system and administrative and institutional rules that affect the implementation of new smart grid solutions (e.g., standards for home automation and economic incentives).

IHSMAG combines different methods according to case studies. In addition to interviews and field observations, the project also includes technical studies of household level interoperability, communication standards and similar challenges. The smart grid solutions examined in the project include EVs, smart metering and feedback to customers.⁹²

BeyWatch: With the BeyWatch project, it is targeted to develop an energy-efficient and user-oriented solution that can balance smart energy monitoring / control and power demand at the home / building and neighbourhood level.

The Grid4EU: Within the scope of the Grid4EU project, it is targeted to test some innovative system concepts and technologies in real size, under the leadership of a group of European DSOs and to highlight and remove some of the barriers (technical, economic, social, environmental or regulatory) in the installation of smart grids. The project focuses on how DSOs can dynamically manage electricity supply and demand, which is crucial for the integration of large amounts of renewable energy, and to ensure that consumers are active participants in their energy preferences.⁹³

EUDEEP: The project brought together eight European energy organizations and targeted removing most of the technical and non-technical barriers that prevent the spread of distributed energy resources (DER) in Europe. By partnering with manufacturers, research organizations, professionals, national agencies, and a bank, they implemented a demanding practice rather than a technology-focused approach. This new approach has provided three temporary "fast-track options" that have accelerated the widespread implementation of DER in Europe by identifying three client portfolios in various market segments that can benefit from DER solutions and by promoting the R&D required to adapt DER technologies to demands.⁹⁴

EWIS European wind integration study: The project targeted to work with all relevant stakeholders, particularly representatives of wind energy generators, and aimed to use the results from the detailed grid and market models of the European transmission system for scenarios that represent urgent and long-term needs. With the recommendations, it targeted to develop European common solutions that would be possible and appropriate against wind integration challenges.⁹⁵

⁹² <https://ses.jrc.ec.europa.eu/ihsmag>

⁹³ JRC, 2012, Smart Grid projects in Europe: Lessons learned and current developments

⁹⁴ <https://cordis.europa.eu/project/id/503516/reporting>

⁹⁵ <http://www.wind-integration.eu/>



This project is funded by the European Union



GROWDERS project; (Reliability and Operability of Distributed Generation Grids using Flexible Storage) examines the implementation of distributed storage system in (portable) grids. GROWDERS is an Illustration of Grid Electric Systems.⁹⁶

HiperDNO: The purpose of this research project is to produce a new distribution grid management system close to real-time HPC solutions with natural security and smart communications for smart distribution network operation and management. It is targeted to develop and show cost effective scalable HPC solutions for realistic distribution grid data traffic and management scenarios through offline field trials involving several distribution grid owners and operators.⁹⁷

Smartcity Malaga Project: Endesa's Project is Europe's largest eco-efficient city initiative and aims to increase energy efficiency, reduce CO2 emissions and boost the use of renewable energy sources. The zone has around 11 MW of renewable generation capacity, which includes numerous roof-mounted photovoltaic installations spread throughout the city, a cogeneration facility, vertical-axis wind turbines and generation systems integrated in street lighting.

The main objectives of the project are automated meter readings, consumers changing their habits related to their consumption, rates and the environmental impact, raising customer awareness, PLC communications to ensure optimal use of the power grid, energy efficiency in public and private buildings, efficient management of public lighting, battery management and the installation of storage capacity in generators, etc.⁹⁸

REMOURBAN: It is a large-scale demonstration project, whose purpose is developing a holistic and replicable model for sustainable urban regeneration, with a jointly approach in the sectors of energy, mobility and ICTs. This project is expected to allow cities increase the efficient use of energy and resources, promote the sustainability of urban transport and drastically reduce greenhouse gas (GHG) emissions, as well as improve the quality of life of their citizens.

The first demonstration will be carried out in Valladolid (309.000 inhabitants) and will consist on the renovation of 400 dwellings (total 24.600 m2), the implementation of renewable energy in the district heating system, the deployment of 50 electrical vehicles and improvement of the charging infrastructure, as well as the development of a city information platform for energy demand management.

The second and third interventions will take place at Nottingham located in central UK and Tepebasi in Eskisehir city. The demonstration at Eskisehir aims at the reduction of 85% in the energy consumption, and a 79% of the CO2 emissions. At least 600 citizens will be directly involved in the demonstration, in which 57 dwellings (9.110 m2) will be retrofitted, a district heating/cooling facility based on biomass will be installed, and 11 hybrid vehicles will be used, in addition to a 50 e-bike rental system. An ICT city management platform will be developed in order to put together all energy and mobility data.⁹⁹

r2cities: This project aims to develop and demonstrate an open and easily replicable strategy for designing, constructing, and managing large scale residential district renovation projects to achieve nearly zero energy cities.

⁹⁶ JRC, 2012, Smart Grid projects in Europe: Lessons learned and current developments

⁹⁷ <https://www.indracompany.com/en/indra/hiperdno-high-performance-computing-technologies-smart-distribution-network-operation>

⁹⁸ <https://www.smart-circle.org/projects/>

⁹⁹ www.remourban.eu



This project is funded by the European Union



Demonstrations will take place in three residential districts that are located in Valladolid, Spain, Kartal-Istanbul, Turkey; and Genova, Italy.¹⁰⁰

Iberdrola's **STAR Project (Network Remote Management and Automation Systems)**, launched in 2009, is an ambitious initiative with the objective of transforming technology in the field of smart grids. The STAR project, with an overall investment of over €2 billion, involves the installation of over 10.6 million smart meters based on PRIME (Power Line Carrier solution) and the adaptation of some 80,000 transformer stations with remote management and monitoring capabilities. With this project, Iberdrola fulfilled its legislative requirements related to remote management development, evolve technologically while improving the company's distribution grid and get the capability of effectively controlling the feed of renewable energy into the grid.

Other smart grid R&D initiatives of Iberdrola are:

UPGRID Project: Iberdrola leads the project in Europe, which seeks to reinforce its capacity as an integrator of active demand and distributed generation in the low voltage grid.

IGREENGrid Project: For developing accurate methods that can be used to integrate renewable energies into electricity distribution grids.

DISCERN Project: which compares various grid intelligence solutions and looks for the most optimised architecture models.

Further, after the development of its first smart network in Castellón, Iberdrola has begun to deploy it at a global level throughout its territory as part of BIDELEK Project. The project will involve deployment of 200,000 meters serving 360,000 inhabitants in Bilbao and around 1100 Smart Transformers.

2.5.4.4 *Smart Meters*

Unlike many other EU countries, Spain has not conducted an economic CBA for an electricity smart metering roll-out and decided to proceed with a full roll-out with a replacement plan for all Spanish domestic meters with contracted power lower than 15 kW. The roll-out covered 100% of 27.8 million meters and intended to run from 2011 till 2018. Deployment included smart meters and the associated communications networks, remote reading and control, data management systems, web portal customer interaction, and some form of dynamic pricing. They differ in size or scale, pricing scheme and in behind-the-meter capabilities such as in-home displays. The smart meter technology deployment in Spain is being developed according to regulation plans. As of 2018, almost 95% of the deployment is completed.

The metering activity is regulated, and DSO is the responsible party for implementation and also for granting third-party access to metering data. The choice for the customer to either accept a rented meter by the DSO at a regulated monthly fee or install his own meter is a legal right in Spain. The financing of the roll-out is through network tariffs and smart metering rental fees (SWD (2014)188, 2014). Practically, the rental fee is included in the network tariff (around 0.92 euro/month + taxes). However, the consumer can buy and install his own smart meter (the cost of the meter is around 100 euro + installation costs). In this case, the consumer is responsible for the smart meter maintenance and upgrade.¹⁰¹

¹⁰⁰ www.r2cities.eu

¹⁰¹ https://www.parent-project.eu/wp-content/uploads/D1.4_Smart-grid-roll-out-and-access-to-metering-data-1.pdf



This project is funded by the European Union



Since there were delays in deployment, the replacement plan was modified with the following steps:



Figure 18: Modified Replacement Plan

The regulation also established the minimum functional requirements for the new smart meter to be installed, mainly characterized by remote bidirectional control for reading, energy management, power demand control, connect/disconnect and hourly metering and option of selecting hourly tariffs. According to the regulation, manufacturers developed smart meter devices for Spanish DSOs using two kind of communications technologies: PRIME and Meters & More. Each one is based on different protocols and structures, although both of them uses PLC (Power Line Communications) using broadband and narrowband, respectively.¹⁰²

In the Country, the Spanish Organizations Consortium was established in 2009 and is responsible for defining and maintaining technical specifications for selecting smart meter devices communication protocols.¹⁰³

As it was mentioned in regulatory structure section, the Voluntary Price for Small Consumer (PVPC), came into force in 2014 to determine the cost of energy on the electricity bill for consumers whose contracted power capacity does not exceed 10 kW. With the new PVPC system the only modification has been the method of calculating the price of producing electricity. Consumers who have a smart meter installed capable of hourly metering have these new prices applied to their bill in accordance with their hourly consumption throughout the day.

2.5.5 Sweden

Sweden's economy is energy intensive and the energy system is characterized by a high degree of electrification. One of the key policies related to smart grid is energy research programmes' supporting extensive research and innovation that have applications in society and the energy research grant's constituting an important means of influence and control for transforming the energy system. By 2030, Sweden should have a vehicle stock that is independent of fossil fuels and, according to a broad Parliamentary 5 party agreement in 2016. The following figure shows, recent figures in theCountry.

¹⁰²<http://www.iea-isgan.org/ami-case-case10-spain/>

¹⁰³MDREG, Study to Evaluate Net Metering Systems in Mediterranean Countries



This project is funded by the European Union



Number of Smart Meters	5.2 Million (100 % of electricity customers)
Number of Electric Vehicles	28,000 ⁽¹⁴⁻⁴⁾
545 000 km Lines of Which:	329 500 km underground and 215 500 km overhead lines
Transmission Lines are:	15 000 km at 400 kV and 220 kV 170 Network Companies (various size, some publicly and privately owned)

Figure 19: Key Smart Grids Facts and Figures by the end of 2018

2.5.5.1 Regulatory Institutions

The Swedish Energy Market Supervisory Board, **Energimarknadsinspektionen (Swedish Energy Markets Inspectorate-EI)** is a supervisory authority on behalf of the Government and belonging to the Ministry of the Environment and Energy. EI monitors compliance with Swedish energy companies' licenses, rules and regulations. EI oversees the Swedish electricity, natural gas and district heating markets and works to improve the functioning and efficiency of these markets. It contributes to active and conscious energy consumers who play a role in the development of national and international energy markets.

The Board's implementation also includes audits to ensure that market players follow energy market laws and regulations. One of its most important tasks is to examine electricity and gas tariffs. Since 2012, the regulation agrees to establish a four-year revenue framework for all electricity grid companies. It also monitors the quality of electrical transmission, evaluates applications and licenses for electrical and gas networks. The board is also tasked with checking whether the costs of connection to the power grid are reasonable. At the same time, it prepares rules and regulations at the national Nordic and European level to harmonize existing regulatory frameworks. The board also publishes information to consumers to raise awareness and activities in the market.

In May 2012, the Swedish Government appointed a **Coordination Council and National Information Platform**¹⁰⁴ for Smart Grids (2012:48). The role of the Coordination Council includes promoting dialogue and cooperation by developing a national information platform and a national action plan for the development of smart grids in Sweden from 2015 to 2030. To highlight long-term results and the need for measures, the Coordination Council has extended its future scenarios to 2050 for the development of smart grids in Sweden. The Council defined some challenges related to smart grids as communication for smart grids, system architecture, energy efficiency, power quality, managing low-cal generation, study of active demand, customer benefits of smart meters, vulnerability for IT threads in smart grids, and characteristic of loads.

¹⁰⁴www.swedishsmartgrid.se



This project is funded by the European Union



Sweden is one of the leader companies in the development, implementation and dissemination of smart grids. Within the Country, there is close cooperation between universities, industry, institutes, institutions, non-Governmental organizations and the education, research and innovation-information triangle initiative.

The Swedish Smart Grid Forum was appointed in 2013 by the **Swedish Ministry of the Environment and Energy** and has 18 members. These members represent central agencies, businesses and organizations and have a wide range of skills in smart networks. The Forum is established as a result of the recommendations from the Swedish Coordination Council for Smart Grid (active 2012–2014). The mission is to implement the action plan, set up by the Council, to further develop a store of knowledge on the website and to support Swedish export within smart grids. The goals of the Swedish Smart Grid Forum are;

- An electricity market with active customers, as well as the robust and effective integration of 100 percent renewable electricity.
- Sweden is a hub for smart grids, with internationally recognized expertise and a natural test bed for smart grids.
- Growing the number and variety of exporting smart grid companies, services and products in Sweden.

The **Swedish Energy Agency** distributes almost all state funding for energy research, and it provides funding for both major research at universities and large-scale demonstration projects in cooperation with industry. The agency also supports the development from technical solution to commercial product. It also promotes energy efficiency and smarter energy usage by conducting information campaigns, making technical purchases, executing business intelligence, and testing and labelling products. The agency also provides financial support to Sweden's municipalities for energy and climate consulting services.

The **National Electrical Safety Board** is the central institution responsible for technical safety issues such as electrical safety and electromagnetic compatibility and makes regulations for electrical installations and electrical devices in these areas. This also means that the Agency has responsibility for new products and installations that can be developed on smart grids. In addition, standardization work is carried out regarding smart grids.

The **Swedish Environmental Management Council** endeavours to contribute to sustainable development by supporting businesses and public administrations in their environmental work in a strategic and cost-effective way.

Svenska Kraftnät (state-owned public service company tasked with managing Sweden's national electricity grid), Vinnova (innovation agency responsible for innovation development and energy transformation), the Swedish Growth Policy Analysis Agency (whose one of the interest areas is sustainable development -one of the special interests that forms an important part of smart grids), Swedish Business World (Swedish Trade and Investment Council), the Swedish Consumer Agency, the National Council of Housing, Building and Planning, Data Inspection Board, the National Postal and Telecom Agency (PTS), the Swedish Civil Risks Agency (MSB), the National Defence Radio Institute (FRA), ITS (Swedish IT Standards Organization), SEK (Swedish Electrical Standards Organization), Swedish Institute of Standards are some other stakeholders involved.

There are also a number of national centres and research and innovation programmes for smart grids, for example the national research programme SampsEL, Swedish Centre for Smart Grids and Energy Storage (SweGRIDS) and KTH ACCESS Linnaeus Centre.



This project is funded by the European Union



In the international arena, Sweden takes part in ISGAN (International Smart Grid Action Network), which is an initiative to promote the development of smart-grids worldwide and which is linked to the “Clean Energy Ministerial”, a high-level process initiated by the United States within the framework of the G20.

2.5.5.2 *Regulatory Structure*

Sustainable development is at the heart of Swedish energy policy, and national targets are far more comprehensive than those for Europe's 20-20-20 targets which are for climate change, renewable energy and energy efficiency. More specifically, there are four national goals that are expected to have a major impact for the demand of future smart grid solutions. These are¹⁰⁵;

- The goal of achieving at least 50% renewable energy by 2020 as a share of total energy use,
- The goal of reaching 20% more efficient energy usage by 2020 with the increased demand side participation,
- Target for spatial planning of 30TWh wind power generation by 2020,
- The goal is to reach an energy generation stock independent of fossil fuels by 2030.

The Energy Services Directive (2006/32/EC) requires the public sector to set a good example regarding energy efficiency and highlights in particular the existing potential in the public procurement of both equipment and services. The provisions of the directive in this area have been incorporated into Swedish law via two ordinances: **the Ordinance (2009:893)** on energy efficiency measures for Government agencies and **the Ordinance (2009:1533)** on state aid to energy efficiency measures in municipalities and county councils. To support the work done by the public sector in this area, the Swedish Energy Agency in cooperation with the Swedish Environmental Management Council, has a special responsibility to provide lists of product specifications for energy efficient equipment.

Sweden is well positioned to be a pioneer in smart grids, and a deregulated, improved electricity market with environmentally friendly customers and a wider information technology infrastructure has already enabled smart meters to be installed in about 90% of Swedish homes.

Sweden is the first EU country to indirectly assign smart meters or, more accurately, automatic meter reading (AMR), which also led to the use of its advanced measurement infrastructure (AMI). The AMR / AMI system architecture consists of meters, data collectors and the data management of Grid Company's billing system.

The first regulation regarding smart meters was adopted in 2003 and in 2009, when the Swedish Parliament decided that monthly invoices should be based on actual monthly consumption of electricity consumers in all residential and small businesses. Prior to the reform, invoicing for most private customers was done annually based on the electricity consumption of previous year. In 2006, additional amendments which reduces the threshold of mandatory hourly metering of customers were made to the legislation for all customers with fuses above 63 A, using the example of consumers with fuses above 200 A. The next important legal step was in 2012 in parliament in order to create a fully developed smart metering infrastructure. It was adoption of a bill that envisages hourly

¹⁰⁵ <http://governmentgazette.eu/?p=5540>



This project is funded by the European Union



measurement to be implemented at no extra cost for subscribers with electricity supply contracts for an hourly basis¹⁰⁶.

In 2013, EI evaluated the impact on market participants of the first roll-out of smart meters in Sweden and submitted a report to the Swedish Government in 2015 suggesting that minimum functional requirements for smart meters should be regulated and presented a preliminary proposal of requirements based on a long-term CBA. In 2016 the Government concluded that it is necessary to develop minimum functional requirements for smart meters before the roll-out of the next generation. In 2017, EI was tasked by the Swedish Government to propose new rules concerning minimum functional requirements for smart meters, based on the previous suggestions in 2015. After restudying the proposal from 2015 and the outcome of the public consultation, EI presented a final proposal concerning minimum functional requirements for smart meters to the Government in November 2017. In September 2018, it was determined that the minimum functional requirements for smart meters should be fulfilled latest by 1st of January 2025 (second generation smart meters)

As a change in the existing legal framework, the Swedish Coordination Council for Smart Grid proposed to provide at least hourly meter data access to demanding customers, without contract and at no extra cost. It has also proposed an open incentive mechanism for socio-economic, low-cost smart grid measures, without restricting competition in the market for new technologies.

As for the smart grids, in 2014, the Council prepared an action plan for the years 2015-2019. The plan consisted of the following:

- The main priority of the Coordination Council's action plan is that smart grids can increase customer competence, while offering customers more options in the market and promoting the development of new products and services. The potential spread of electricity generation from intermittent energy sources such as the sun and wind are another important factor that affects the need for smart grid solutions in the future.
- Driving forces for smart grids are primarily market-based. The purpose of the action plan is to ensure long-term planning and to facilitate adaptation to future challenges. The plan should adopt a holistic approach, with the main focus being on customer benefit and an efficient and sustainable resource utilization and a safe electricity supply. Smart grids are primarily a tool to achieve the desired level of customer and public interest, e.g. greater energy efficiency, electrification of the transport industry and a sustainable energy system. Achieving these targets requires long-term development efforts, where smart grids can make an important contribution.
- The development of smart grids is closely related to the development of the European electricity market and poses complex problems that need to be analysed carefully. It is also important that the process of adapting to new conditions in the electricity market (a large percentage of intermittent generation, active customers with completely new consumption patterns, etc.) begins as soon as possible. This will give the Swedes practical experience before the challenges become more urgent.

The Council recommended the political framework and market terms and conditions as follows;

- In order to take advantage of the new opportunities smart grids can offer, a political framework should be developed to continue the competition in the non-encouraged electricity market. Market terms and

¹⁰⁶ <http://www.iea-isan.org/ami-case-case08-sweden/>



This project is funded by the European Union



conditions should be designed to provide a clear incentive for socio-economic, cost-effective smart grid measures without restricting competition in the market for new technology.

- In order to cope with the future challenges of the electrical system, basic rules in the market will need to be developed so that both the system and the grid can benefit from smart grid solutions. It stipulates demand response and energy storage flexibility. Similar importance should be given to the modernization of electrical grids.
- The operation of future smart energy systems needs more automation to control the physical processes of electricity generation and distribution, and advanced IT systems to deal with a wider flow of information (measurement data, field information, work orders, customer data, etc.). Knowledge management of smart grids requires awareness of security and integrity.
- Smart grids also mean new conditions for collaboration with other parts of the energy system. Integration between the electrical system and energy carriers such as gas and district heating can provide greater scope for storing heat and cooling properties. The Grid may request more flexibility in the electrification of vehicle traffic and when the electric vehicle is charged. Smart networks can play an important role in this. Scope of energy efficiency is also affected from different smart grid solutions. In electrical systems of future, the capacity need will be as important as the energy need. And this will have an impact on how energy efficiency is designed and coordinated with various demand response options.
- The widespread increase of intermittent electricity generation in Sweden and Northern Europe will determine demands for different levels of the electrical system. In addition, the composition and location of intermittent electricity generation are decisive factors. To cope with these long-term challenges, system-level effects need to be better understood and so that rules can be changed in a timely manner.

The Council made the following recommendations on customer participation and social dimensions;

- Many of the suggestions and recommendations have a clear customer perspective, focusing primarily on the preconditions and needs that support customers that have active participation in smart grids and its new opportunities. Particular emphasis is placed on consumer perspective and personal integrity. Knowledge of the things that determine people's preferences and their interest in smart grid solutions is also an important part of the customer perspective. The ways in which metering data and information are made more accessible to customers are discussed. Focused on rule changes, clearer price and cost information from market players and the functional needs of next-generation smart meters. Moreover, social aspects and resources between smart grids and other social developments were emphasized. Smart grids are important for sustainable community progress and development of smart cities. It was emphasized that more information and data should be exchanged to take advantage of the potential to contribute to the development of community planning, energy systems and smart grids. There is a synergy between the smart products and services developed in the energy sector and other fields. Although this development is primarily market-based, information and knowledge still need to be spread.
- In the R&D, innovation and growth section of the action plan, how Sweden can best benefit from the development of smart grids and how to create the conditions for the growth in Swedish industry is explored. In two recommendations regarding the need for knowledge and skills supply, the importance of new skill requirements created by the development of smart grids and making training programs more attractive are emphasized. The need for promoting research, development and innovation is focused on.



This project is funded by the European Union



- Important aspects are a thematic research plan and an integrated strategy proposal for innovation. The importance of strengthening and using existing constructs and promoting more collaboration are also emphasized as a main priority.
- Test and pilot projects play a vital role in initiatives which involve education, research and innovation_ the triangle of knowledge. Pilot projects can also help develop new market models.

Sweden has a strong position in many of the technical fields for development of future smart grid systems and has been well praised in international comparisons and publications. But Sweden is a small export-dependent country and therefore in a globalized world, Sweden's position on smart grids becomes more important. Elements such as standardization and interoperability are highlighted as important tools.

Finally, the action plan has finalized in a discussion on long-term measures that are not directly linked to the recommendations in the action plan. In this plan, how to revise and develop the tools that are in use today in order to cope up with longer term expectations of changing conditions of the market is discussed. An important condition is the rules that govern the European market, which will cause changes in the Swedish market. Even economic instruments such as green electricity certificates and energy taxes should be reviewed from a long-term perspective. Finally, opportunities in the public sector are highlighted, e.g. public procurement, tenders, and procurement of innovation.

In 2019, According to Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, Ministry of the Environment and Energy published Sweden's **draft Integrated National Energy and Climate Plan**. The plan consists of description of Sweden's integrated national energy and climate policies including smart grids.

2.5.5.3 *Investment Incentives for DSOs*

In Sweden, all assets that are used and needed in the network business are included in the RAB. The absolute majority of assets are owned by DSOs, but even if they are rented, they are included in the RAB (cost of smart meters has little direct impact on OPEX and is included within RAB). When DSOs report the outcome of their revenues for a regulation period (which are to be compared with the revenue cap), all kinds of revenues are included. Mainly they consist of revenues from the tariffs for distribution and connection, but every other kind of revenues in the regulated business are included as well. All kind of subsidies are seen as revenues and subsidies fill up a part of the revenue cap and reduces the possibility for ordinary revenues. On the other hand, EU funded investment project are generally treated as any other funded project. The investment would increase the RAB but the fund itself would be treated as a revenue which means in reduces the revenue cap. So, the increase of the RAB is more or less used by the fund, it is neutral. For instance, large scale projects with a character of a pilot project and financed partly by EU-funds might be classified by the Regulator as non-regulated business.

In more detail when the smart meters are considered the following applies;

- EI determines a revenue cap for each DSO for a period of four years at a time. The minimum functional requirements may increase the cost for smart meters. Therefore, it is important to consider how costs related to meters are handled in the revenue-cap regulation to facilitate the roll-out of the next generation smart meters. There are both operating expenses (OPEX) and capital expenses (CAPEX) connected to meters.



This project is funded by the European Union



- The OPEX can for example be affected by changes in the costs associated with reading and using meter data. Changing to more advanced meters can both increase and decrease OPEX. On the one hand, more data should be handled. IT security issues, more expensive software, more competence requirements etcetera will increase OPEX. On the other hand, better IT systems, more automation and more information from meter data possibly lead to more efficient operation in the distribution system. The OPEX part in the revenue cap regulation is based on the DSO's actual historical OPEX with annual efficiency requirements of 1.00-1.82 % per year based on a data envelopment analysis (DEA). Hence, new meters do not change the OPEX part in the revenue cap, which means incentives for the DSOs to reduce its actual OPEX as much as possible.
- When the DSO invest or re-invest in a new component such as a meter, the CAPEX part of the revenue cap increases. EI has a norm price list of component categories, so first the DSO must identify which component category that best fits the actual investment. The norm cost is then input to the CAPEX calculation. The CAPEX consists of two parts: return and depreciation. All meters have a regulatory depreciation time of ten years (for most other power system equipment the depreciation time is much longer). So, if the norm price for example is 1,000 EUR, then the DSO would be compensated with 1,000/10 for ten years. The return part is based on the norm value, the age and the rate of return (a WACC method is used). If the meter in the example is seven years old, it has lost 60 % of its value (600 of 1000 €, 100 €/year depreciation for the first six years), which gives an age adjusted value of 400 € (1,000 – 6*100 €). The annual return is the equal to WACC*400€.
- The revenue cap regulation also includes incentive schemes based on several indicators for continuity of supply, losses and for having a more even load. Smart meters can have indirect impact to help the DSO improve such indicators in a longer perspective.¹⁰⁷

In Sweden there are already incentives in the regulation model for quality/security of supply and for efficient utilization of the power grid. The later one focus on reducing network losses and improving the load factor. These kinds of bonus/malus system are a good ambition but need to be developed to really give us the incentives wanted. There is an ongoing project at the Regulator to develop these incentives. (EDSO, 2017)

National Funding¹⁰⁸: The main publicly supported framework for research, innovation and demonstration in the smart grid spectrum is the Swedish Energy's programme **INTERACT**. The programme has a vision for 2050 and projects funded through the programme are selected on the basis that they can yield results contributing to certain societal effects by 2030. Over the last five years, SEA has provided approximately €50m of funding for smart grids. Funding for individual projects range between €0.05m to ~€2.5m. Roughly 50% is supporting applied research and 40% goes towards innovation and demonstration projects. About 10% of the funding is directed to basic research.

SweGRIDS is an important centre for smart grids and energy storage which besides the national programme SamspeL constitutes a significant share of the RD&I collaboration activities on smart grids between industry and universities. The centre is located at KTH and Uppsala University and receives substantial funding from the Swedish Energy Agency

International Position¹⁰⁹: Sweden is actively participating in the European SET-plan collaboration on smart grids, mainly through the multilateral member-state initiative ERA-Net Smart Energy Systems, that is joint programming

¹⁰⁷ Huang Y, Grahn E., Jaakonantti L, Wallnerström C., December 2018, Smart Meters in Sweden, Lessons Learned and New Regulations

¹⁰⁸ <https://www.ppc-ag.com/projekte/e-energy/>

¹⁰⁹ <https://www.ppc-ag.com/projekte/e-energy/>



This project is funded by the European Union



platform with participation of 30 funding partners in 23 European countries and regions, collaborating on a common vision for Smart Energy Systems in Europe. The initiative arranges yearly joint RD&I calls for transnational collaboration projects and where specifically Smart Grids is one of two main focus areas. Furthermore, to foster transnational learning and maximize impact, ERA-Net SES developed the Knowledge Community as one of its central instruments. This network consists of the funded projects, other bodies within ERA-Net SES as well as external stakeholders.

Through IEA and the Clean Energy Ministerial Sweden is also actively participating in the International Smart Grid Action Network, **ISGAN** and Sweden has currently an active role in the executive committee.

Sweden has a national energy research policy and a national road map for smart grids (developed by the Swedish Smart Grid Forum). There is also an overarching governmental energy policy, for which the energy RD&I works as a key trial and implementation tool.

Sample Projects:

- The Swedish Energy Agency is the responsible agency for energy research in Sweden and already co-finances several smart grid programmes. The Swedish electrical power industry is active in the field of smart grids and the Agency has approved support to two large-scale pilot projects, one in Norra Djurgårdsstaden, which is mainly a cooperation project between two companies, ABB and Fortum, and one on Gotland, which is a cooperation project between ABB and Vattenfall (for more information, please see under Best practice examples).
 - o **Norra Djurgårdsstaden:** In October 2010, the Swedish Energy Agency, in partnership with VINNOVA, has approved financial support for a pre-study aimed at developing a concept for a future pilot area for development and field installation of new technology providing both general and specific knowledge about the optimisation, control, maintenance and regulation of future smart-grids. This pilot area consists of what is known as Norra Djurgårdsstaden which is in the City of Stockholm and is one of Europe's most extensive urban development areas. A total of 10,000 new homes and 30,000 new workplaces were planned to be combined with modern port operations and other strategic infrastructure.
 - o **Energy Check (Energikollen):** Project was developed by Logica in partnership with Växjö Energi, is a good example of an innovative solution for "eco-visualisation" which, because of its competitive element, has mobilised the inhabitants of Växjö and promotes climate-smart behaviour.
 - o **Green IT Homes Project:** The project gives consumers more control over their electricity bills, enables them to remote-control their heating, lighting and alarms by mobile phone and makes them aware of their ecological footprint. Green IT Homes is aimed at housebuilders, house-owners and rental property owners. It is a cooperation project between the Swedish consultancy firm Elicit, the Finnish company Posintra, the Interactive Institute and IMCG (International Management Consulting Group). The project is being partly financed by VINNOVA to the tune of SEK 1.3 million (EUR 138 500).
- **The Swedish Smart Grid Forum** was appointed as a national forum by the Swedish Ministry of Energy and Environment, following the recommendations of the Coordination Council, which was actively involved in Smart Grids between 2012 and 2014. The mission of this Forum has been defined as implementing the



This project is funded by the European Union



action plan created by the Coordination Council, developing a data and information store on a website and supporting Swedish exports for smart grid products.

- **Self-Healing Grid:** In this project, new technology is installed in the DSO Öresundskraft's grid in the city of Helsingborg, to enable better fault detection and response. Two medium voltage loops are included in the project, with two different types of functionality. The new installations will limit the downtime of the grid when there is a fault, as the system automatically will find a new way for electricity to pass the fault or make location of the fault easier. This will reduce downtime for the customers and make more stable operation of the grid possible.
- **Power management in bus garage:** A new bus garage is being constructed in the city of Uppsala and it is foreseen that this would lead to a significant load on the power grid, and as Uppsala is experiencing capacity challenges, this might be an issue at times with power peaks. To cope with this situation, a project has been initiated to cooperate with close-by players such as *IKEA*, grocery retailer *ICA* and property owners in order to investigate the possibilities for flexibility in the area.
- **Continuous cable monitoring:** DSO Öresundskraft aims to decrease downtime that results from faults in medium voltage cables and in secondary substations. By installing partial discharge monitoring at select points in the network, the goal is to minimize both duration (SAIDI) and frequency (SAIFI) of downtime in the medium voltage grid as well as gaining knowledge about the health in their grid, which is vital when planning maintenance and reinvestments.
- **Dynamic line rating:** Around 2008, DSO Vattenfall started receiving an increased number of requests to connect large amounts of wind power to their grid. This was often to be done in areas where the grid is weak, and Vattenfall wanted to find a way to accommodate these connections in the existing grid.
- **Self-healing grid in Härryda:** Local grid operator Härryda energi aims to be a forerunner when it comes to smart grids, and one of their projects is a so-called self-healing grid. The technology is tested in an open 10 kV network loop, where there are seven network stations with cable sections between them. In each network station, there is equipment that monitors the cable, and automatically can re-route the power flow if there is a cable fault.
- **Accurate positioning of faults in the power grid:** DSO Skellefteå Kraft operates an extensive power grid in the north of Sweden that covers a substantial geographical area. In order to reduce the resources that are needed for fault detection, Skellefteå Kraft has opted to install a system that monitors the grid in real time, and automatically takes action when there is a deviation.
- The national research program is an important founder of the research of the Elektra Electrotechnical Institutes. The program is funded by the electricity energy industry and the Swedish Energy Agency through Elforsk, respectively. The program is worth a total of 80 million Krona from 2013 to 2017. The new phase in the Elektra program is to facilitate the transformation of the energy system in a sustainable direction, help reduce energy failures and contribute to a more efficient electricity grid and energy use. The Elektra program and the funding it offers are made public in all Swedish higher education institutions, and a large portion of the money goes to students researching electro-technology and related subjects.
- **Swedish Smart Grids and Energy Storage Centre (SweGRIDS):** SweGRIDS (Swedish Smart Grids and Energy Centre) is a national platform for research and development in the field of electrical energy engineering and storage. Its main partners include KTH, Uppsala University, ABB and Vattenfall. This is a 10-year long- term investment that began in 2011. Research programs have a strong connection with innovation projects



This project is funded by the European Union



launched by Swedish branches at KICInno Energy in smart grids and storage. SweGRIDs funds PhD research projects at universities and colleges.

- **KTH Access to Linnaeus Centre:** The Autonomous Complex Communication Network, Signal and Systems (ACCESS) is one of the leading research centres in Europe in networked systems. The centre has an annual research budget of 100 million Swedish kronor (110,000 euros) funded by the Swedish Research Council, the EU, VINNOVA, the Foundation for Strategic Research (SSF) and the Knut and Alice Wallenberg Foundation (KAW), and covers over 55 PhD researchers and more than 100 PhD students. The research areas it covers include cyber-physical systems, communication infrastructure, big data, network-based services, and security.
- **STandUP for Energy:** STandUP for Energy is a collaboration project among Uppsala University, KTH, Swedish University of Agricultural Sciences (SLU) and Luleå University of Technology. The main goal of STandUP for Energy is to reduce large-scale renewable electricity generation costs for consumers and develop cost-effective and energy-efficient hybrid and electric vehicles. STandUP for energy develops new technologies for efficient and flexible control of the power system, advanced flexible conversion systems and power transformers, along with the new design of traditional components to meet future demands in a more flexible energy system. Another area of development is small-scale electricity generation, central charging stations for electric vehicles and reliable distribution networks that allow energy storage and optimization of ICT infrastructure for new consumer services.
- **Northern European Power Perspectives (NEPP):** The Northern European Power Perspectives (NEPP) research programme brings a holistic approach to changes in electricity market, demand and electricity networks. Participants are KTH, Electrical Energy Systems, Chalmers, Sustainable Energy Systems and Electrical Engineering, Profu and Sweco.
- **High Voltage Valley (HVV):** HVV is a natural platform of cooperation in Ludvika; here, multinationals in the region, ABB, small companies in the region, Sweden's leading technical university colleges and public actors are collaborating to strengthen the region's position in the field of electrical energy transfer based on electrical energy engineering.
- Swedish electricity provider Borås Elnät will implement its grid modernization programme in the city of **Borås in Västra Götaland** County within the scope of the regulation. Under the terms, the utility will deploy Itron's Industrial IoT network, replacing existing meters with 46,000 smart electric meters to meet new functional requirements in Sweden. With the interoperable IoT network, it will be equipped to manage smart city applications like smart streetlights, smart parking and traffic management.
- **Strategy for EV charging:** Around 2015-2016, parking company Göteborg Parkering developed a strategy on how to meet a rising demand for vehicle charging in the city of Gothenburg.
- **Vehicle to grid in Kungsbacka:** The municipality of Kungsbacka is performing a project where vehicle to grid (V2G) technology is tested. As Kungsbacka is an area with a high penetration of solar power generation, the municipality wishes to utilize this environment friendly electricity as far as it is possible. To accomplish this, the batteries of the municipality's electric cars is used as an energy storage, and energy can be moved in time to smoothen the power usage in Kungsbacka.
- **Vehicle to grid in Örebro:** In the view of the public housing company in the city of Örebro, ÖBO, electric cars are to be seen as mobile Energy Storages. By installing V2G systems, where an electric car and its battery can act as a load or a source of electricity, the storing capacity of the car battery is utilized.



This project is funded by the European Union



- In 2016, DSO Vattenfall started the project **Low Voltage Monitoring**, where the purpose is to use data from the smart meters installed at Vattenfall's customers, to monitor the health of the low voltage grid. The project started as a test, but soon proved to be successful and today includes roughly 75-85 % of Vattenfall's meters. This is enough to monitor their entire low voltage grid.¹¹⁰

2.5.5.4 Smart Meters

Sweden is very much in the forefront of development as regards the installation of smart meters. Between 2004 and 2009, Sweden has introduced automatic meter-reading for all electricity customers. The consumption of major customers (>63A) is registered by the hour and for smaller customers every month. The electricity industry has adapted its systems to the new regulations and the administration of most of the meter readings is now done in a quality-assured way. This means that the price can be set by the hour for major customers and per month for smaller ones. Furthermore, all customers can now pay for their actual consumption retroactively and follow their consumption statistics on a monthly basis.

For Sweden, the first step to getting the customer to participate in a more efficient market was to increase consumption awareness. Increased customer awareness is an important element of the AMI / AMR spread in Sweden. When customers started switching from annual meter readings to monthly readings, they became more aware and worried about electricity usage. This encouraged consumers to participate in the next technology phase and market pricing stage, a more active retail market.

With the new legislative amendment in 2017, all electricity consumers can now request hourly metering without extra cost. In Sweden, the DSO is responsible for the registration and reporting of values. The DSO is obliged to report values in the common standard electronic data interchange format, upon request from the customer. If the customer has opted for hourly metering, the DSO must make the metering data available online. A timeline of the reform and the status of smart meters in Sweden is shown in Figure.

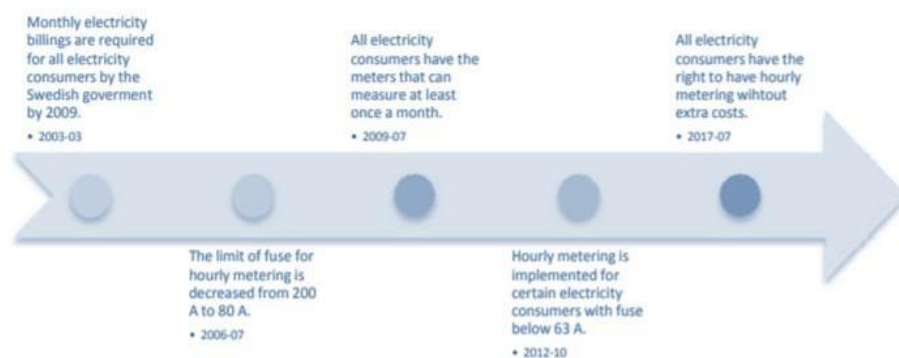


Figure 20: Timeline of the Development of Smart Meters in Sweden

The first regulation regarding smart meters was adopted in 2003, which required monthly metering for small consumers and hourly metering for larger consumers by 2009. This led to the roll-out of the first generation of smart meters in Sweden. The functionality of smart meters has since then evolved from automatic reading of data once a month to more frequent data measuring and remote control. Based on the lessons learned from the first roll-out of smart meters and on the development of functionality of smart meters, EI concluded that it is necessary to

¹¹⁰ <http://swedishsmartgrid.se/>



This project is funded by the European Union



develop minimum functional requirements for smart meters before the roll-out of the next generation. Ei presented a final proposal concerning minimum functional requirements for smart meters to the Government in November 2017. The proposed functional requirements focus on both providing more information to consumers to increase their interest in being active and more information to the DSOs to increase their efficiency. Furthermore, the proposal also states that the new functionality should be implemented in a way that protects consumer privacy and data security. The minimum functional requirements, which were then included in the ordinance for metering, calculating and reporting electricity, cover the following areas:

- Extended measurement,
- Registration of active energy every hour or fifteen minutes and power outages,
- Customer interface,
- Remote collection of 344 345 measured data and power outages,
- Remote updating of software, settings and control the power of the meter.

All the meters in the low voltage network should fulfil these requirements latest by 2025. Within the next few years, many of the current electricity meters in Sweden will be replaced, as they have reached their economic lifespan. Introducing minimum functional requirements for smart meters will ensure all consumers the same right to the technical solutions and data security, furthermore, it facilitates a fair competition among commercial developer

Over the years since the smart metering system became widespread, many DSOs have discovered that, besides the financial benefits expected in service delivery, they provide intangible benefits in service quality, customer satisfaction and increased safety. Better understanding of network behaviour and load model allowed network companies to make more strategic decisions about infrastructure updates and reduce the risk of assets being over-sized. Many future services, a platform for other smart grid technologies, will be enabled by the data and functionality of AMI.



This project is funded by the European Union



2.5.6 Recap of EU Countries

	United Kingdom	Germany	Italy	Spain	Sweden
Specific mechanisms to incentivize smart grids innovation ¹¹¹	Yes (adjusted within regulatory period)	Treated like other costs	Yes (adjusted within regulatory period)	Treated like other costs	Treated like other costs
Regulatory incentives to innovation activities	Low Carbon Network Fund (LCNF) included funds for trialling smart technologies in previous years. It was replaced with Network Innovation Competition (NIC), and Network Innovation Allowance (NIA), which are limited amounts. DNOs present their smart grid solutions in their businessplans. There are incentives in RIIO for smart solutions including DSR for efficiency and managing network loads and demands.	DSOs can apply for the cost recognition of R&D projects, and NRA is allowed to approve revenue adjustment in case projects receive public finance and DSO carries 50 % of the cost. Additional cost for SG is not approved by the NRA for the majority of projects.	Investment made in SG pilots selected by the NRA was treated in the same way as other investment but receiving a premium on the WACC (+2%) for 12 years. After 2015, output-based deployment projects started to be implemented.	Additional costs were not taken into account in the reference grid model. However, if DSOs get EU fund, 10% is added into the RAB. There is not any specific program /mechanism to fund SG pilots. Some basic R&D projects are partially financed in the national and European R&D programs. Current projects are fully funded by the companies developing them.	All assets that are used and needed in the network business are included in the RAB (for instancesmartmetersasCAPEX). Large scale projects with a character of a pilot project and financed partly by EU-funds might be classified as non-regulated business.
Fostering of innovation/R&D in regulation ¹¹²	Foster	Rather hamper	Rather foster	Rather hamper	Rather hamper

¹¹¹ Eurelectric, 2016, Innovation incentives for DSOs - a must in the new energy market development

¹¹² Eurelectric, 2016, Innovation incentives for DSOs - a must in the new energy market development





This project is funded by the European Union

	United Kingdom	Germany	Italy	Spain	Sweden
Funding	All (National (RIIO), EU, Private Funding) Mostly private funding before LCNF.	All but mostly National (e-energy) & Private Funding Integrated municipal energy suppliers and several federations provide funding	All but mostly EU, Private Funding. The projects under NRA regulation are financed by electricity tariffs and monitored by AEEG. Other projects have been launched by the Government through EC funding which is not monitored by AEEG.	National, EU, Private Funding. Subsidies are provided by Local Authorities and some Government institutions.	All but mostly EU, Private Funding.



This project is funded by the European Union



	United Kingdom	Germany	Italy	Spain	Sweden
Implementation of energy policies	DECC: responsible for high level policy making Ofgem: independent body, operating within the legal framework determined by the UK Government and the European Union. Incentives are introduced by Ofgem. DECC and Ofgem works in cooperation and established Smart Grid Forum in 2011. In terms of smart meters, the Smart Metering Implementation Programme is led by Department for Business, Energy & Industrial Strategy (BEIS), regulated by Ofgem, and smart meter delivered by energy suppliers. The Government's role includes developing smart metering policy and strategy, providing the right framework against which energy suppliers and network operators can plan, and ensuring benefits are delivered to consumers. Ofgem is responsible for the regulation (including monitoring, reporting and enforcement) of the licence obligations placed on energy suppliers and network operators to deliver smart meters. In due course, the Government's intention is that smart metering should be a self-sustaining system governed by industry and regulated by Ofgem.	There are 16 federal states with their own Governments. They have their own budget and they are independent to initiate their own projects and can prioritize different focus areas such as smart grids.	Ministry of Economic Development (MISE) defines the strategic lines and sets out general principles AEEG (NRA) has a significant role in development of smart grids, launched a competition-based procedure to incentivize smart grid/demand response projects	Ministry of Industry, Energy and Tourism develops legislative proposal and prepares national action/strategy plans in the process of developing Smart City in Spain, also approves the distributors' smart meter equipment and replacement protocols. CNMC (NRA) monitors development of smart grids.	Coordination Council and National Information Platform for Smart Grids, appointed by the Government promotes dialogue and cooperation by developing a national information platform and a national action plan for the development of smart grids in Sweden from 2015 to 2030. In January 2020, the Government commissioned the Swedish Energy Agency and the Energy Market Inspectorate (EI) to produce proposals on how the Forum's work can be taken further. In addition, EI has also monitors the compliance with the regulations



This project is funded by the European Union



	United Kingdom	Germany	Italy	Spain	Sweden
Any platform for smart grid	Smart Grid Forum	SmartGrids Baden-Württemberg	Smart Grids italia	FutuRed	Swedish Smart Grid Forum
Monitoring demonstration projects and roadmaps ¹¹³	All companies running projects must produce progress reports every six months. These reports must include the progress they have made against their project plan and the learning that the project has delivered in the previous six months. The company must also explain the activities that it has undertaken to disseminate the learning. All companies must also produce a comprehensive report following the conclusion of the project. These reports must explain how other parties can replicate the implementation and outcomes of the project. The consultation on the structure of these reports has recently been issued. Ofgem, Government, DSOs and the Smart Grid Forum are responsible for monitoring the route-map.	As part of the process for selecting which projects are funded, companies' approaches on progress reporting and disseminating learning are evaluated. High quality learning dissemination activities that either build on best practice from other demonstration projects or incorporate innovative approaches is expected.	For AEEG projects, a work progress report has to be sent by the involved DSOs to the NRA every six months. Thereafter, monitoring is through ad-hoc meetings and result dissemination	The NRA has limited information about demonstration projects, as it is not NRA's responsibility to monitor third party projects and agreements in which CNE is not an active member of the project.	Swedish Smart Grid Forum (established with the Government decision) follow up the implementation of the action plan for smart grids developed by the Coordinating Council for Smart Grids. (http://swedishsmartgrid.se/)
Incentives for OPEX related to innovation	Yes	No	No	No	No

¹¹³ CEER, 2014, Status Review on European Regulatory Approaches Enabling Smart Grids Solutions ("Smart Regulation")



This project is funded by the European Union

	United Kingdom	Germany	Italy	Spain	Sweden
CBA (for smart meters)	Positive	Negative	Positive	No CBA	Positive
Meter ownership and installation belongs to	Energy supplier	DSO or 3rd party meter operator	DSO	DSO	DSO
Considered market actors in smart meters rollout ¹¹⁴	Supplier Consumer State/Society	Supplier Consumer State/Society TSO Balance Responsible BRP Producer Independent aggregator	DSO Supplier NRA Consumer State/Society TSO BRP Telecom service provider	No CBA	DSO Supplier NRA Consumer State/Society
Market drivers for smart meter roll-out ¹⁰¹	Digitalize retail market to foster innovation and new services by private actors Support actions tackling fuel poverty	Enable dynamic tariffs for households and SMEs Digitalize distribution grid and optimize network operations Digitalize retail market to foster innovation and new services by private actors Integrate decentralized energy resources with flexible access (load shedding, infeed curtailment) Support actions tackling fuel poverty Support energy efficiency	Enable dynamic tariffs for households and SMEs Digitalize distribution grid and optimize network operations Digitalize retail market to foster innovation and new services by private actors Support actions tackling fuel poverty Support energy efficiency	Digitalize distribution grid and optimize network operations Digitalize retail market to foster innovation and new services by private actors Support energy efficiency	Enable dynamic tariffs for households and SMEs Digitalize distribution grid and optimize network operations Digitalize retail market to foster innovation and new services by private actors

¹¹⁴ EC, December 2019, Benchmarking smart metering deployment in the EU-28



This project is funded by the European Union



	United Kingdom	Germany	Italy	Spain	Sweden
Total smart meter penetration rate ¹⁰¹	19.9% (as of 2018)	Not available	98.5% (as of 2018)	93.1% (as of 2018)	100%



This project is funded by the European Union



2.5.7 Challenges and Barriers^{115 116}

Challenges and barriers related to development of smart grids in EU countries might be listed as follows:

- Incentives to encourage network operators to choose investment solutions that offer the most cost-effective solutions (e.g. In United Kingdom, capital efficiency requires that the DNOs employ the most cost-effective network development strategies.)
- Incentives to encourage network operators to choose innovative solutions/incentives for network operators to encourage efficient use of electricity and renewable electricity production (e.g. In United Kingdom, incentives are provided for the best innovation projects that help all network operators understand the measures needed to provide environmental benefits and security of supply for value for money. In Italy, the index used for selecting demonstration projects considers the benefits of increasing the renewable electricity supply and the reduction of losses.)
- Standards on smart grid stakeholders (e.g. In Germany, there is a differentiation between smart and conventional grids. There are special requirements for technical protection and communication between market partners using smart meters. Likewise, in United Kingdom, standards on smart grid technology are important for interoperability within a smart grid.)
- Active participation in the development of smart grids by stakeholders (e.g. In Spain, manufacturers will need to provide appropriate equipment and so will need to be more actively involved in a smart grid. Similarly, in Portugal, hardware and software developers will need to innovate as new services are offered to customers. In Italy, the level of stakeholder involvement will increase alongside smart grid development.)
- The roles and relationships of relevant stakeholders to encourage the introduction of new services or markets (In Germany, incentives must be created for some roles, for example aggregators and consumers. In United Kingdom, new stakeholder roles and relationships must be defined as new services are introduced in a smart grid.)
- The introduction of new tariffs to incentivise more efficient network use (e.g. In Finland and France, new tariffs are being developed with the advent of smart grids.)
- Unbundling that cause uncertainty about the responsibility regarding the smart grid investments (e.g. In Portugal, unbundling activities introduce new regulatory challenges since potential new services for smart grids will be provided by a combination of DSOs and suppliers.)
- Data protection, security (e.g. in Germany, there are strict data protection laws, which is a very sensitive area, especially for the end consumer and standardisation and here above all compatibility of ICT and appropriate processes for interfaces are barriers)¹¹⁷
- Lack of clear regulatory framework and existing complex regulation (e.g. in Germany after coming into force of the digitisation act legal, uncertainty relating to load management and dynamic pricing, 3rd Energy

¹¹⁵ CEER, February 2014, CEER Status Review on European Regulatory Approaches Enabling Smart Grids Solutions ("Smart Regulation")

¹¹⁶ Mc Kinsey, 2012, How Europe is approaching smart grid investments

¹¹⁷ Swedish Smart Grid, June 2018, SMART GRID MARKET ANALYSIS: GERMANY



This project is funded by the European Union



packages being mostly related with smart meters but not with other smart grid components, unclear incentive methods)

- Lack of customer demand and applications (e.g. in Germany, although technology is not a problem, there are not many electric vehicles or smart home applications are not common etc. This goes hand in hand with the fact that business cases are still lacking. In addition, there is lack of awareness and limited understanding in EU, related to smart grids)¹¹⁸
- Lack of EU-wise technical standards (e.g. different utilities might use different communication technologies)

2.6 Regulatory Approaches for Selected Smart Grid Components in EU

2.6.1 Key Performance Indicators Used by Regulatory Organizations

In order to measure and evaluate the effects of smart grids, some key performance indicators have been defined in the EU and the USA. In Europe, [the EU Working Group for Smart Grids](#) identified the outcomes of ideal smart grids and ideal smart grid applications in 2010, and measured the benefits achieved through some key performance indicators. On the other hand, the European Electricity Grid Initiative (EEGI) followed a different method and divided the ideal smart grid into thematic areas. The contribution of projects to progress in each thematic area and system level is analysed. There are some similar aspects between the two methods, and as a general approach, both methods first describe the characteristics of ideal smart grids in service or critical thematic areas, then identify key performance indicators to measure outputs and progress.

The table below lists the benefits and KPIs published by the EU Smart Grid Working Group ¹¹⁹:

Table 7: EU Smart Grid Key Performance Indicators

Benefits and KPIs	
	Increased Sustainability
1	Quantitative reduction of carbon emissions
2	Environmental impact of the electricity network infrastructure
3	Reduction of accidents and risks related to production technologies
	Adequate Capacity in Transmission and Distribution Networks to Reach Electricity to Consumers
4	Capacity for distributed energy sources in distribution networks
5	Maximum power that can be delivered to transmission networks without the risk of constraints

¹¹⁸Swedish Smart Grid, June 2018, SMART GRID MARKET ANALYSIS: GERMANY

¹¹⁹Assessing Smart Grid Benefits and Impacts: EU and US Initiatives, Joint Report EC JRC - US DOE, 2012



This project is funded by the European Union



Benefits and KPIs	
6	Energy that cannot be withdrawn from renewable energy sources due to constraint and/or security risk
7	Optimized use of capital and assets
Adequate Network Connection and Access for All Network Users	
8	Initial connection fees for producers, consumers, and both
9	Network tariffs for producers, consumers, and both
10	Methods used to calculate tariffs and prices
11	Connection time for the new user
12	Optimization of new equipment design that gives the best benefit / cost ratio
13	Faster innovation with clear / open standards
Adequate Level of Security and Supply Quality	
14	The ratio of reliable available production capacity to peak demand
15	Electrical energy rate produced from renewable energy sources
16	Measured satisfaction of network users regarding the network service they have received
17	Power system stability
18	Frequency and duration of downtime per customer
19	Voltage quality performance of electrical networks (e.g. voltage and frequency deviations)
Increased Efficiency and Better Service in Electricity Supply and Network Operations	
20	The level of transmission and distribution network losses. Storage reduces losses but active flow control increases losses
21	The ratio between minimum and maximum electricity demand in a given time period
22	% Use of electrical network components (e.g. average load)



This project is funded by the European Union



Benefits and KPIs	
23	Demand side participation and energy efficiency criteria in the electricity market
24	Availability of network components (planned and unplanned maintenance) and their impact on network performance
25	Actual availability of grid capacity according to standard values (e.g. distributed energy sources, net transfer capacity in transmission networks)
Effective Support of International Electricity Markets and Increased Interconnection Capacity with Load Flow Control	
26	The ratio of interconnection capacity of a country / region to electricity demand
27	Maximization and utilization of interconnection capacities, particularly in accordance with electricity cross-border trade regulations and constraint management guidelines
28	Constraint leases between interconnections
Coordinated Network Development with Common European, Regional and Local Network Planning for Optimization of Transmission Network Infrastructure	
29	The impact of constraints on outputs and prices in national / regional markets
30	Social benefit-cost ratio of proposed infrastructure investments
31	Total welfare increase (e.g. always running the longest production facilities to meet actual demand)
32	Time required for licensing / authorization of the new electricity transmission infrastructure
33	Time required for the construction of the new electricity transmission infrastructure
Increased Consumer Awareness and New Players' Participation in the Market	
34	Demand side participation in the electricity markets and energy efficiency
35	Percentage of customers using timed usage / critical peak / real-time dynamic pricing
36	Change of electricity consumption patterns after new pricing mechanisms
37	% ratio of users with intermittent load behaviour
38	Percentage of demand participation in market-based designs for demand flexibility



This project is funded by the European Union



Benefits and KPIs	
39	Percentage of participation in ancillary services at low voltage level
Informing Consumers in Decisions to Meet EU Energy Efficiency Targets	
40	Base / Peak Load Rate
41	The relationship between energy demand and electricity market price
42	Understanding of actual energy consumption and freely requesting of data by customers
43	Consumers can request past energy consumption information free of charge and in a way that can compare between options in the market.
44	To be able to participate in the relevant energy market for the purchase and sale of electricity
45	Establishing an easily understandable link between energy prices and consumer behaviour
Establishing Market Mechanisms for New Energy Services such as Energy Efficiency or Energy Consultancy to Customers	
46	Simple and / or automatic changes in consumers' energy consumption with the formation of demand / response signals
47	Clear identification of data ownership and determination of data processes
48	Accessibility of data related to physical network
49	Physical connection authorization, requirements and fees being transparent
50	Effective handling of customer complaints
Decreasing Pressure on Decreasing or Increasing of amount on Consumer Invoices	
51	Transparent and healthy processes for evaluating the benefits of application exceeding costs in the regions where the installation takes place
52	Regulatory mechanisms reflecting benefits to consumer invoices
53	New smart tariffs that provide tangible benefits to the customer or community
54	The market design is compatible with consumers' network usage

2.6.2 Regulations Regarding Smart Metering

2.6.2.1 Smart Metering in EU Legislation¹²⁰

Various Directives and smart meter regulations were published till now both at EU and national level. The following figure shows the regulatory developments in EU. As it was mentioned in brief in smart grid legislation development section, Directive 2006/32/EC²⁰ on Energy End-Use Efficiency and Energy Services suggested that appropriate billing information should be provided to consumers via competitively priced individual meters that reflect their actual consumption in order to enable them to regulate their energy consumption



Figure 21: Development of Smart Meter Legislation in EU

The Third Energy Package (2009/72/EC) required the implementation of smart metering systems for the long-term benefit of consumers of Member States. This practice was based on a CBA which are expected to be completed by September 3, 2012.

The Commission Recommendation 2012/148/EU²³ on the preparation for the roll-out of smart metering systems of 9 March 2012 made the definition of smart meters and provided guidance to Member States on the design of smart metering systems to ensure the protection of personal data. In addition, a set of common minimum functional requirements for smart metering systems for electricity were listed in order to make them fit for purpose and help secure consumer benefits and increases in energy efficiency.

Together with the Directive 2012/27/EU²⁴ on energy efficiency, the energy saving target was updated to 20% by 2020. Additional instructions on the deployment and on the minimum common features of smart metering systems as well as on data protection and privacy of final customers were also provided. The Energy Efficiency Directive which is in line with these developments and realized the provisions in the Third Package¹²¹, supports the development of energy services based on data from smart meters, demand response and dynamic prices¹²².

¹²⁰REPORT FROM THE COMMISSION Benchmarking smart metering deployment in the EU-27 with a focus on electricity /*COM/2014/0356 final*/

¹²¹ Energy Efficiency Directive (2012/27/EU).

¹²² 'Demand response' is to be understood as voluntary changes by end-consumers of their usual electricity use patterns - in response to market signals (such as time-variable electricity prices or incentive payments) or following the acceptance of consumers' bids (on their own or through aggregation) to sell in organized energy electricity markets their will to change their demand for electricity at a given point in time. Accordingly, demand response should be neither involuntary nor unremunerated. (Staff Working Document 05.11.2013).



This project is funded by the European Union



Directive 2014/32/EU²⁶, on the other hand, harmonizes the national laws for making available on the market measuring instruments and Commission Recommendation 2014/724/EU²⁹ on the data protection impact assessment template for smart grid and smart metering systems provides guidance to Member States on the use of this DPIA Template to help ensure the fundamental rights to protection of personal data and to privacy in the deployment of smart grid applications and systems and smart metering roll-out.

Within the scope of the Directive 2014/94/EU³⁰ on the deployment of alternative fuels, it is stated that the recharging of electric vehicles at recharging points accessible to the public shall, if technically feasible and economically reasonable, make use of intelligent metering systems.

In 2014, a first benchmarking report was presented by the European Commission, presenting the CBAs' outcome. As of July 2018, all but two Member States have conducted at least one CBA for a largescale rollout of electricity smart meters to at least 80% by 2020, with the results for most of these being positive.

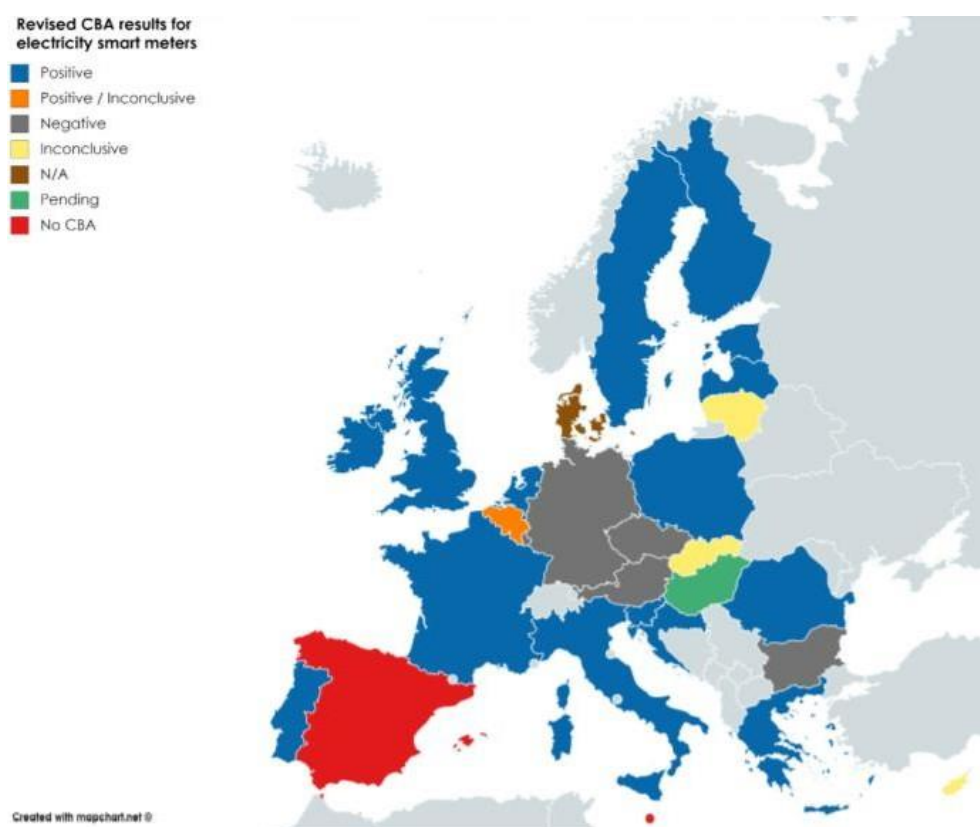


Figure 22: Revised CBA Results Electricity Smart Meters Considering a Large-Scale Rollout to at least 80% by 2020 (as of July 2018)¹²³

Costs considered within the scope of CBA analysis included CAPEX (investment in smart grid, investment in IT, investment in Telecom, investment in in home display, sunk cost of conventional meters) and OPEX (IT maintenance, network management and front end, telecom, change management, unplanned renewal and failures

¹²³ Tractabel, Engie, June 2019, European smart metering benchmark



This project is funded by the European Union



of smart meter, revenue reduction, meter reading, call centre and customer service, consumer engagement program).

On the other hand, benefits have been bill reduction due to energy efficiency, bill reduction due to dynamic pricing, provision of explicit flexibility services, increased competition in retail market, easier access to photovoltaic production, meter reading & operation savings, operation & maintenance of assets, distribution capacity deferral, transmission capacity deferral, generation capacity deferral, technical losses reduction, non-technical (administrative, including fraud) losses, outage management (based on societal value of lost load), outage management (based on reduced customer indemnification), CO₂ and air pollution. Not all of the countries used all of the cost or benefit items in their study.

As of 2018, 33.83% of all electricity metering points were equipped with a smart meter (ca. 99,080,000 smart meters). Taken separately, households' electricity metering points and SMEs metering points were equipped at 34.5% and 27.52%, respectively.

Recently in 2019, new Electricity Directive (2019/944/EU) was published, updating and putting forward some provisions that are of direct relevance to smart metering and its use as a tool for demand-side management and flexibility.

2.6.2.2 Meter, Tariff, Unit Price

Value of smart meters for energy systems and consumers: The following table shows some information about the cost and benefit of smart meters, which was taken into account within the scope of CBA performed in 2018.

Although there are differences due to the differences in basic distribution parameters, available data show that a smart metering system can cause customer an average cost of €200-€250. The cost per measuring point ranges from €38 to €546.

Table 8: Key Electricity CBA Parameters

	Range of Value	Average
Lifetime	8 to 50 years	16±8 years (71%)
Evaluation period	8 to 50 years	22±13 years (60%)
Costs per metering points	€38 to €546	€211 ± €117 (57%)
Benefits per metering points	€19 to €493	€216 ± €150 (46%)
Energy savings	5.42% - 7.85%	N/A

On the other hand, TOTEX considered in the CBA in 2013 and 2018 are as follows for the selected countries:

Table 9: Costs and Benefits per Meter



This project is funded by the European Union



	TOTEX (€/meter) in 2018	TOTEX (€/meter) in 2013	Benefit (€/meter) in 2013	Benefit (€/meter) in 2018
UK	232	161	352	377
Italy	97	94	176	176
Germany	546	546	493	493
Sweden	288	288	323	323
Spain	120	-	105	-

Smart metering systems are expected to save €309 in electricity and provide a total energy saving of 3% for each user in total. Savings value varies among countries. It has been stated that Finland and Sweden have 1-3% energy savings among the countries that have completed the deployment of the smart metering system.

2.6.2.3 Progress on Smart Metering in EU-27 ¹²⁴

Analysis shows that significant progress has been made. Sweden, Finland, Italy, Estonia, Malta, Spain and Denmark have already a wide-scale roll-out for electricity in place today. Most countries will reach such a wide-scale roll-out (to at least 80 % of the consumers) in the period 2020-2025. About one third of the Member States will roll-out smart meters by 2030 or later, as their latest CBA is still negative. According to the recast Electricity Directive¹⁸, these Member States will have to perform a CBA every 4 years. Once the result of the CBA is positive, at least 80 % of the final consumers shall be equipped with smart metering systems within 7 years from the date of the positive assessment.

¹²⁴ European Commission DG Energy, 2018, European Smart Metering Benchmark



This project is funded by the European Union



Figure 23: Electricity Smart Meters Deployment Strategy Foreseen by the Manufacturer Landis+Gyr

In January 2018, 33.83% of all electricity metering points in the EU-28 were equipped with a smart meter (ca. 99,080,000 smart meters). Taken separately, households' electricity metering points and SMEs metering points were equipped at 34.5% and 27.52% respectively. By 2020, based on the originally announced rollout plans 127,593,300 additional smart meters were to be installed within the EU-28 (setting the total number of smart meters to ca. 226 million). That would correspond to a penetration ratio of electricity smart meters of ca. 78%. In 2018;

- 2 Member States did not perform a CBA or were unable to provide the suggested information to compute comparable indicators, namely Bulgaria and Hungary, neither in 2014 nor in 2018.
- 8 Member States did not update their initial CBA: Denmark, France, Germany, Netherland, Malta, Romania, Slovakia and Sweden.
- 4 Member States have performed their first CBA that occurred after the publication of the first benchmarking report (2014): Croatia and Cyprus show a positive result, while costs took over benefits in Slovenia and Spain.
- Member States that have updated their CBA may have found different results than the initial one: in Latvia and Lithuania, the new CBA produced a positive result; while the contrary happened in Austria and Luxembourg (for both countries the estimated benefits in the updated CBA accounted for only ca. 10% of the benefits estimated in the initial CBA). In spite of the negative outcome of their revised CBA, these two Member States are still pursuing the smart meters deployment process.



This project is funded by the European Union



- In Czechia and Belgium, an updated CBA has confirmed the initial negative result, while the remaining 8 Member States (Estonia, Finland, Greece, Ireland, Italy, Poland, Portugal, UK) confirmed their initial positive assessment of smart metering deployment.
- In 2018, in five member countries (Austria, Bulgaria, Czechia, Germany, Luxemburg), CBA reports on the widespread usage of smart meters by 2020 have concluded negative. However, smart meters were found to be economical for certain customer groups in some countries.
- In most Member States, a legal framework has been established to regulate issues such as legislation and timelines or technical specifications for smart meters on electricity.

2.6.2.4 Electricity Meters Ownership and Information Retrieval

- In 15 of the 16 member countries that decided to continue the large-scale smart metering system roll out process, distribution system operators (DSO) undertook the ownership of the meters and the information retrieval systems, to be financed from the network tariffs. In UK ownership belongs to energy supplier.
- The information retrieval in four Member States (Denmark, Estonia, Poland and the UK) will be carried out by independent information transfer centres.
- A similar picture indicates that in countries where roll out of smart metering systems has not begun by 2020, except the Czechia, Germany and Slovakia, alternatives can be regarded for data retrieval and ownership and DSOs may be responsible for implementation, ownership and data processing.

2.6.2.5 Minimum Specifications Expected from the Smart Meters

Smart metering systems should be carefully designed and basically have the following functions:

In order to ensure technical and commercial interoperability or to add functionality at a later stage, it must be equipped with appropriate functions in accordance with standards and recommendations in Commission Recommendation 2012/148/EU¹²⁵. These are;

- There must be a guarantee of information security and confidentiality;
- Should improve demand-side management and other energy services;
- It should support retail markets that fully benefit consumers and the energy system.

The minimum specifications of smart meters are listed below;

1. Provide direct readings to the consumer and any third party determined by the consumer,
2. Frequently update the readings in Article 1 to allow the use of information to save energy,
3. Allow the meters to be read remotely by the grid operator,
4. Provide bidirectional communication between smart metering system and external networks for maintenance and control of the metering system,
5. It should allow frequent readings for information to be used for network planning,

¹²⁵ Commission Recommendation 2012/148/EU, OJL73, 13.3.2012, p.9;



This project is funded by the European Union



6. Support advanced tariff systems,
7. It must allow remote opening/closing of the supply and/or flow or power limitation,
8. Provide secure data communication,
9. Ensure fraud prevention and detection,
10. Provide import / export and reactive measurement

8 Member States has reported that they have rolled out and expanded smart metering in electricity in large scale up until 2020, in compliance with recommendations in the 2012/148/EU Recommendation.

Frequency of updating consumption data and making use of this data by consumers and third parties is the most difficult function of smart metering systems. This functionality will support consumers with direct feedback on costs, thus making it easier for consumers to make informed choices about their consumption and will also develop new retail services and products to be offered. It has been determined that the smart metering system does not comply with this functionality in seven of the member countries who increased usage of smart meters until 2020 and in three member countries that did not expand smart metering. If the smart metering system fails to provide this functionality, member countries should make sure that this functionality can be added later or that this functionality can be met by other settings.

There is no direct link between the common minimum functionality range considered for the smart metering systems to be used and the total cost. In other words, choosing fewer items from the common set of minimum functionalities does not necessarily mean that they will be cheaper systems. Indeed, the difference in 'cost-per-point' data among Member States shows that total investment is more affected by other parameters. These are;

- Initial conditions;
- Local labour expenses;
- Geographical structure;
- Additional features beyond the minimum set of functionalities,
- General scenarios, discount rates and evaluation periods in the relevant CBAs.

This creates a challenging situation for the full implementation of the minimum functions from the beginning. If the Member State's CBA does not support this approach, it is strongly recommended to ensure that the systems to be deployed can be upgraded to support at least 'smart' services and products in the future. Choosing a non-optimal, non-flexible, non-upgradeable system will then lead to higher costs when significant changes or a complete replacement are required.

For now, only a few Member State guidelines have been set on the functional requirements of smart metering systems. Others leave the analysis of the options to the parties responsible for the delivery, mostly to the distribution system operators, without setting clear incentives or conditions for functionality that also benefit consumers.

Standards and measures for data protection and security are key to understanding the full potential of smart meters in the EU.



This project is funded by the European Union



Consumer privacy must be protected when accessing data to manage the internal energy market's business processes. Therefore, they must provide the protection of personal data rights secured by Article 8 of this legislation. As a result of the studies conducted so far, the following concerns about privacy have been identified:

- The risk of creating user profiles through high frequency data reading, i.e. the risk of gathering sensitive information about the end user's energy footprint,
- Access to information without complying with privacy policies which are put in place to protect confidential data.

Lessons learned from pilot programs and operational experience

Based on the experience gained from pilot programs completed or ongoing to date, the following points should be taken into account when planning the roll out of smart meters:

- To benefit from the widespread implementation of smart meter infrastructure:
 - Using existing standards and correct functions to ensure technical and commercial interoperability, guarantee data confidentiality and security, and provide full benefits to consumers and the energysystem;
 - Assessing the need for a specific system, such as data privacy and security, under national and EU legislation, prior to the roll out of the system;
- Attracting the consumer from the very beginning into the process:
 - Establishing a communication strategy and information campaign;
 - To gain consumer trust and belief; it is important for consumers to understand what data is being transferred and how to access it;
 - Using metering data to provide feedback to the customer and to allow the development of new products and customer-oriented services;
 - Offering appropriate, user-friendly tools, mechanisms and attractive incentives to reward consumer participation;
- Take measures to encourage all stakeholders to accelerate the development and procurement of smart metering products and services;
- Take measures to ensure timely development, implementation of the legislation, or reassuring grid operators in investing in smart meter technology and improving related services;
- To ensure that experience that is gained in techno-economic issues, in the wide metering roll outs, consumer participation and market developments of smart metering services are taken into account in ongoing small-scale product roll outs or best pilot practices.



This project is funded by the European Union



2.6.2.6 Gas, Water, Electricity Joint Smart Metering

Directive 2014/32/EU¹²⁶ - European Union legislation on sale and commissioning of measuring instruments has two main objectives:

1. To determine the basic conditions that any device or system with a measuring function must meet;
2. To provide a high level of public protection.

The Directive establishes uniform rules for the sale of measuring instruments. Legally controlled measurement tools are used for various measurement tasks in the areas of public health and safety and fair trade.

2.6.3 Legislation on Energy Storage Systems

Electricity storage development has not been considered a priority for the energy system in the past, as the benefits of storage in a fossil fuel-based electrical system are limited and emerging technologies are not economical for large-scale storage. Storage solutions have become an important cornerstone in the energy system, with rapid advances in new technological solutions (e.g. batteries and hydrogen) and an increasing share of variable renewable energy. The EU supports R&D, related to storage through various initiatives, particularly in the SET Plan, Fuel Cells, Smart Grids and Hydrogen JUactivities.

The Energy Storage meeting held by DG ENER in 2015 contributed greatly to the discussions about the future of the energy storage area, and in general, it was concluded that the market and its regulatory framework lags behind the technological progress and needs. A number of obstacles have been identified, such as access to networks, double / excessive network charges, or inability to interact with value streams with other sectors (industry, agriculture, etc.). The wide variety of issues identified suggests that the further development of the regulatory framework and market mechanisms of storage is needed for a full contribution of storage space to a cost-effective energy system.

The information and opinions included in the results of the "Regulation on Energy Storage Issues" workshop held in Brussels on 1 June 2016 by the Expert Group EG3, which focuses on the "Regulatory recommendations for the spread of the smart grid" of the Smart Grids Working Group established by the European Commission were reported. However, these information and opinions are not yet official and may not reflect the position of the European Commission.

According to the report, all participants agreed that technology is advancing, and prices are falling, but regulation continues to hamper the development of energy storage. All stakeholders requested a common definition of "energy storage" and a clear set of roles and responsibilities to draft.

The European Commission and regulatory agencies have recognized that many regulatory problems hinder the development of the energy storage area, and the most important are:

- Unclear rules for ownership;
- Unclear rules for accessing thenetwork;

¹²⁶ Directive 2014/32/EU - rules relating to the making available on the market of measuring instruments and COMMISSION DELEGATED DIRECTIVE (EU) 2015/13 of 31 October 2014 amending Annex III to Directive 2014/32/EU of the European Parliament and of the Council, as regards the flowrate range of water meters. It repeals Directive 2004/22/EC with effect from 20 April 2016.



This project is funded by the European Union



- Energy storage, which is not taken into account in network planning due to the lack of incentives for TSOs and DSOs to do so;
- Uncertainty about network fees and charges;
- Lack of markets for services provided to the network.

Regarding ownership, all participants agreed that primarily energy storage is a market activity, but network operators should not be prohibited from owning and using storage facilities under exceptional conditions strictly defined by national regulatory agencies.

However, no consensus has been reached on the following issues:

- How should the energy storage area be taxed?
- Should support plans be used for energy storage activities?
- Does it require a specific regulatory framework?
- Is a certain class of assets required for energy storage?

On the one hand, it is claimed that Renewable Energy Sources (RES) and energy storage complement each other, so energy storage should benefit from the same support that RES has experienced in the past, while on the other hand, it is considered that the RES support disrupts the power markets and therefore the expansion of energy storage should not follow the same path.

The European Commission is working on storage solutions and to support energy storage;

- In June 2016, "definitions and principles"¹²⁷ and
- In February 2017, 'Energy storage - its role in electricity'¹²⁸

He published two Working Papers. These documents provide information about the role of energy storage with electricity, offer the advantages of different technologies and innovative solutions in different contexts, and discuss possible other policy approaches, set out definitions and principles.

Definitions and Principles

High-level principles for the future framework for storage need to be defined to support optimal investments in energy storage. These investments should be based on market income rather than subsidies and be activated with predictability and be allowed to build on the various value streams offered by storage facilities (e.g. network balancing services, avoiding restriction of variable production, de-carbonization).

Development and financing of energy storage can be based on the following principles:

¹²⁷ EC Report: Proposed definition and principal for energy storage. June 2016 <https://ec.europa.eu/energy/sites/ener/files/documents/Proposed%20definition%20and%20principles%20for%20energy%20storage.pdf>

¹²⁸ EC / SWD (2017) 61 Final Report: Energy Storage-the role of electricity.1 February 2017 http://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf



This project is funded by the European Union



- Energy storage should be developed to the extent that the total cost of the energy system with new storage capacity is lower than that of the non-storage system.
- Regarding the electricity grid, energy storage should be rewarded for peer-based services which are provided through demand-side management or flexible production by alternative suppliers.
- Contribution of energy storage as a supportive tool for the integration of variable renewable energy, electricity grid or other economic sectors to increase energy security and de-carbonization. The costs to avoid due to the reduction of variable renewable energy and the carbon reduction of spare capacities, large-scale energy storage can support the development of the business area.
- When a generator or consumer chooses to integrate a storage plant in its place, this should not lead to less positive treatment in terms of obligations or ultimately supporting the energy system, should be supported by R&D projects in practice of the Energy Union and gradually should be deployed as a supporter for the renewable energy integration and more cost-effective energy market.

In 2019, the New Electricity Market Directive was published as stated in previous sections. The directive aims to reduce barriers to energy storage, and mandates non-discriminatory and competitive procurement of balancing services and fair rules in relation to network access and charging. The directive has adopted a wide definition of energy storage, encompassing both reconversion to electricity or conversion into another energy carrier. Energy storage is also recognized as a distinct asset class, separate from generation.

There are also provisions entitling TSOs and DSOs to own and operate storage assets under certain circumstances which might result in narrower or broader markets for storage services offered by independent storage operators in different Member States.

Role of Energy Storage in Electricity:

Energy storage is an important component in providing flexibility and supporting renewable energy integration in the energy system. It can balance central and distributed electricity generation, but also contributes to supply security. Energy storage will have a complementary effect on demand side management, flexible generation and network development. Energy storage can also contribute to de-carbonization of other economic sectors and support increased share of the integration of variable renewable energy in transportation, buildings or industries.

Therefore, energy storage can have a comprehensive impact on the implementation of the Energy Union, especially with its contribution to the domestic market and de-carbonization aspects. The role of energy storage with electricity, which technologies and innovative solutions appear more appropriate for different purposes, and possible policy approaches are evaluated within the framework of clean energy for all Europeans.

The Market Design Initiative offers a framework for a suitable playing field for all flexibility solutions in the power grid. At the same time, the Renewable Energy Directive supports energy storage to integrate renewable energies in relation to consumers' right to electricity generation and self-consumption, as well as non-biologically fuels. In addition, this document provides a consistent basis for future initiatives and thoughts on the integration of renewable electricity into other economic sectors and an overview of existing energy storage technologies that have improved significantly in recent years.

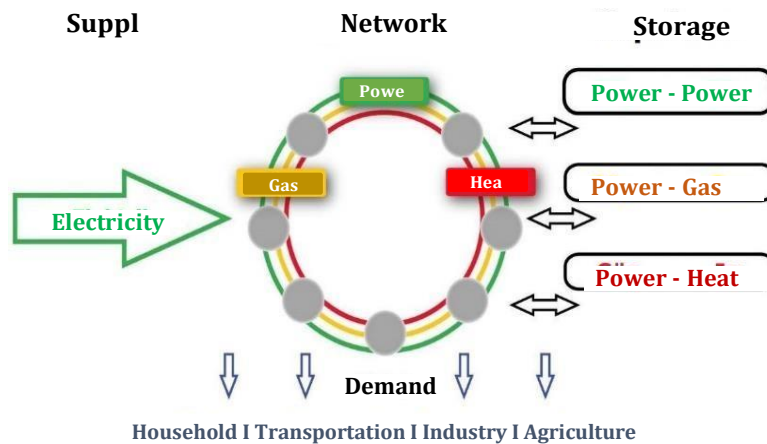


Figure 24: Energy Storage; Flexibility Components in the Electrical System

Today, pump-hydraulic storage represents the most mature technology however, batteries, compressed air, heat storage and hydrogen contribute to the electricity grid and energy system with an increasing amount of services. It is necessary to determine which solution of a storage technology can provide the optimal set of services in a defined location. Several different storage technologies have evolved rapidly in recent years, but more advanced technological progress and cost competitiveness continue to be necessary for large-scale dissemination. Therefore, the development of storage technologies is an important component of the "Strategic Energy Technology Plan" and is also defined as the main priority of "Communication on Accelerating Clean Energy Innovations". It can reduce excessive price fluctuations with increasing amounts of electricity storage by making market regulations that allow the energy storage system to contribute effectively to the energy system. Storage practices in the EU-level energy system will need to be harmonized, as it will support an EU-level energy market and move into integration with other energy markets. The proposed market design initiative should introduce a number of elements that will facilitate investments in energy storage to the electricity markets. Investments should rely on market revenue instead of subsidies, better predictability should be provided in relation to contract services, and storage facilities should be allowed to be structured in various value flows (for example, ancillary services including network balancing services, avoiding the restriction of variable electricity, de-carbonization of other sectors). Innovative technologies currently under development will benefit from efforts to bring these new solutions to the markets, taking into account the maturity of technology and relevant Government aid rules. Storage, along with other resources such as demand-side management, should be considered at both the transmission and distribution level in network planning. Access to the network connection must be provided by the network operator as for other flexibility solutions. The market must remove regulatory and administrative barriers for the establishment and operation of storage facilities. In the context of participation in energy markets, a suitable playground must be created for storage operations across EU-wide storage. Storage operators should be allowed to provide multiple services to electrical system operators and also participate in other commercial activities with other economic actors (e.g. the chemical industry). Some special services provided to network operators by storage facilities can be seen as an alternative to network expansion and this should be reflected in investment analysis. Storage services should be traded in competitive markets, where new flexibility products will provide market value that reflects the system benefits of storage space. In accordance with the market design initiative proposal, owners of storage facilities must be independent of network operators, with clearly defined exceptions.

Finally, an integrated approach will be needed to allow energy storage to play an effective role in relation to other economic sectors. Various mechanisms can support markets for integrated solutions such as power for gas or



This project is funded by the European Union



liquids, power for heat or integration of variable renewable electricity as raw materials (e.g. refinement, fertilization, transportation) in transportation or industry. Such solutions will support de-carbonization in various economic sectors as well as provide additional economic opportunities for energy storage.

Energy storage has not yet improved its full potential in energy markets. This is because; on the one hand, some technologies were not widely developed, on the other hand, the regulatory framework was not in a position to accommodate new flexible solutions. Support for electricity generation, regulated prices and green certificate fees has affected the development of energy storage. What's more, energy storage faced many different regulatory frameworks among Member States with market inefficiency as a result of this fragmentation. There is no consistency among Member States in intervening in storage in the energy system. For example, storage facilities in several countries have been subject to network fees, both as consumers and generators, in other countries only as generators or with other special regimes. In some cases, the total cost of the electricity system will be reduced by decreasing administrative loads and making it possible to access non-discriminatory networks for energy storage. New legislative proposals for market design in the context of clean energy for all Europeans¹²⁹ support the cost-effective use of energy storage solutions, covering aspects of the energy markets, regulatory framework, system planning and specific technical aspects.

So far, the energy storage option has not always been adequately considered in the context of electrical system planning. The market design initiative addresses this issue, with particular emphasis on storage, as an element of distribution system planning. The market design initiative proposal also comes with a series of general provisions that will be beneficial for energy storage.

Improving cross-border trade and trading shorter periods will better reward the flexibility provided by storage space. The proposed dynamic pricing agreements should further improve the energy storage market. Similarly, consumers' right to generate and consume their own electricity can lead to increased demand for storage services and small-scale storage solutions. In addition, recognition and support of demand aggregators should encourage the wider and more efficient use of storage facilities. Storage can also be used in a range of areas, from participating in capacity markets to providing de-carbonization backup capacities. These can be achieved in the context of the growing share of renewable electricity, the main driving force of energy storage. The improved cost and performance of energy storage should also increase its use for ancillary services and balancing. Moreover, early storage business areas are likely to be found in intraday markets, where trade volume is much higher, with the spread of renewable energy sources.

In addition, in Europe, deeper research is needed to clarify the definition of electrical energy storage, create new markets for ancillary services, design technological-natural-neutral market rules and further explore the necessity of electrical energy storage¹³⁰.

By ENTSO-E, Energy Storage is defined as follows:

"Energy Storage means a device used to store energy and can be used to balance the system".

¹²⁹<https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition>

¹³⁰ EPRG Working paper 1614 (2016) "Overcoming barriers to electrical energy storage: Comparing California and Europe" by F. Castellano Ruz and M.G. Pollitt



This project is funded by the European Union



The European Association for Storage of Energy (EASE) has proposed the following definition, stating that the other definition restricts the storage systems' frequency control, black-start capacity, island mode operation and fast synchronization capabilities, and prevents participation in ancillary services:

"An electrical storage facility for the electrical vector is a facility used to absorb and store electricity from different types of energy. The release of this energy over a controlled period of time may take the form of electricity, gas, thermal energy and other energy-bearing forms".

Developments in energy storage systems and Important Projects;

Grid-connected energy storage systems are seen as promising solutions to provide ancillary services to power grids and play an important role in the development of smart grids. Up until now, as 99%,¹³¹ HEPPs with pump storage have been installed as energy storage systems, more advanced battery technologies have been installed in pilot projects and studies have indicated their main advantages and shortcomings. The expected developments according to the current state of storage technologies and time zone are given below.

Table 10: Main Developments in Storage (Technology Priorities)

Past and Present	Short Term	Medium / Long Term
Pump Storage HEPP	Innovative Pump Storage HEPP	Advanced Pump Storage HEPP
Batteries	Batteries	Hydrogen
		Advanced Batteries
		Thermal Storage (local level and Concentrated Solar Plant (CSP) technology

The main concern of generally accepted technologies is overall cost, limited charge cycle (or lifetime), discharge depth, low energy density and sustainability of materials used. Vanadium Redox Flow Batteries (VRFB) is a promising option to alleviate many of these shortcomings, and pilot projects using this technology are implemented both in Europe and in the United States¹³². In the study using MATLAB / Simulink, it can be shown how a VRFB based storage device can provide ancillary services by focusing on frequency regulation and peak shaving functions. The study offers a storage system in the medium voltage transformer centre and demands a small network load profile and fast charging stations caused by the residential site. This model also includes an inverter controller that provides a clear power output from the battery system so that it can deliver both services at the same time. Simulation results show that the VRFB storage device can effectively regulate frequency when performing peak shaving services due to the rapid response time. VRFB potential in network-connected systems is being discussed to raise awareness of decision makers, especially when identifying key challenges for wider application of storage systems, particularly in connection with market structure and standardization requirements.

¹³¹ The future role and challenges of energy storage (DG ENER Working Paper)

¹³² <https://ec.europa.eu/jrc/en/publication/smart-grid-energy-storage-controller-frequency-regulation-and-peak-shaving-using-vanadium-redox-flow>



This project is funded by the European Union



Germany as an Example¹³³:

In Germany, storage capacity is mainly provided through large pumped hydro storage facilities, but there are only few new investments. In this regard, battery storage is of interest in the market with new technologies such as power-to-hydrogen and other 'power-to-x' applications.

In Germany, there are two different use cases for battery storage being residential solutions, mostly in combination with PV systems, and large scale or industrial systems, which either secure electric supply for large consumers, provide reserve control or ancillary services, or a combination thereof. At present, more than 20 large scale battery storage systems (1 MW to 48 MW) are operating in Germany, and several large-scale systems are expected to be commissioned in the next 24 months. On the residential side, around 385 MW of battery storage has been installed to date.

The key driver for the development of energy storage in Germany is the Energy Transition (Energiewende) and the ambitious national renewable energy targets. In addition, electric vehicles (EVs), e-mobility and charging infrastructure are also increasingly driving progress in energy storage solutions. However, there are some commercial and regulatory challenges faced. Those are;

- Storage facilities' being treated as consumers when drawing electricity and consumption's being subject to several taxes, levies and charges, paid by the end consumer
- The regulatory framework's being highly complex and requires case-by case consideration, especially when a device is supposed to be operated in multi-use scenarios.
- The uncertainty regarding price forecasts on the Central European balancing market for large-scale battery storage facilities.

The need for fast and flexible storage systems will further increase in the near future, as base-loaded power plants (e.g. coal-fired power plants or nuclear power plants) are replaced by increasingly variable renewable generation (e.g. wind or photovoltaic) resources in EU countries. Energy storage projects developed to meet this need are given in the table below.

Table 11: Selected Energy Storage Projects

Name of the Facility	Type	Location	Power (MW)	Capacity (MWh)	Date	Description
Project 1000 - Pfaffenboden HEPP	Pumped Storage HEPP	Molln / Austria	300	1.8	2019	Wien Energie GmbH / voltage and frequency control have ancillary services / will support more RES production in Germany and Czechia together with Austria

¹³³<https://www.nortonrosefulbright.com/en/knowledge/publications/8b5285f4/regulatory-progress-for-energy-storage-in-europe#:~:text=European%20Union,-The%20Electricity%20Market&text=The%20directive%20aims%20to%20reduce,to%20network%20access%20and%20charging.>



This project is funded by the European Union



Name of the Facility	Type	Location	Power (MW)	Capacity (MWh)	Date	Description
Project 1001 - Kaunertal HEPP (additional)	Pumped Storage HEPP	Austria	1076	152	2028	TIWAG / Have ability to participate in all ancillary services / will provide more RES penetration in Austria and Germany
Project 1002 - iLand HEPP	Marine Type Pumped Storage HEPP	Belgium	550	2	2021	THV iLand / Integrated with marine type RES project / supports market integration and balancing / frequency control ancillary services capability
Project 1003-PCI Yadenitsa HEPP	Pumped Storage HEPP	Bulgaria	864	5.2	2021	NATSIONALNA ELEKTRICHESKA KOMPANIA EAD / Charia Pumped Storage HEPP increasing its capacity / supports more efficient operation of nuclear and thermal power plants / has frequency control ancillary service capability
Project 1004 - Muuga HEPP	Pumped Storage HEPP	Estonia	500	6	2023	Energiasalv OÜ / France advantageous in being close to a nuclear power plant and its load / supports marine type RES penetration / especially has secondary frequency control ancillary service capability
Project 1005 - CAES Cheshire	Compressed Air Energy Storage	United Kingdom	268	1.608	2022	Gaelectric Energy Storage Ltd./ supports RES integration / has power-frequency control ancillary service capability
Project 1006 - Agios Georgios & Pyrgos HEPP	Pumped Storage HEPP	Greece	594	3436	2021	TERNA ENERGY SA / Increases the stability and flexibility of the Greek network / Supports RES penetration / has all kinds of ancillary service capabilities



This project is funded by the European Union



Name of the Facility	Type	Location	Power (MW)	Capacity (MWh)	Date	Description
Project 1007 - MAREX storage	Pumped Storage HEPP	Ireland	1500	6	2020	Organic Power Ltd. / Supports the Irish and UK network by storing excess RES production and support trade / has power-frequency ancillary service capability
Project 1008 - SouthItalyBattery EnergyStorage	Battery Energy Storage	Italy	250	1.7	2030	eliminates the need to reduce excessive RES production due to Terna-grid congestion and supports penetration / provides primary and tertiary reserves / because it is modular and mobile, the system can be shifted to the congested regions
Project 1009 - Kruonis HEPP Addition	Pumped Storage HEPP	Lithuania	225	10.8	2020	Lietuvos energijos gamyba / Increases the flexibility and reliability of the Baltic grid / Supports RES penetration / power-frequency control ancillary service capability
Project 1010 - CAES Larne	Compressed Air Energy Storage	Northern Ireland	330	2	2020	Gaelectric Energy Storage Ltd. / Ensures supply security of Northern Ireland / supports RES penetration / has primary, secondary and tertiary reserve ancillary service
Project1011- MONT-NEGRE HEPP	Pumped Storage HEPP	Zaragoza / Spain	3300	75.11	2020	Ingenieria Pontificia SL / will act as an energy storage of Southwestern Europe and support market integration / power-frequency control ancillary service capability
Project 1012 - Navaleo HEPP	Pumped Storage HEPP	Leon / Spain	541	3.5	2018	CDR TREMOR SL / Balances variable production of RES and supports additional penetration / ensures grid



This project is funded by the European Union



Name of the Facility	Type	Location	Power (MW)	Capacity (MWh)	Date	Description
						stability / has all kinds of ancillary service capabilities
Project 1013 - CAES Zuidwending	Compressed Air Energy Storage	Netherlands	330	2.64	2021	Gaelectric Energy Storage Ltd / supports production-demand balance and RES integration / primary and secondary frequency control and tertiary reserve ancillary service capability
Project 1014 - Coire Glas	Pumped Storage HEPP	Scotland / The United Kingdom	600	30	2023	SSE / supports supply security and energy diversity / reduces additional transmission investments / has all kinds of ancillary services
Project 1015 - Cruachan II	Pumped Storage HEPP	Scotland / The United Kingdom	600	7.2	2025	Scottish Power / support more efficient operation of conventional power plants and supports greater RES penetration / have all kinds of ancillary service capabilities
Project 1016 - ANGS: Abengoa North Germany Storage	Melted Salt Thermal Energy Storage	Germany	140	1680	2019	Abengoa / Supports new RES penetration to be installed in Northern Germany / Eliminates the congestion in the North-South transmission corridor / Has frequency and voltage control ancillary service capability
Project 1017 - ASSS: Abengoa Southern Spain Storage	Battery Energy Storage	Spain	225	0.675	2019	Abengoa / supports the management of variability arising from RES production and penetration of new RES / ensures supply security by being active in case of failure, decrease frequency oscillations due



This project is funded by the European Union



Name of the Facility	Type	Location	Power (MW)	Capacity (MWh)	Date	Description
						to rapid response / Has frequency and voltage control ancillary service capability
Project 1018 - ANSS: Abengoa Northern Spain Storage	Battery Energy Storage	Spain	225	0.675	2019	Abengoa / supports the management of variability arising from RES production and penetration of new RES / ensures supply security by being active in case of failure, decrease frequency oscillations due to rapid response / Has frequency and voltage control ancillary service capability
Project 1019 - GIRONES & RAIMATS HEPP	Pumped Storage HEPP	Spain	3400	24.5	2024	Grupo Romero Polo / will reduce losses as it is close to France, three Nuclear reactors and a large load centre / will play an important role in secondary frequency control
Project 1020 - GIBREX STORAGE HEPP	Pumped Storage HEPP	Spain	1500	10	2022	Organic Power Ltd. / It will eliminate network congestions due to the production of wind power plants in north of Portugal / have all kinds of ancillary service capabilities.
Project 1021 - Donegal Storage Project	Pumped Storage HEPP	Ireland and Northern Boundary Ireland	1500	120	2022	Promoted Pump Storage Energy Ltd. / supports the Irish and UK grid by storing excessive RES production, and supports trade, supports more efficient operation of thermal power plants /



This project is funded by the European Union



Name of the Facility	Type	Location	Power (MW)	Capacity (MWh)	Date	Description
						has power-frequency and reactive power support ancillary service capabilities.
Project 1022 - CARES (Compressed Air Renewable Energy Storage)	Compressed Air Renewable Energy Storage	Britain	500	2.5	2017	Storelectric Ltd / provides balancing service by storing excess RES production, and supports trade, ensures decarbonization by replacing thermal power plants / has power-frequency and reactive power support ancillary service capability



This project is funded by the European Union



2.6.4 Demand Side Management (DSM) Regulations

By shifting their energy demand to a period when energy is relatively cheap or abundant, households and commercial users might reduce the pressure in the energy system, thereby lowering their bills and getting more benefits. This type of consumer activities helps optimizing the use of generation, transmission and distribution infrastructure, thereby prevent system crashes (Black-out), increase the efficiency of the energy system and reduce new and costly investment requirements. When energy demand reacts to the market or system, individual consumers and industries benefit from reduced energy costs, and society meets its energy needs with minimal supply, transmission and distribution capacity. This is a win-win solution for all of the parties.

Greater demand-side management increases zero carbon wind and solar energy integration. Changes in renewable energy generation require a more complex energy system planning to balance and control supply and demand. Enabling demand-side management technology and services, including energy storage¹³⁴, allows to cope with variable generation, by reducing infrastructure costs and capacity needs.

Recently, demand-side management programs started to be implemented EU-wise. Regulatory developments create a momentum that needs to be sustained, to provide wider demand-side management and greater potential benefits for consumers. Phased commissioning of smart meter systems, development of network codes (especially connection, operation and balancing of the system and directives on tariffs) and adaptation of the Electricity Directive (2009/72f/EC) and Energy Efficiency Directive (2012/27/EU), creates the right conditions for policy makers, regulators, grid operators and energy businesses that trigger greater demand-side participation.

Existing provisions in EU legislation (3rd Energy Package Electricity Directive and Energy Efficiency Directive)¹³⁵ enable demand side management. This framework sets out the requirements and responsibilities that shall be implemented by Member States, National Energy Regulators, TSOs and DSOs to ensure and improve demand-side management, and to allow further development of market and consumer satisfaction.

2.6.4.1 Basic Definitions

Demand-side management of end users shall be considered as making voluntary changes in general electricity consumption patterns in response to market signals (such as time-of-use electricity prices or incentive payments), based on the provisions of EU demand-side participation legislation¹³⁶ or the acceptance of an offer (on its own or through the demand aggregator) at a certain point within a certain time frame in organized electricity markets. Parameters in the electrical system are; amount of power change, its duration, rate of change, duration of response, location, etc.

The definitions in legislation regarding demand side management players are as follows:

- Residential, industrial and commercial consumers profit from demand shifts directly or through a demand aggregator at dynamic or differentiated retail prices, or they offer demand reduction in organized electricity markets or they are encouraged to shift loads at strategic times;

¹³⁴ Both local and larger scale solutions including fuel cell and hydrogen technologies are being explored.

¹³⁵ Directive 2006/32 / EC of the European Parliament and of the Council of 5 April 2006 on energy enduse efficiency and energy services, OJ L114, 27.4.2006.

¹³⁶ Namely the "Electricity Directive" (2009/72 / EC) and the "Energy Efficiency Directive" (2012/27 / EU) and Smart Grids COM (2011) 202 and the Staff Working Document "Guidance note on Article 15 of Directive 2012 / 27 / EU on energy efficiency".



This project is funded by the European Union



- Aggregators combine residential, commercial and small industry demands, and larger industries actively participate in electricity markets or they engage in demand-side management programs offered by system operators.
- Retailers can also provide consumers with aggregation service, directly or in conjunction with an independent demand aggregator. This includes the load sale in the balancing market as well as its use in its own trading portfolio for wholesale energy markets.
- Suppliers provide the right incentives to consumers, including dynamic pricing plans that reward consumers' movements. This could lower revenue from energy sales, so suppliers should refocus their business models to blend sales and service.
- Smart meter and equipment manufacturers will provide demand-side management in their production processes in a standardized manner, implement technical solutions containing IT sector content and ensure interoperability of components, communication and control technologies used in other industrial sectors.
- National Regulatory Authorities play an important role by enabling the development of retail tariffs to support dynamic pricing to increase participation in demand-side management, ensuring that network tariffs do not contain components that hinder participation in demand-side management, and by ensuring fair and transparent access of demand-side management to the retail and wholesale markets.
- TSOs and DSOs, responsible for balancing the network, open the network to new players such as aggregators, and regulate supply and demand by encouraging their access and participation in ancillary services and other system services markets. Distribution System Operators also have the role of harmonizing demand-side management implemented by individual or small consumers and micro-producers in the distribution network. DSOs can collaborate with aggregators and other service providers on the use of demand-side management and decreasing local network congestions.

2.6.4.2 Relationship between DSM and Other Smart Grid Components

Utilizing smart meter and smart grid technology: Smart meter solutions provide the technical prerequisite for measuring "real time" consumption, while the smart grid can offer even more automated, demand-side management measures. These can open the way to more optimal equilibrium throughout the supply chain, thereby offering more affordable prices for consumers.

To fully support demand-side management, smart meter systems should include the common minimum functionalities specified in Commission Recommendation 2012/148 / EU¹³⁷. The following functionalities are especially important for residential consumers:

- Updating readings every 15 minutes at most, and

¹³⁷ OJEU L73 of 13.04.2012 p.9, Commission Recommendation 2012/148 / EU of 9 March 2012 on "preparations for the roll-out of smart metering systems" specifies key common minimum functionalities for smart metering systems that will assist consumers. In particular its Art.42 sets up the common minimum functionalities for smart metering systems which should be able to deliver accurate measures of actual consumption and bidirectional communication enable dynamic pricing and improve management of the grid.



This project is funded by the European Union



- A standardized interface that visually provides information about individual consumption data and information about market conditions and service or price options regarding this data.

DSOs should be ready to install smart meters according to the consumer's demand and compliance with applicable technical standards. In addition, energy companies (suppliers or third-party service providers) need to develop innovative and meaningful solutions to help consumers recognize and adapt their demands.

Consumers shall be aware of and understand the values and conditions of the program. Given the relative complexity of the issue, vulnerable consumers must be protected from exclusion and the market must be transparent. Experience in the technological development and telecommunications industry shows that, the expectation that smart meter systems will be cheaper strengthens confidence in the program.

Creating the necessary framework for smart devices and energy management systems: Building the necessary framework for smart appliances and energy management systems, smart devices and home automation are the tools that make it easier for all consumers to lower their bills and take advantage of demand-side management, thus enabling them to be included in comprehensive demand-side management activities. Therefore, device-based demand-side management should be simple and accessible by everyone and should not be limited to expensive high-quality products.

Although device-based demand-side management is based on tariff structures, business models, and smart metering that offer consumers flexibility, an appropriate framework is also required to facilitate marketing of smart devices and management solutions at home. Solutions that facilitate the transfer of energy consumer profiles to other energy service providers¹³⁸ should be established to encourage competition in the energy services market in line with customer requests.

The Energy Label is a tool that can trigger consumer awareness and participation. It helps the market to be highly transparent and also provides incentives for manufacturers to invest in smart technology and manufacture a wide range of smart devices. It can offer solid benchmarks to encourage smart device purchase.

Eco-design, in line with the energy label, regulates certain key aspects associated with the rise of the market, such as access to relevant data, and forces interoperability¹³⁹.

It also allows to optimize the energy use of smart technologies for demand-side management. In addition, their impact on vulnerable consumer groups, affordability and comfort, product performance and warranty, interactions with central building control systems and micro production units are issues to be investigated and addressed in this context. To this end, Commission services identified priority smart devices/meters in the 2012-2014 Ecodesign work plan. The work within the framework of Ecodesign will be closely related to the results of ongoing standardization studies¹⁴⁰.

¹³⁸ Compliant with relevant data protection legislation and in particular Directive 95/46 / EC.

¹³⁹ Key elements of that framework could be a definition of smartness and basic smart features for appliances; access of smart appliances and energy management systems to relevant information, such as almost real-time / forecast pricing, load, metering and grid-status information; capability to communicate and interact with energy management and building control systems (and / or smart metering systems where relevant), across technologies / protocols to achieve full interoperability, which might lead to a "plug and play" scheme.

¹⁴⁰ Interoperability in particular will depend heavily on standardization. The results of Mandate 441 to the European standardization organizations CEN, CENELEC and ETSI will establish European standards for the interoperability of smart meters (electricity, gas, water and heat), including communication protocols and additional functionalities.

Storage technology and services (especially those with heating systems): Internal heating and hot water systems represent an excellent storage potential that can be used to increase power system flexibility. For example, the thermal storage tank installed in the UK and Ireland is 17 GW. Actively managing at least, a part of this burden can reduce production needs, allow for easier integration of renewable resources, and achieve significant savings on customers' electricity bills. Moreover, it can be expected that rapid growth in the use of domestic hot water and heat pumps for the heating of houses, gradual replacement of today's electric heaters in the near future and offer greater flexibility potential.

Bringing these technologies and energy management systems to a wider range requires successful business models to be replicated for demand-side management, including innovation and market purchase criteria in the upcoming Horizon 2020 program.

2.6.4.3 DSM Management Roles and Responsibilities

Role and responsibilities, incentives, infrastructure requirements and necessary arrangements for the activation of demand-side management are included in the regulatory recommendations report¹⁴¹ for the extension of demand-side management by the Expert Group EG3, which focuses on "Regulatory recommendations for the deployment of the smart grid" of the Smart Networks Working Group established by the European Commission.

In order to activate the demand-side management market, one must specifically acknowledge that a company can fulfil more than one role, and roles and responsibilities must be clear. For demand-side use, there is a need to strike an appropriate balance among consumers and their BRPs, TSOs, DSOs and aggregators who are encouraged to participate in demand-side management. The figure below shows possible relationships between future market roles for demand-side management services.

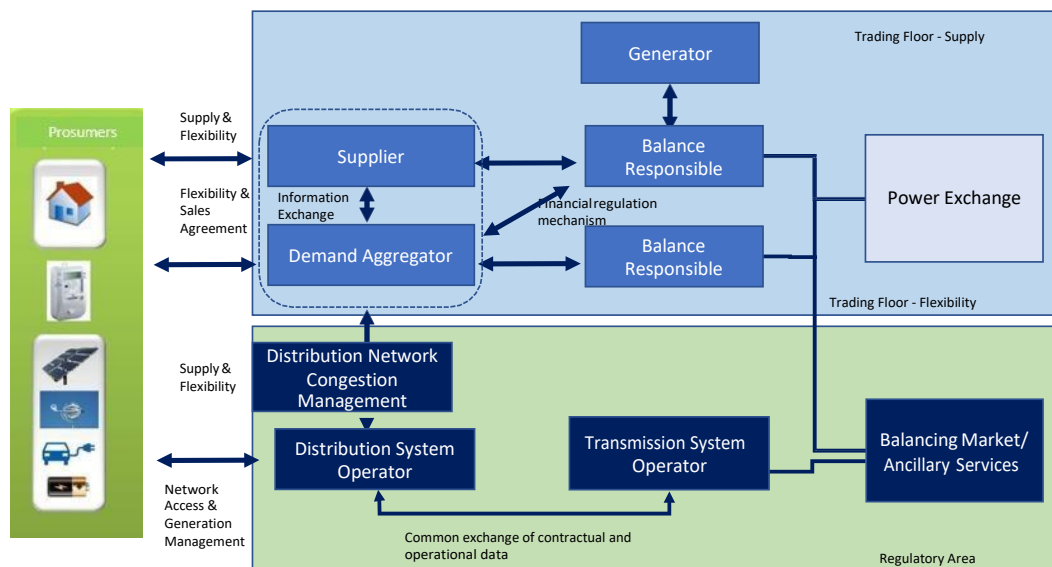


Figure 25: Possible Relationships between Demand Side Management and Future Market Roles

¹⁴¹ SGTF-EG3 Report: Regulatory Recommendations for the Deployment of Flexibility. January 2015



This project is funded by the European Union



Dissemination of demand-side management is supported, as in distributed generation, in line with the goal of expanding electrification in heating and transportation in order to reduce carbon emissions according to EU Commission's 2030 Policies. In this case, to deal with the more complex planning, control and balancing challenges, the following topics are developed, and recommendations are made on Flexible Service;

- Demand-side management
- Regulatory and commercial adjustments
- Incentives

With demand-side management, system users are expected to change their generation-consumption according to the signal to be sent (residential and commercial consumers), so that system operators will be able to balance the system and manage the constraints at an efficient cost without reinforcement investments. On the other hand, it is worked on having the demand side management providers' benefit through direct payment or energy savings. Market regulation is needed to gain full capacity demand side management benefits.

It is stated that smart grid technologies and devices that are simple and easily used by the customers are required, and smart grid products and services should be clear and simple in accordance with the standards. Thus, demand side management can be provided by using smart grid.

Legislative barriers need to be removed with new commercial and regulatory adjustments. In the current situation, consumers can offer their demand side management capacities to the day ahead, intraday and balancing market, and only motivated and willing consumers offer demand-side flexibility. Regulatory and commercial adjustments should enable industry, commercial and residential consumers to bid flexible offers to the organized electricity market.

The involvement of demand side management in the energy market should be considered as a flexible resource equivalent to existing resources at all levels of the energy market.

Consumers should be able to access the market with the best offer or service providers. The operation of the total load in all markets should be legalized; demand aggregators and suppliers should be able to provide flexible service on behalf of customers on the same terms.

For the applicability of flexibility, the offer needs to be reliable, applicable, simple, and customers also need to be protected and strengthened. It is important for consumers to have clear and measurable benefits and to provide appropriate general information and tools to compare flexible offers.

This reveals the need of consumers for access to data and dynamic pricing, especially for residential consumers, to participate in the energy markets.

Benefits of demand-side flexibility; should be shared appropriately and in a way that does not affect anyone negatively (especially vulnerable consumers).

To ensure cost-effective market coordination for demand-side management; well-defined and appropriate measurement and validation protocols are needed. A smart meter system is required to measure and reconcile transactions if the flexible demand gathered wants to join the balancing market. An important part of enabling demand-side resources for market participation in the case of volume-based demand-side management is the use



This project is funded by the European Union



of the “baseline” method to measure the flexibility provided by the consumer. If there are contractual arrangements among the market participants (Balancing Responsible Party (BRP), Supplier, Distribution Company, Transmission Company, Demand Aggregator), they should be simple, convenient and reflect the relevant benefits, costs and risks for all parties.

Contractual arrangement should grant the customer access to all service providers without prior permission of other market participants. Standard contracts, standard communication procedures among demand aggregation service providers, BRP and suppliers, straight-smooth contract process and fair financial adjustment mechanisms should be provided. When relevant; contracts, communication and money flows should be able to be routed through an independent third party.

When consumers contract with the independent demand aggregator, there should be a financial adjustment mechanism to ensure who will be paid for the energy consumed by the end customer and generated by the market.

This mechanism should protect BRP from unfair costs as it fulfils its balancing requirements.

Distribution companies should have the opportunity to use flexible services that is beneficial for both the consumers and the network. Distribution System users can benefit from this new service, which enriches the competitive market with appropriate regulations. Depending on the state of the system to reduce potential contradictions with the distribution companies’ network operation; It is necessary to distinguish whether the constraint is eliminated with the commercial demand side management service or internal network control and the planned demand aggregation action should be “visible”.

Distribution companies should be able to identify different system states and market participants should be able to access transparent information about the state of the system (e.g. traffic light concept). In addition, access to data without discrimination is essential for the operation of the distribution network and the function of the energy market.

The data manager, which in many countries is managed by Distribution Companies, must provide existing and new data on time, appropriately and evenly through the market platform. The Transmission System Operator should act as a natural market facilitator by providing communication and compromise service between BRP, Demand Aggregator and supplier. For example; the balancing market is usually the first entry point for investment in large-scale demand-side flexibility. In order to ensure a fair competitive environment in the market, it is necessary to generally decide the level of investment in flexible service.

Data exchange on coordination, communication and interoperability with regard to activities between TSO and DSOs is very important in the development of the flexible market.

Incentives for Demand Side Management;

- Speeding up the market entry,
- Introduce the changes it will bring to the current market,
- Ensure the efficiency of the investment decision,
- Information-based solutions should be implemented in the long run or contribute to programs that change customer behaviour.



This project is funded by the European Union



Incentives should be made to demonstrate the value of demand-side management for the client and to achieve efficient market function, or through Government policies or regulations. Businesses and market players may need incentives for demand-side management. These are;

Consumers → improved price signal;

Transmission-distribution companies; to be able to make efficient investments, the value of

Flexibility = Investment Expenditure of strengthening investments, which are no longer necessary - CAPEX + OPEX.

If the demand side management service can delay TSO and DSO investments, the benefit of flexibility is the return of the investment as much as the delay period.

For companies that are not subject to regulation and compete; the efficient operation of the market (telecommunications operators, ICT (Information and Communication Technologies)) or the interoperability of manufacturers' (material) product and protocols, in addition the expansion of smart grid areas are synergies.

Respecting the roles and responsibilities of each party facilitates the efficient dissemination of the smart grid infrastructure while operating the safe and secure energy grid (electricity and natural gas) and thus the use of the demand-side management option. In addition, the use of information-based ICT solutions for networks and the efficient dissemination of smart networks should be taken into consideration, and pilot applications that improve the knowledge-based (innovative) technology, business and commercial regulatory infrastructure level among network and telecommunication operators should be supported.

Finally, incentives should be provided for this transition at the first stage to enable residential consumers to participate in the market and to speed up the purchase of smart devices.

Consequently, the aim should be to ensure equality in demand side access to the electricity market and to treat all the related players equally and in this direction;

- The participation of new players should be allowed with the regulation of the current market model rules and necessary commercial adjustments,
- Network operators should be encouraged to provide and use flexibility to optimize network investments and operation,
- To support the development of new products and the competitive market, data managers should be guaranteed to provide data to relevant service providers in a transparent and non-discriminatory manner, and
- End-user prices and consumer policies should reward demand-side management and promote consumer use, while there is necessary protection and a clear framework for residential consumers.

2.6.4.4 Demand Connection and Performance Requirements

The harmonized rules have been determined by the Regulation (EU) No 2016/1388 and 17 August 2016 "Creating Demand Connection Network Code"¹⁴² to provide a clear legal framework for grid connections of demand facilities and distribution systems, to facilitate electricity trade across the European Union, to ensure system security, to

¹⁴² COMMISSION REGULATION (EU) 2016/1388 of 17 August 2016 establishing a Network Code on Demand Connection



This project is funded by the European Union



facilitate the integration of renewable electric resources, to increase competition, to facilitate the integration of energy resources and to allow more efficient use of networks and resources for the benefit of consumers. Member States have an obligation to enforce this code no later than three years after it enters into force.

For system safety, the regulation emphasizes that historically, technical capabilities of generation facilities form the backbone, however, that demand facilities are expected to play a more important role in the future, and that regular coordination at the level of transmission and distribution networks, and that equipment connected to transmission and distribution networks is sufficiently durable to cope with failures are basic prerequisites.

Regulatory Bodies must take into account reasonable costs that are effective in the implementation of this Regulation by system operators in determining or approving transmission or distribution tariffs or methodologies, or when approving the terms of connection and access to national networks.

The requirements of the regulation should be applied to demand facilities/distribution facilities/closed distribution facilities which will be newly connected to transmission, distribution and closed distribution¹⁴³ (distribution system in a certain geographical region, to which customers outside industry, commercial etc. are connected) systems for participation in demand side management. It should also apply to existing demand facilities/distribution facilities/closed distribution facilities who wish to participate in demand-side management. Definitions in regulation are as follows;

'Demand unit' is an indivisible set of facilities that can be actively controlled by a demand facility owner or operator of a closed distribution system, which can be individually or widely regulated as part of the demand collection process by third parties;

"Demand aggregation" is a range of demand facilities or closed distribution systems that can function as a single facility or closed distribution system to provide one or more demand-side management services;

Demand Response Unit Document (DRUD), is a document covering the necessary data and declarations, including the technical requirements and declaration of conformity specified in the regulation, submitted to the relevant system operator by the demand owner for demand units who participate in the demand side management and connected to a voltage level above 1000 V or closed distribution system operator;

The demand-side management services given to system operators are defined in a similar way to the services of generation facilities and are generally divided into the following categories:

1. Remote Controlled

- Active power control; changing the demand according to the time specified by the relevant system operator and the instructions sent,
- Reactive power control; voltage control by disconnecting or reconnecting static compensation facilities according to the instructions of the relevant system operator,
- Constraint management; demand side control, if specified, by frequency or voltage control or both according to the pre-alarm signal sent by the system operator.

2. Independently Controlled

¹⁴³ Article 28 of Directive 2009/72/EC



This project is funded by the European Union



- System frequency control; Change of demand as linear when there is a 0.01Hz deviation at the system frequency measured every 0.2 seconds,
- Very fast active power control; if the rate of change of system frequency is above the defined level, the demand changes within 2 seconds at the latest.

In addition, the above-mentioned demand side management services must be demonstrated with tests (compliance tests) and simulations that they are provided in accordance with the regulation. DRUD containing the results must be presented to the relevant system operators, and the relevant agreements must be made directly or through demand aggregators.

Tasks of the relevant system operator;

1. The relevant system operator will assess the compliance of the demand facility to the regulation throughout its lifetime and will inform the demand side about the outcome of the assessment.
2. The relevant system operator has the right to ask the demand owner to carry out compliance tests and simulations after the failure, partial or complete replacement of any equipment according to a repeated plan or general scheme. The owner of the demand facility will be notified of the outcome of these compliance tests and simulations.
3. The relevant system operator will make the list of information and documents to be complied with by the demand facility owner open to the public within the framework of the harmonization process. The list covers at least the following information, documents and requirements:
 - All documentation and certificates to be provided by the owner of the demand facilities;
 - Details of the technical data requested by the demand unit regarding network connection or operation;
 - Requirements for static and dynamic system studies models;
 - Timeline to provide system data required to carry out the work;
 - Works of demand facilities owner to show stable and dynamic performance;
 - Conditions and procedures, including scope, for enrolment of equipment certificates;
 - Requirements and procedures for the use of relevant equipment certificates issued by the accredited unit to the owner of the demand.
4. The relevant system operator will publicly disclose the distribution of responsibility for compliance test, simulation and monitoring.
5. The relevant system operator may delegate the monitoring of compliance performance to third parties in whole or part. In such cases, the relevant system operator will continue to ensure compliance, which includes entering the confidentiality commitments with the transferee.



This project is funded by the European Union



2.6.4.5 **Legislative Amendment Proposals**

Flexibility within the scope of regulatory joint opinion on ACER-CEER's Clean Energy legislative proposals¹⁴⁴:

“The ability of the electrical system to react to supply and demand fluctuations while at the same time maintaining system reliability”

and the following legislative amendment recommendations were made:

- An integrated approach is required to support market flexibility;
 - It is required that all consumers have the opportunity to participate in relevant markets and other regulations, including through aggregation, for flexibility assessment.
 - An independent aggregator¹⁴⁵ is useful and is recommended to enable independent aggregation unless a national implementation assessment alternative is proposed by Member States that better serves system efficiency and can be implemented effectively. Such an evaluation can be supported by an analysis of the competitive environment in the retail markets of the Member States. This focuses not on the type of aggregator but on the facilitation (effectiveness) of aggregation.
 - In implementing independent aggregation models, Member States must ensure:
 - Access of independent aggregators to the market should not be taken by the suppliers to the detriment of consumers;
 - Regulations should ensure resold energy payments ('compensation'). This payment for resold energy can be facilitated through a central financial settlement or based on contractual relationships between customers and suppliers but does not require any contractual relationship between the supplier and the independent aggregator.
- Flexibility to Support (Distribution) Network Operations;
 - DSOs should not be discriminatory when providing and using flexibility, and in this context adequate segregation is essential in their activities.
 - The use of flexibility by DSOs should not be exclusive and should be able to take advantage of other arrangements to assess flexibility, such as participation in the balancing market.
 - TSOs and DSOs are responsible for coordinating with each other, including providing and achieving flexibility.

The diagram below shows a simplified framework of the integrated elements of the predicted flexibility.

¹⁴⁴ European Energy Regulators' White Paper # 3 Facilitating flexibility Relevant to European Commission's Clean Energy Proposals, 22 May 2017 is defined as

¹⁴⁵ For the revised Electricity Directive in the Clean Energy legislative package proposal, "" independent aggregator "" means a collector not affiliated with a supplier or any other market participant".



This project is funded by the European Union

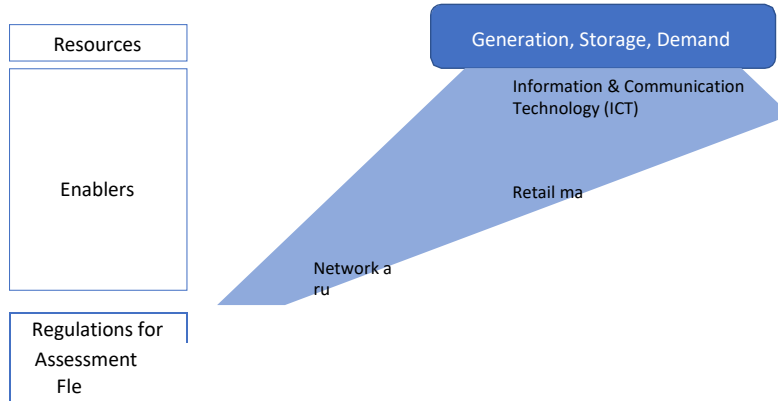


Figure 26: Predicted Structure of the Flexibility System

Regulations Regarding the Relationship between Ancillary Services and Smart Grid Components

The United States Federal Energy Regulatory Commission has defined (FERC)¹⁴⁶, Ancillary services as follows:

"Given the obligations in the control areas, the services necessary to support the transmission of electrical energy from the seller to the buyer and to maintain reliable operations of these interconnected transmission systems in these control areas."

It is also stated that traditionally ancillary services are provided by generators, however, the integration of variable RES production and the development of smart grid technologies require a change in the hardware that can be used to provide ancillary services.

Ancillary services in the European Commission legislation are similarly defined as the "services required to support the transmission capacity beginning from energy sources to loads while maintaining the reliable operation of the transmission service provider". However, the functions have been expanded, including services such as distributed generators, storage systems and manual and automatic frequency restoration reserves (mFRR and aFRR) and reactive power provided by demand-side management. In cases where the deviation in frequency takes more than 30 seconds, FRR replaces the frequency containment reserve (FCR) and its activation time is between 30 seconds to 15 minutes.

The increase in the prevalence of distributed generation facilities in the distribution network creates significant effects on the concepts of operation, control, protection and reliability in existing power systems. Active and reactive power flows are beginning to be bidirectional. The intermittent nature of renewable energy sources (Cloud transitions, sudden changes in wind speed) causes sudden changes in power systems. In addition, the operation of the distributed generation plants with a constant power factor independent of the network operating conditions causes active power surges on connection points. Also, in case of demand changes for electrical energy, their constant power supply to the distribution system causes increased network failures and reverse power flows from the distribution system to the transmission.¹⁴⁷

¹⁴⁶ The United States Federal Energy Regulatory Commission (FERC)

¹⁴⁷ M. Delfanti, A. Galliani and V. Olivieri, "The New Role DSOs: Ancillary Services from RES Towards A Local Dispatch", CIRED Rome, 11-12 June 2014.



This project is funded by the European Union



With the increasing prevalence of distributed generation systems and technological developments, distribution networks are evolving from their existing traditional structure towards smart grid models with features such as remote monitoring and control. The advantages of the smart grids against the traditional grids are given below.

Figure 27: Comparison of Business Processes in Traditional and Smart Grids

Ancillary services are currently provided mostly by the transmission system operator through the transmission facilities at the transmission system level. Distribution system operators are expected to regulate the voltage profile and balance the need for reactive power or supply it from the transmission system in order to provide energy reliability and quality to their end consumers in their area of responsibility. The control of wind turbines and PV systems connected from many points of the distribution network and the stability and reliability of the network are evaluated in the context of ancillary services. Renewable resource-based distributed production facilities and evolving demand-side involvement offer new opportunities for distribution companies. It also causes the emergence of new business areas such as aggregator in the electricity markets.¹⁴⁸

The R&D project "Increasing the Penetration of Renewable Energy Sources in the Distribution Grid by Developing Control Strategies and Using Ancillary Services", supported by the European Commission was launched in 2013¹⁴⁹. Within the scope of the project, participation in ancillary services and the management of low and medium voltage renewable energy sources are aimed. For ancillary services, special emphasis was placed on voltage control and reserve capacity.

A study is carried out on ancillary services that can be provided from the facilities that produce electricity from renewable energy sources, which was launched in 2015 by the Danish Public Service Obligation. Within the scope of the study, technical capacities for ancillary services that can be provided from wind and solar power plants,

¹⁴⁸ AF Gubina, A. Tuerk, J. Pucker and G. Taljan, "Policy Framework Conditions for Provision of Ancillary Services in a Distribution Network by Distributed RES Generation" PowerTech, 2015 IEEE Eindhoven.

¹⁴⁹ European Commission, "Increasing the Penetration of Renewable Energy Sources in the Distribution Grid by Developing Control Strategies and using Ancillary Services", 2013.



This project is funded by the European Union



whose are increasingly infiltrate electricity generation in the relevant country were examined. Research is done with regards to communication, information technologies, and legal frameworks.¹⁵⁰

In the RServiceS (Providing Network Support From Variable Renewable Sources) project, which is supported by European Union Smart Energy Program, which has stakeholders such as European Distribution System Operators, solar power system producers, the capabilities and costs of PV systems in terms of their participation in ancillary services were researched. The objectives of the project are given below:¹⁵¹

- Analysing the requirements of providing voltage and frequency control ancillary services, due to increasing wind and solar power generation in European power systems
- Identifying ancillary services that can be provided from wind and solar power producers to assist system operators in current and future network operating conditions
- Determining the factors affecting ancillary services in these producers
- Europe wide calculation of costs related to ancillary services provided from these producers

In the light of these studies, an evaluation of the participation in ancillary services at the distribution level in terms of technical, economic and business models and an infrastructure for future applications will be created.

Ancillary services mechanisms that support the delivery of energy from the producer to the consumer by making use of production, transmission and control equipment, are of great importance for system operators who have responsibility for the safe and reliable operation of interconnected networks. These services consist of mandatory or competitive participation.¹⁵²

The definition of ancillary services needs to be updated with the increase in the level of influence of the generation facilities in the distribution level, and it is expected to include distribution system operators. Moreover, it will be possible to evaluate smart grid concepts such as demand side management and energy storage systems under the umbrella of ancillary services.

Supporting the grid with energy storage systems started to be implemented in California State in 2008. The company called "A123 Systems" has implemented energy storage systems with Nano phosphate Li-Ion battery technology in renewable energy producers and contributed to frequency regulation in the grid with energy storage systems of 20 MW installed power. Furthermore, by utilizing the dynamic response feature of storage systems, it contributes to post-outage recovery processes after interruption¹⁵³.

The usability of distributed generation facility technologies in ancillary services has been studied in the literature, and the table below shows the ability of different types of generator technologies to participate in ancillary services¹⁵⁴. In particular, it is seen that inverter-based facilities have the necessary potential to provide ancillary service support.

¹⁵⁰ DTU Wind Energy, "Technical Feasibility of Ancillary Services provided by ReGen Plants", 2015-2018.

¹⁵¹ <http://www.reservices-project.eu/wp-content/uploads/RServiceS-D4-1-Final.pdf>

¹⁵² Eurelectric: Connection rules for generation and management for ancillary services, Ref: 2000-130-0003, 2000.

¹⁵³ Vartanian, C.; "Grid stability battery systems for renewable energy success," Energy Conversion Congress and Exposition (ECCE), 2010 IEEE, Sept. 2010

¹⁵⁴ Braun, M., "Technological Control Capabilities of DER to Provide Future Ancillary Services", International Journal of Distributed Energy Resources, p:200, 2006.



This project is funded by the European Union



Table 12: Contribution Levels of Generator Technologies to Ancillary Services

Control Capabilities	Asynchronous Generator	Double Feed Asynchronous Generator	Synchronous Generator	Inverter Based
Reactive Power Control	No	Good level	Very Good Level	Very Good Level
Direct Voltage Control	No	Good level	Very Good Level	Very Good Level
Power Quality Improvement	No	Good level	No	Very Good Level
Supporting the System in Failure	Very little	Good level	Low level	Very Good Level

In a similar study,¹⁵⁵ generator types of the plants that use different fuels are compared in terms of possible ancillary service potentials. Plants with synchronous and double feed asynchronous generators can provide active and reactive power support and island mode operation services.

Table 13: Ability to Provide Ancillary Service of Different Generator Types

Plant Type	Generator Type		Ancillary Services Type		
			Active Power Control	Reactive Power Control	Island Mode
RES (Wind)	Synchronous		Yes	Yes	Yes
	Asynchronous	Pitch Control	Yes	No	No
		Stall control	No	No	No
	Double Feed Asynchronous		Yes	Yes	Yes
Biogas	Synchronous		Yes	Yes	Yes
Combined Cycle	Synchronous		Yes	Yes, but at a limited level	Yes
Hydroelectric	Asynchronous		No	No	No

Potential ancillary services available to distribution networks are summarized below:

- Voltage Control
- Congestion Management



This project is funded by the European Union

¹⁵⁵ Korpikiewicz, G., J., Bronk, L. and Pakulski, T., “Methodology of Using Ancillary Services Provided by Distributed Generation for Planning and Development of MV Network Processes”, ActaEnergetica, 2014.





This project is funded by the European Union

- Minimizing Network Losses (Optimization of Grid Losses)
- Improvement of Voltage Quality
- Network Restoration / Black Start
- Island Mode Operation (Islanded Operation)

Market Models and Legislation Infrastructure

Today, generation resources in the distribution system participate in the TSO's ancillary services market. However, participation is still limited, with wide range of products and rules across countries. DSOs rarely use flexible resources to solve local network problems. If the TSO uses resources from the distribution network, this service is often organized without the involvement of DSO, which can potentially cause problems in the event of increased volume. The growing need for cooperation between system operators is recognized by many stakeholders and EU regulations.

Five different coordination schemes have been proposed to organize the coordination between system operators in the study of “Basic schemes of TSO-DSO coordination and providing ancillary services”¹⁵⁶ under the scope of Horizon 2020 of the EU. EU and national network regulations¹⁵⁷ and EU directives¹⁵⁸ are based on these studies. Each coordination pattern is characterized by a specific set of roles and a detailed market design by system operators. Differences between coordination plans have a major impact on the procurement phase of ancillary services (AS) or local system services. The processes of pre-qualification, activation and analysis of flexible resources are quite similar in coordination schemes;

In the central AS market model; TSO operates the AS market without the extensive participation of DSO for both sources at the transmission and distribution level.

In the local AS market model; DSO creates a local market for connected resources in the distribution network. DSO collects the remaining offers after the local network constraints are resolved and submits them to the TSO.

Responsibility in shared balancing model; balancing responsibilities are shared between TSO and DSO according to a predefined program. While DSO creates a local market to comply with the program agreed upon with TSO, TSO does not have access to the sources connected to the distribution network.

Common TSO-DSO AS market model; TSO and DSO have a common cost reduction goal for AS provided by TSO and DSO resources. This common goal can be achieved by joint operation of a common market (centralized variant) or by the dynamic integration of a local market operated by DSO and/or the decentralized TSO market (decentralized variant).

Integrated flexibility market model; the market is open to regulated (TSOs, DSOs) and unregulated market parties (BRPs, CMPs) to guarantee impartiality and requires an independent market operator.

¹⁵⁶ European Union's Horizon 2020 research and innovation programme under grant agreement No 691405 “Basic schemes for TSO-DSO coordination and ancillary services provision”, 02.12.2016.

¹⁵⁷ EU network codes can be found in ENTSO-E network codes. National network codes may be found on the website of the respective TSOs.

¹⁵⁸ Energy Efficiency Directive



This project is funded by the European Union



All of the different coordination schemes have specific benefits and features related to TSO, DSO, and other relevant market participants and market operation.

In addition, the applicability of each coordination scheme is much dependent on the regulatory framework. Today, the centralized AS market model is in line with current regulations. Other coordination schemes require extensive changes regarding TSO and DSO roles.

Implementing a coordination order: The national organizational structure of TSOs and DSOs varies depending on the number of system operators and the way they interact. In addition, establishing a specific coordination order will have an impact on other markets, such as the intra-day market. Depending on the services offered in the AS market and compared to intra-day markets, these markets need to be integrated to work together or in alternation.

Increasing distributed energy sources in the distribution network provides opportunities for system operators to provide ancillary services from the distribution network, and in this context, different mechanisms for coordination between TSO and DSO are examined. The main key mechanisms are listed below¹⁵⁹;

1. The choice of the appropriate coordination scheme depends on many factors such as the type of ancillary services, normal operation and emergencies, grid status, installed amount of RES, current market design and regulatory framework.
2. TSO-DSO coordination can be regulated on a country basis, but national TSO-DSO coordination regulations should be included in the EU harmonization and integration process. This means that processes and systems must be organized dynamically to foresee future harmonization and integration.
3. The feasibility of coordination plans depends very much on the evolution of DSO roles and responsibilities.
4. A choice must be made between the benefits of a particular coordination scheme and the cost of implementing it. For example, it can be very expensive to install a real-time fully monitored system, where all DSO restrictions can be tracked so that restrictions cannot be violated in any way.
5. The choice of a particular coordination scheme does not mean that this scheme can never be adapted to other schemes. Across the coordination schemes, the role and responsibilities of DSO are gradually increasing. Depending on national development stage, one country can switch from one coordination scheme to another. In particular, the Central AS market model, the Common TSO-DSO AS market model (centralized variant) and the Integrated Flexibility market model share a common market architecture in terms of the platform and ICT requirements. A shift between these coordination plans is essentially a question of changing roles and responsibilities. The shared balancing responsibility model can be seen as a multiplication of the same market architecture. The local AS market model and the Common TSO-DSO AS market model (decentralized variant) share a common market architecture.
6. The purchase of AS from the distribution grid should be clear, easy to understand, reliable, low cost and fast regardless of the coordination scheme. If the interaction models are too complex, the value of small flexibility providers of distributed generation can be decrease too much.
7. Regardless of the coordination scheme, the supply of AS from the distribution grid must be transparent, non-discriminatory and neutral. This is particularly relevant for small DSOs that are not subject to regulation in a vertically integrated position which also provides increased flexibility.

¹⁵⁹ European Union's Horizon 2020 research and innovation programme under grant agreement No 691405 "Basic schemes for TSO-DSO coordination and ancillary services provision", 02.12.2016.



This project is funded by the European Union



8. Close cooperation between TSOs and DSOs is required for the operation of the networks they are responsible for and the safe management of data.

In the literature, many studies have been carried out regarding the market model and legislative structure for obtaining ancillary services support from distributed generation plants connected to the distribution network. For example; in the study by Delfanti et al.,^{160, 161} three different models were proposed:

Extended Administration Centre

In this model, the distributed generation facilities that are connected at all voltage levels will present their estimates of the amount of energy they can give to the power system in the day-ahead market. All power plants will participate in ancillary services under the supervision of the transmission system operator. Distributed generation facilities will carry out planned generation activities without causing imbalance in the network. In this model, the transmission system operator regulates the production plans and the state of the power plants in the market.

Local Administration Centre under Distribution System Operator's Control

In this model, the distribution system operator provides ancillary services in line with its own requirements both by making use of local generation and by managing the system resources. The request of transmission system operator for ancillary services is carried out by the distribution system operator. According to the expanded Central Administration model, the distribution company is directly in the ancillary services market. It purchases the flexibility offered by distributed generation facilities and demand response aggregators in emergencies. In addition, the transmission system operator is evaluating offers for ancillary services provided by traditional generation facilities. The figure below shows the local administration model under the control of the distribution operator.

Figure 28: Local Administration Model under Distribution Operator's Control

¹⁶⁰ J. Mutale, G. Strbac "Development of contract structures for ancillary services from distributed generation", deliverable of task 5.5 of the DISPOWER project, University of Manchester, March 2005.

¹⁶¹ L. Lo Schiavo, M. Delfanti, E. Fumagalli, V. Olivieri "Changing the regulation for regulating the change: Innovation-driven regulatory developments for smart grids, smart metering and e-mobility in Italy" (2013) Energy Policy, 57, pp. 506-517.



This project is funded by the European Union



Planned Program Model

In this model, the distribution system operator is obliged to provide plans for ancillary services rather than making bids to the transmission system operator for the purchase of ancillary services directly. It limits the imbalances by creating production profiles suitable for distributed generation connected to the distribution network. Thus, the transmission system operator organizes purchases for ancillary services.

It is anticipated that the coordination of the distribution and transmission system operators will become more important with the proposed business models. It requires the data to be shared with the system operators via communication infrastructure, such as the instant production amount provided from the distributed power plants and the amount of energy it can supply to the daytime power system.

As a result, the increase in the penetration level of the distributed generation facilities within the distribution system requires adaptations in conventional network operation. Ancillary services used in operating the transmission network under reliable and safe conditions are also evaluated for the level of distribution in international studies and distribution level ancillary services are researched within the scope of various projects. With the spread of distributed generation plants and technological developments, smart grid models with remote monitoring and control capabilities are gaining importance.

Distribution system operators can increase the stability and reliability of the network within the scope of ancillary services by making use of renewable energy sources such as wind and solar which are connected to the MV network. Distributed generation facilities and evolving demand-side management offer new opportunities for distribution companies. However, due to the fact that the existing legal infrastructure and market model are not suitable for such studies, studies on the technical and economic aspects of ancillary services in distribution grids are underway. In addition, the relevant market and business processes need to be researched and developed in terms of technical and economic evaluations.

RESERVES study¹⁶² for this purpose addresses changes in the future European energy system:

- High share of variable renewable areas → shifting needs and opportunities for giving most needed ancillary services
- Liberalization of the electricity market, including the market, network codes and the market connection requirements for the development of ancillary service markets.

The main goal of the studies is to establish reference baseline and policy recommendations for future network codes and market designs in regard to ancillary services from variable renewable sources. Short-term effect: Providing cost-based ancillary services compatible with Europe from wind and solar. Long-term effect: To support EU's single electricity market, which operates efficiently with cost-effective integration of variable renewable energy sources and increased grid management and system security. Methodology:

- Techno-economic analysis of both system requirements for ancillary services and providing these services from wind and solar power generation.

¹⁶² <http://ec.europa.eu/energy/intelligent/projects/en/projects/reservices>



This project is funded by the European Union



- Case studies to investigate the need for services under different scenarios and determine the costs and options to deliver these services.

What's new in this project:

- Evaluation of system requirements at high RES penetration levels and determination of common terminology
- Evaluation of both wind and solar PV
- Simulating future systems at transmission and distribution level

Target groups: System operators, energy regulators, policy makers, market players, renewable energy industry. As a result of the studies;

- Simulating the needs and possibilities of providing ancillary services in scenarios with high wind and solar penetration (50% and more) in representative areas in Europe,
- Calculation of specific costs of ancillary services provided to the grid operators from wind (offshore and onshore) and PV installed at the transmission and distribution level,
- Designing the European ancillary services market, drawing up recommendations on economic aspects of the provision of wind and solar PV and their ancillary services and the cross-border trade aspects,
- Interaction with stakeholders related to thematic workshops, papers, publications etc. in various regions in Europe

are aimed. In addition, lessons will be derived on technical and regulatory constraints in development of an ancillary market.

2.6.5 Interoperability and Standardization

Interoperability and Standardization was studied by the Expert Group 1 (EG 1), which focuses on the Smart Grid Standards of the Smart Grids Working Group established by the European Commission.

EG 1 conducted a survey and evaluation study in 17 Member States of the European Union to determine the degree of interoperability of existing and planned smart metering systems with other components and operations of the energy system. When determining the requirements for energy supply and demand-side flexibility, compliance with the a, b and f articles of the European Commission's 2012/148/EU Recommendations on the Roll-out of Smart Metering Systems was taken into account. These recommendations are;

- (a) Provide readings directly to the customer and any third party designated by the consumer. This functionality is essential in a smart metering system, as direct consumer feedback is essential to ensure energy savings on the demand side. There is a significant consensus on provision of standardised interfaces which would enable energy management solutions in 'real time', such as home automation, and different demand response schemes and facilitate secure delivery of data directly to the customer. Accurate, user-friendly and timely readings provided directly from the interface of customer's choice to the customer and any third party designated by the consumer are strongly recommended since they are the key to running demand response services, taking 'online' energy-saving decisions and effective integration of distributed energy resources. In order to stimulate energy saving, Member States are strongly recommended to



This project is funded by the European Union



ensure that final customers using smart metering systems are equipped with a standardised interface which provides visualised individual consumption data to the consumer.

- (b) Update the readings referred to in point (a) frequently enough to allow the information to be used to achieve energy savings. This functionality relates purely to the demand side, namely the end customer. If consumers are to rely on the information provided by the system, they need to see the information responding to their action. The rate has to be adapted to the response time of the energy-consuming or energy-producing products. The general consensus is that an update rate of every 15 minutes is needed at least. Further developments and new energy services are likely to lead to faster communications. It is also recommended that the smart metering system should be able to store customer consumption data for a reasonable time in order to allow the customer and any third party designated by the consumer to consult and retrieve data on past consumption. This should make it possible to calculate costs related to consumption.
- (c) Support advanced tariff systems. This functionality relates to both the demand side and the supply side. Smart metering systems should include advance tariff structures, time-of-use registers and remote tariff control. This should help consumers and network operators to achieve energy efficiencies and save costs by reducing the peaks in energy demand. This functionality, together with functionalities referred to in points (a) and (b), is a key driving force for empowering the consumer and for improving the energy efficiency of the supply system. It is strongly recommended that the smart metering system allows automatic transfer of information about advanced tariffs options to the final customers, e.g. via standardised interface mentioned under (a).

Studies focus on measuring infrastructure and interfaces up to smart meters in the Communication Software and the provision of profiles for the following interfaces:

- H1 is the interface that provides one-way communication between the smart meter and a simple external display device (if applicable).
- H2 is the interface for intelligent network communication that exchanges information between advanced meter infrastructure (AMI) and demand-side management applications. H2 connects the smart meter gateway (LNAP) and the energy management gateway. H2 provides bidirectional communication for home automation end devices, which can include advanced consumer displays.
- Note: H3 stands for a similar connection between NNAP and the energy management gateway. As a result of the survey conducted by Working Group EG1 in 2015, it was determined that the H3 interface was not planned to be used.

The H1 and H2 interfaces are shown in the diagram below. This diagram is a functional representation of the demand-side management communication architecture, whereas in physical deployments, functions and interfaces can be combined.



This project is funded by the European Union

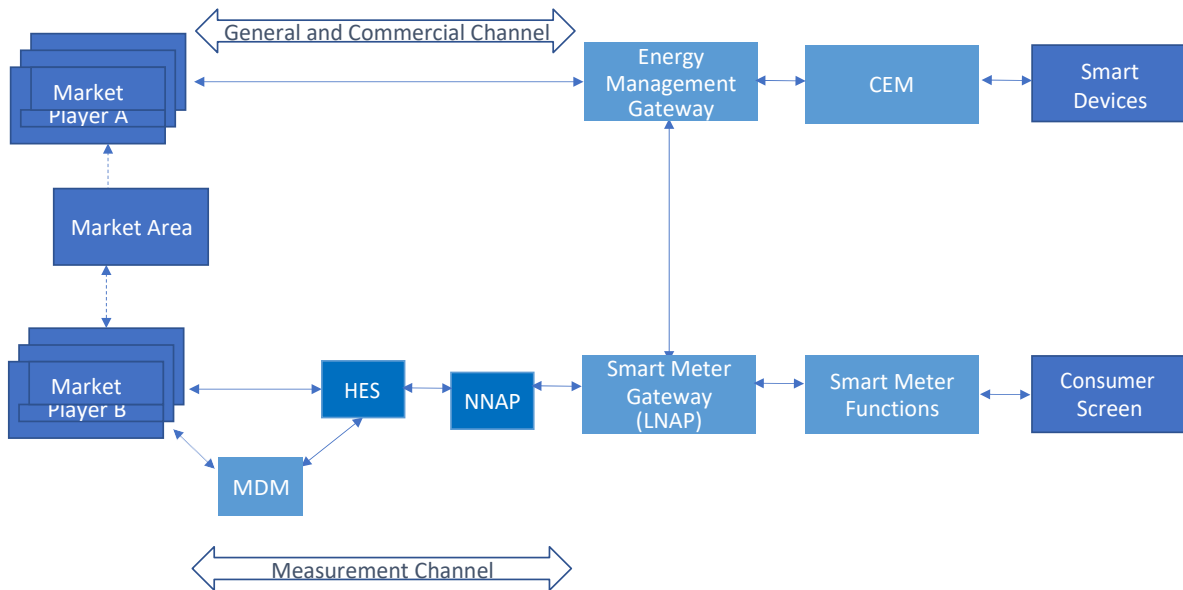


Figure 29: Standardization of Demand Side Management Communication Architecture

The general and commercial channel (the horizontal line at the top of this diagram) will generally be used for consumer-oriented energy services and operations (including demand-side management) over the Internet. The regulated smart grid communication / operations use the measuring channel shown in the lower half of the diagram. In most EU Member States, the measurement channel is operated by the Distribution System Operator.

Market player A can be any party, such as suppliers, demand aggregators and other service companies that use the general and commercial channel to access the energy operating gateway.

Market player B is the DSO of the EU member country operating the advanced metering system.

MDM = Meter Data Management system that manages meter configuration and stores data collected from connected meters

HES = Head End System that collects data from measuring tips and sends information to connected measuring devices

LNAP = Local Network Access Point that connects to in-house meters and smart devices (often referred to as "smart meter gateway")

NNAP = Neighbourhood Network Access Point that connects to multiple homes and collects data (often referred to as "Data Concentrator").

CEM = Consumer Energy Management system that manages local demand and production

Experts Group 1 (EG 1) commissioned with M/490 code at the end of 2014 by the European Commission to focus on "Smart Grid Standards", published its final report on methodologies and definitions to facilitate the

interoperability of smart grids¹⁶³. This final report revealed that simply choosing communication standards is not enough to guarantee interoperability. The study conducted by EG1 in 2015 showed that the various Member States of the EU did not take the additional measures necessary to ensure interoperability, and there are several risk areas, especially in terms of interoperability. These are;

- Some smart metering / smart grid standards were not available when existing smart meters and smart grids were planned to be expanded,
- EU Member States did not always provide specific information about the standards or technical specifications to be used in their responses to the survey.
- Additional features (use cases, data definitions, and complementary standards) are not defined in the majority of EU Member States.

For this reason, the use of additional or accompanying specifications called Basic Application Profiles (BAPs) was encouraged. BAP is a document that explains how standards or technical specifications are applied to support the needs of a particular national infrastructure. In addition, the Basic Application Interoperability Test Profiles (BAIOPs) were used to check that the selected profile meets the technical requirements. BAIOPs can also be called BAP Test Specifications.

The flowchart below shows the main steps of the process that define how to achieve full interoperability.

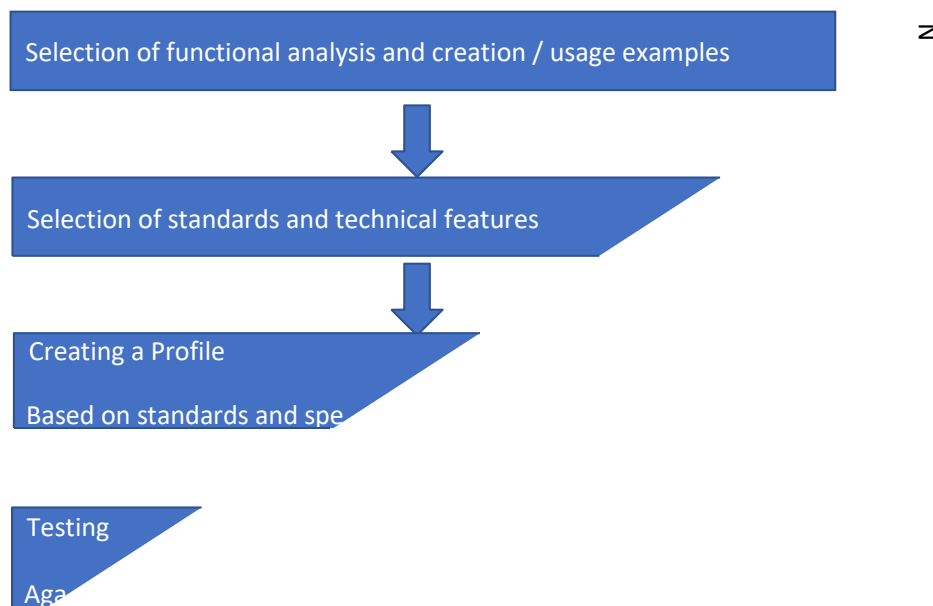


Figure 30: Interoperability Process

¹⁶³Smart Grid Co-ordination Group report "Smart Grid Interoperability"

ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Interoperability_Report.pdf



This project is funded by the European Union



The process begins by defining the functions of knowledge transfer by analysing what data is to be exchanged. These functions can be captured in standard use cases¹⁶⁴.

Standards and specifications can be selected based on functions and architecture designed from general views¹⁶⁵.

Profiling standards / specifications; it determines how, and which options are used to make the products of several manufacturers interoperable at the most cost-effective way.

Interoperability testing is also an important consideration. It confirms that applications are compatible with standards / specifications (conformity test) and exchange information according to predefined use cases (mutual usability test) and aims to ensure interoperability with other infrastructure components. Therefore, testing procedures should be specified to check that the technical requirements of the selected profile are met.

As a result, the Expert Group EG1, which completed its studies in June 2016 under the coordination of the Smart Grid Working Group, focused on its interoperability with "H1" and "H2" interfaces in the large-scale roll-out of smart metering systems.

The studies describe the accompanying documents, the Basic Application Profiles (BAP) and the BAP Test Specifications (BAIOPs), how the standards or technical specifications can be extended and how compliance with BAP is assessed.

In addition to specifying the standards / definitions to be used, BAP defines how they will be used, the data to be exchanged, how this exchange will be functional through their use cases. The BAP Test Specification describes testing of compliance with BAP, and the interoperability process within the smart metering system. BAPs and Test Features are essential to ensure and maintain interoperability.

In the report, the descriptions of the BAPs and the BAP Test specifications are presented as templates to help member countries and other stakeholders involved in the development of complementary documents, in particular Interface Flexibility and interoperability of the relevant interfaces. For this purpose, templates were prepared on the basis of some existing member country examples.

The Regulatory Bodies recommended the development of documents for the measuring infrastructure from Head End System to Smart Meter and for their interfaces related to H1 and H2, especially their profile creation, in planning smart metering / smart grid planning systems by EU Member States, and other stakeholders in EU Member States.

¹⁶⁴Smart Meters Co-ordination Group report - use cases

http://collaborationclc.iec.ch/LotusQuickr/clc_cenclcetsi_smcg/PageLibraryC125772900753598.ns

f/0/DAA0ACC7AB5CD4DCC1257AC90052507E/\$file/SMCG_Sec0060_DC_UseCaseReport.pdf NB – not directly available except via the CEN/CENELEC Collaboration tool

¹⁶⁵Smart Grid Co-ordination Group report - Smart Grid Set of Standards Version 3.1

ftp://ftp.cenelec.eu/EN/EuropeanStandardization/HotTopics/SmartGrids/SGCG_Standards_Report.pdf ve Smart Meters Co-ordination Group report TR 50572: "Functional reference architecture for communications in smart metering systems"

ftp://ftp.cen.eu/cen/Sectors/List/Measurement/Smartmeters/CENCLCETSI_TR50572.pdf



This project is funded by the European Union



These documents should adequately define data exchange through H1/H2 interfaces used to inform consumers or the parties determined by the consumers. They will explain the data to be exchanged, the functionality of this exchange (e.g. use cases), the standards to be used (including data formats) and how to use these standards.

This document describes recommendations for the content of the accompanying documents (Basic Application Profiles and BAP Test specifications) required for interoperability and maintenance.

2.6.6 Regulations on Communication Infrastructures for Smart Grids

The communication solution is not processed in a separate standard or structure for smart grids. All communication structures can be used, provided that they validate energy-oriented factors of countries or the Unions. Communication solutions are supervised by the relevant communication Regulator. E.g. FCC in USA, CER and DCENR in cooperation in EU, etc. energy companies cooperate with communication regulators. The main goal is to support development without hampering the standards.

Therefore, a separate smart grid communication structure or standard is not used. CEN-CENELEC-ETSI, IEC, IEEE etc. used in the EU based on the work of international standard institutions, address the desired energy delays and capacities according to their applications. Regulation of communication side is left to the communication regulators, but the restrictions are made without delaying the essence of the work.

Energy companies are deciding on the communication infrastructures they will use according to their flexibility and forward-looking activities. Ex. Hydro One in Canada, CEZ in the Czechia and ESB in Ireland have decided on which infrastructures to use by performing feasibility and expectation analysis. Decisions are made by assessing the advantages, present communication infrastructure in the country, future expectations, current regulations and possibilities for application in the field.

The communication practices that are in place in the countries with smart grids are in line with the grid ownership. Since the USA is fully privatized, all investments are covered by them. NERC (national) and FERC (federal) regulators also checks for the protection of end-users, reviews whether the directives issued by ARRA and the Government have been followed, and if not, the penalties are given. CAPEX and OPEX are therefore handled entirely by cost-benefit analysis. In Continental Europe, strong companies specialized in the market, which were former public owned monopolies are dominant. E.g. EDF in France, ENEL in Italy, Iberdrola in Spain, etc. can be examples. The competitive environment remains in a city or in regional basis and the grid is owned by the investor. A state ownership or controlling or financing investments are differing factors. In the USA, funds for smart grids have been created within ARRA, financing is provided, and audits are carried out if projects are accepted. It is possible to benefit from this fund, but institutions have to act in accordance with the country's policy.

In the specified field applications (Duke, PG&E, Hydro One etc.), use of public grid is not subject to value-added separate from the State or Regulator. Energy companies act on their own realities, as public communications networks often meet the domestic expectations. CAPEX support can only be supported entirely through the smart grid fund established in countries or unions.

Since almost all of the solutions are required to be future-oriented, interoperability or transitive nature are closely inspected by regulators (Energy and Communication), and in inconsistent cases, the regulations are followed, and penalties are imposed. The communication environment to be selected is decided as a result of the feasibility evaluation studies. Wired solutions as well as wireless can be found. In some countries, migration to the fibre



This project is funded by the European Union



environment (in case of Germany) started to be discussed throughout the country. All decisions and technological evaluations are made based on the facts of the respective countries.

2.6.7 Smart Grids Cyber Security and Data Ownership Regulations

The topic of security is carried out and implemented under the smart grid structure and operation in many countries and regions. While North America predominantly uses the publications and regulations of the USA's NERC, NIST, and FERC, Continental Europe continues with the CEN-CENELEC-ETSI trio.

The concept of cyber security for smart grids begins with understanding the fact that smart grids are actually an ICT solution. Since smart grid market is developing rapidly especially in North America, almost all of the standards and regulations regarding the market are of North American origin. In the European Union, some activities have started basing on NIST.

Historical developments on this issue are as follows:

- 1998: Establishment of the Energy Sector Information Sharing and Analysis Centre (ES-ISAC), its main purpose is to provide information, leadership and coordination for North America (Canada, USA and Partially Mexico)
- 2000: Publication of the first Station Security Standard by IEEE (IEEE SA 1402-2000)
- 2002: The first physical security guide published by NERC
- 2004: ESCC (Energy Sector Coordination Council) was established and assumed an ELDER-like task
- 2005: The Energy Policy Act and NERC Physical Security V3 have been released.
- 2006: National Conservation Plan, US Department of Energy's Energy Sector Plan and Backup Transformer Material Program published
- 2008: Remedial Transformer Program and NERC safety standard released
- 2010: Critical road map by ESCC
- 2011: First Network Security Exercises (Grid Security Exercise - GridEx 1) organized by NERC
- 2012: NERC Redundant ECT Database was created
- 2013: First FERC Electricity Highlights Study was published, Metcalf Station Attack was made, and NERC physical security methods were published
- 2013: GridEx 2
- 2014: CIP 2014 released
- 2013: the EU Cybersecurity strategy (JOIN (2013)01 final)
- 2016: the Directive on Security of Network and Information Systems (the NIS Directive) (EU) 2016/1148
- 2016: the Directive on Security of Network and Information Systems (the NIS Directive) (EU) 2016/1148 (general)
- 2017: the Cybersecurity Package (JOIN (2017) 450 final), which also includes the Cybersecurity Act (general)



This project is funded by the European Union



- 2019: Recommendation C (2019)240 final and SWD (2019)1240 final) to implement horizontal cybersecurity rules
- 2020: EU Security Union Strategy

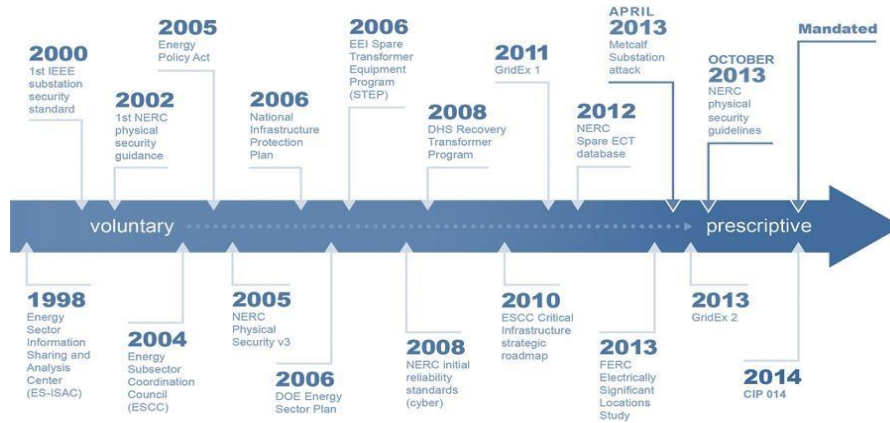


Figure 31: Cyber Security Development Map for Smart Grids

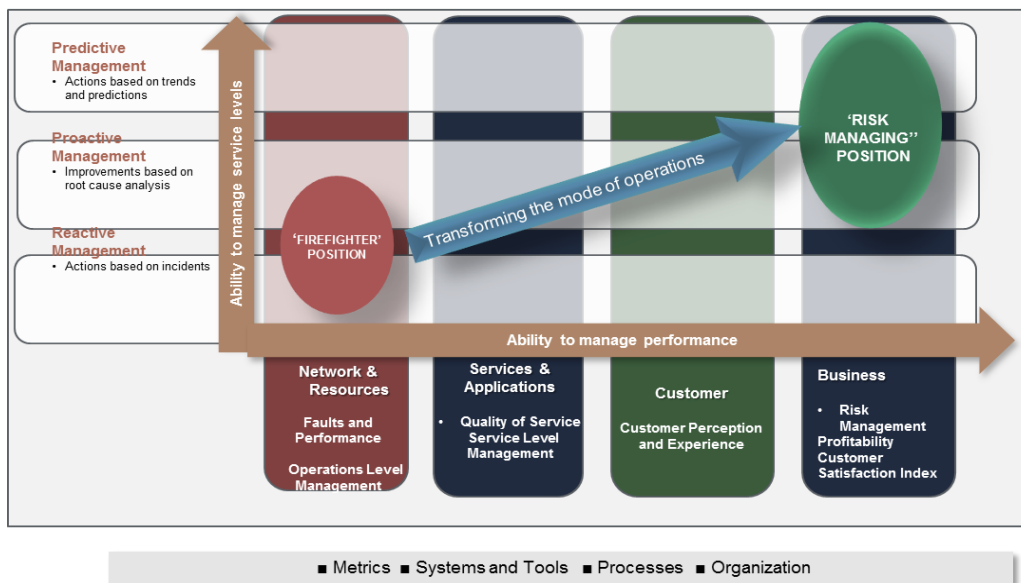


Figure 32: Transition from Firefighting to Risk Elimination

Over time, there is a clear transition from firefighting or putting out fires to preventive, risk-eliminating flow to security activities.

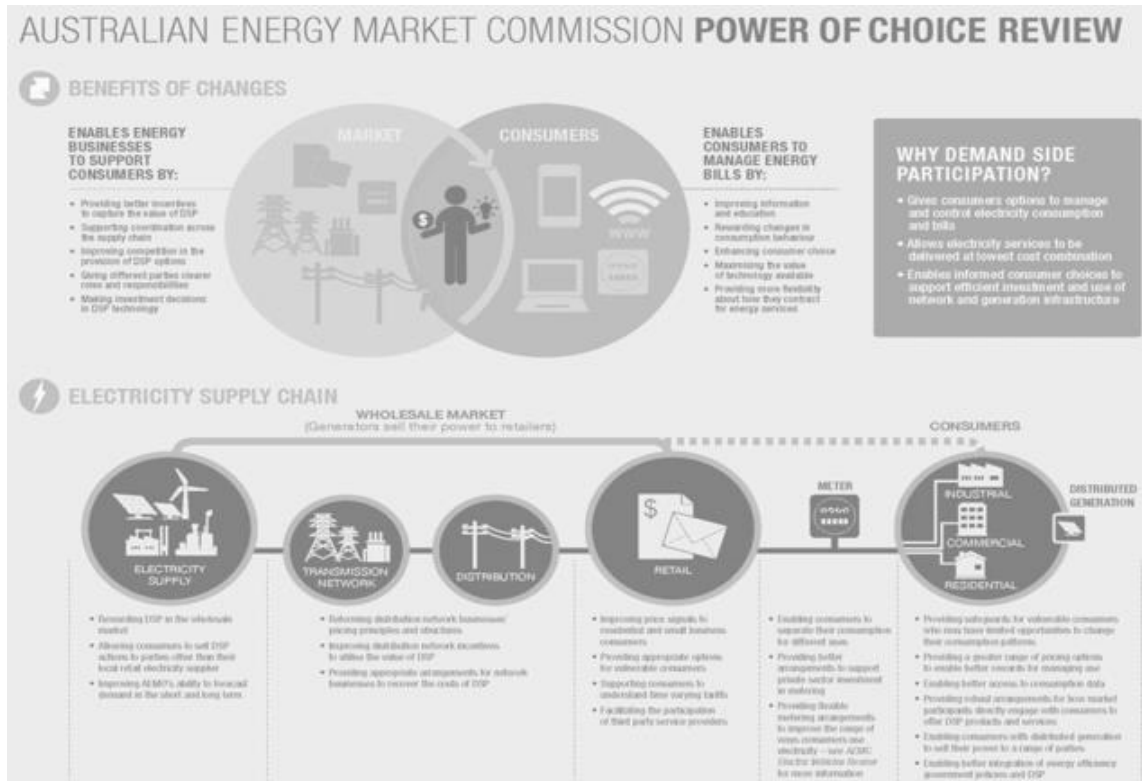


Figure 33: Australia "Power of Choice" Summary

The main key issue is to ensure the security of ICT services. The security of the entire process from generation to consumption is addressed, especially since almost all of the energy is managed over ICT. The personal information security has also taken a serious place in the issues recently.

Organizations such as NERC, FERC publish and adapt to cyber security regulations first. Equivalent organizations in other geographic regions tailor these to their local conditions.

In the Standards for Smart Grids document published in 2011 by CEN-CENELEC-ETSI, Cross/Overlapping issues, Layer-based issues (Production, Transmission, Distribution, Smart Meter, Industry, Home & Building, Demand Forecast) and roles of market players was classified.

Although there is no guidance, preferring the communication infrastructure which also provides the security infrastructure is recommended. Unfortunately, collaboration does not exist, while energy sector addresses issues within itself, communication sector addresses its own field. Structure is in parallel with Turkey's applications. As the main difference, energy companies which have more opportunity to conduct business with less regulation are more flexible and can implement the communication systems within certain rules (Duke Energy, PG&E etc.) and they are kept under control in terms of communication by organizations such as FCC.

Audits are carried out for compliance with standards, through inspections within the frame of pre-determined technical values, or through inspection upon complaints.

The best example of sanctions and punishment system is of United Kingdom's Ofgem. As explained above, routine, upon complaint, and random audits and inspections occur, and penalties are given if there is non-compliance to



This project is funded by the European Union



regulations, and these penalties are donated to affected customers or charities. Ofgem keeps very small amounts of these penalties to its own.

These audits could be on the topics such as material standards, tariffs, invoicing issues, and timely response to customer complaints etc.

International standards are indispensable, and audits necessarily refer to precedents or other regulations. Localized evaluations come into play if necessary.

Recently in June 2018 the Commission initiated a dedicated work stream on energy under the NIS Cooperation Group, which was established in the NIS Directive and which aims to exchange best practices between Member States on identification, mitigation and management of cyber risks.

In April 2019, EC adopted sector-specific guidance (recommendation C (2019)240 final and SWD (2019)1240 final) to implement horizontal cybersecurity rules and to increase awareness and preparedness in the energy sector.

Additionally, the clean energy for all Europeans package and the regulation on risk preparedness are related to measures on cybersecurity. Expert group 2 of the Smart grids task force was mandated to investigate further in 2017 and in June 2019 their recommendations on implementation.¹⁶⁶

2.6.8 Regulations on Renewable Energy Sources Integration

According to the European Commission's SWD (2016) document¹⁶⁷, currently 27.5% of electricity in Europe is generated using renewable energy, and by 2030 this rate is expected to be 50%. It is more important than ever to increase the share of renewable energies in electricity and to develop flexible demand, generation and storage solutions, with the increasing use of electricity in traditionally fossil fuelled sectors such as transportation, heating and cooling. A new regulatory framework is needed to address these challenges and opportunities. For this reason, with the revised Renewable Energy Directive and new recommendations for a new market design, it is aimed to deepen the integration of the internal energy market, strengthen consumers, increase regional and EU-wide cooperation and provide the right signals for investment, thus ensuring safe, sustainable and competitive electrical systems.

2.6.8.1 Distribution Grid Connection

Strengthening sustainable electricity supply through the improvement of the distribution network (DG-GRID)¹⁶⁸ regulatory framework for distributed generation was carried out in 2005 and repeated in 2010. In this study, distributed generation has been defined as “generating electricity from a large number of small energy sources by reducing the distance that energy must be carried”. DG-Grid focused on four main objectives;

1. Review existing EU economic and regulatory frameworks for electricity networks and markets and identify how to remove barriers to renewable energy sources (RES) and combined heat and electricity (CHP),
2. To analyse the interaction between regulations, the capacity of RES and CHP installed, and innovative grids,

¹⁶⁶ https://ec.europa.eu/energy/topics/energy-security/critical-infrastructure-and-cybersecurity_en?redir=1

¹⁶⁷ <http://ec.europa.eu/transparency/regdoc/rep/10102/2016/EN/SWD-2016-410-F1-EN-MAIN-PART-1.PDF>

¹⁶⁸ <http://ec.europa.eu/energy/intelligent/projects/en/projects/dg-grid>



This project is funded by the European Union



3. To evaluate the impact of market penetration of RES and CHP by inspecting changes in income and expenditure flows, to develop business models for an economically viable grid system and to evaluate cost / benefit analysis of different regulatory designs,
4. To develop guidelines for better integration of grid planning, regulations and distributed generation.

As a result;

- A comprehensive review of electrical regulations in EU Member States;
- Analysis of possible innovations and long-term development of electrical grids;
- Assessment of costs and benefits to grids in large-scale roll outs;
- Analysis of regulations for economically viable grid systems;
- Recommendations and guidelines for a regulatory framework developed for distribution grids are set.

Lessons learned;

- The regulatory framework should include incentives for DSOs to integrate distributed generation. Operational and capital expenditures and pricing plans for preliminary assessments should take into account the connectivity and management of distributed generation. Additional incentives should be considered to encourage innovation and R&D activities of DSOs.
- Deep connection charges which include grid retrofit costs should be avoided. Any shallow approach grid connection policy can be adopted, or the system pricing methodology can be reorganized to financially cover the contribution of distributed generation to network costs.
- If the market rules agree to bring together small individual generators, the participation of distributed generation in ancillary services and balancing markets can be increased. In balancing regulations, the time interval to submit the estimated generation should be reduced.

It was known that deep connection fees for distributed generation constitute an important network access barrier and affect the penetration of distributed generation in United Kingdom distribution systems. Radical changes in the distribution fee structure of electricity to meet and promote the RES targets of countries are necessary in order to eliminate the high barrier for distributed generation placement rate. Two main solutions have been identified and proposed. The first is to switch from the deep connection costs to shallow or non-shallow connection policies, and the second is to reformulate the distribution system usage (DUoS) pricing methodology to allow for distributed generation's contribution to grid costs. As a result, in April 2005, a shallow connection pricing policy or "temporary arrangements" was implemented for distributed generation in the United Kingdom. Temporary regulations were replaced by Ofgem in 2010 with long-term regulations.

2.6.8.2 Renewable Energy Support Schemes

The "Case Study of Renewable Energy Support Schemes in Europe"¹⁶⁹ report by CEER shows the scope and cost structures of support schemes for renewable energy sources across Europe. The CEER report covering 28 EU Member States highlights the amount of RES support, the type of support scheme, and the expenditures (technology) of RES support, and in summary the following main conclusions are reached;

¹⁶⁹ CEER Status Review of Renewables Support Schemes in Europe, C16-SDE-56-03, 11.04.2017



This project is funded by the European Union



- The weighted average paid in 2015 for renewable generation is about 110 €/MWh above the wholesale price.
- RES support schemes are an important cost for electricity consumers.
- The types of RES support schemes vary in Europe. These are;
 - Direct tariff support in 21 countries (feed-in tariffs, FITs),
 - Green Certificate support in 7 countries,
 - In addition, RES power plants are not responsible for balancing in 14 of the 28 countries.
- The amount and cost of RES support differ in terms of countries and technology.
- The cost of RES support is financed either by taxes or non-tax payments such as the consumer bill.
- The proportion of RES generation in gross electricity production differs too much among countries. In 2014;
 - 1% in Norway,
 - 62% in Denmark,
 - EU countries have an average of 16%.
- Photovoltaic, hydro and bioenergy are supported the most.

Moreover, in the Market Monitoring Report, CEER-ACER¹⁷⁰ states that RES subsidies have a significant and increasing rate in the average electricity consumer bills in Europe, with an average increase of 6% in 2012 to 13% in 2015.

This data shows that CEER: aims to draw the attention of policy makers to the importance of efficiently designing RES support plans to minimize costs. CEER supports the European Commission's proposals to integrate RES into the market and give balancing responsibility and the phasing out efforts to eliminate the priority production advantage. Issues such as RES targets, support type and procedures for determining support levels, access to the grid, balancing levels in load shedding, balancing responsibility levels and consumer empowerment through smart metering will all be the focus of discussions in the coming years.

2.6.8.3 Standards and Secondary Legislation

Increasing the penetration of renewable energy requires changes in standards and secondary legislation, grid codes in order to ensure that energy systems remain reliable and robust. Below is a brief overview of current developments and trends.

Standards:

The European Electrotechnical Standardization Committee CENELEC is working on CLC / TS 50549-2, a technical specification designed for plants connected to medium voltage distribution power grids. This comprehensive study covers normal frequency and voltage operating ranges, frequency oscillation rate, stay online in low and high voltage failures, voltage support, power quality and reconnection and synchronization after disconnection.

¹⁷⁰ CEER-ACER Market Monitoring Report (Retail Volume, November 2016)



This project is funded by the European Union



Institute of Electrical and Electronics Engineers, IEEE Standard 519-2014, has published a revision for IEEE Recommended Practice and Electric Power Systems Harmonic Control Requirements, as a result, IEEE Standard 519-1992 has been overridden. The main approach of the standard is that users are responsible for limiting harmonic currents, and system owners / operators are responsible for managing voltage quality at the point of common coupling (PCC). The main changes are; measurement techniques time-varying harmonic limits, low voltage harmonic limits (<1 kV) and intermediate harmonic limits. In general, it is recommended to comply with the measurement techniques specified in IEC 61000-4-7 and that both "very short (3 sec.)" and "short (10 min.)" evaluation methods comply with IEC61000-4-30.

The Chinese National Energy Administration (NEA) has issued a statement to speed up testing and certification efforts to guarantee the quality of wind power equipment. Accordingly, all turbine parts, rotor blades, gearboxes, generators, converters, controllers and bearings, that will be used in newly established network projects, including distributed power projects, should pass type test in compliance with "UK / Z25458-2010 Wind Turbine Certification Rules and Procedures".

Certification is done by a certification body which is granted certification excellence by CNCA (China Certification and Accreditation Agency). The standard came into force on 1 July 2015. Wind energy developers are excluding non-certified products from the tender.

Grid Codes

Network code requirements can be roughly divided into two sub-categories: static requirements for steady-state behaviour of wind farms and dynamic requirements for temporary behaviour of wind farms or sometimes individual wind turbines during failure conditions. While there are changes to the static requirements, most of the changes concern dynamic requirements, namely troubleshooting, transient over-voltage and events that support the system. In general, many of the recent changes have been associated with high voltage ride through (HVRT) requirements in the range of 120-130% and positive array mains voltage support in lines which have similar specifications as SDLWindV in Germany. These requirements are typically defined at the point where a wind energy is connected to the grid (common connection point), but sometimes it can also be defined at the point (connection point) where a single wind turbine is connected to the grid.

Europe: Progress has been made for grid code harmonization, which has been a binding EU regulation since May 2016 and has been in force under the EU laws, in the form of the national grid code regulation (NC RfG, National Code Regulation for Generation). This "umbrella" grid code was developed by the European Electricity Transmission System Operators Network (ENTSO-E), which includes 42 member transmission system operators (TSOs) from 35 countries. While NC RfG includes many common network connection requests, a large percentage of them are "not comprehensive", meaning that detailed specifications will be determined at the national level. This national implementation phase of RfG is still ongoing in EU Member States and is expected to be completed by 2018.

China: Grid code developments in China normally follow Europe, and the latest network code revision is GB / T 19963-2011. One of the most controversial aspects relates not to low voltage ride through (LVRT) performance, but to the wind turbines' high voltage ride through (HVRT) capabilities. These requirements are typically considered to be fulfilled in wind farms rather than wind turbine levels. However, the trend in China is that this is clearly a turbine level condition. In general, wind turbines must be able to remain connected to the grid if there is temporary overvoltage at the turbine network interconnection point (1.30 pu / 0.2 sec; 1.25 pu / 0.8 sec; 1.15 pu / 8.0 sec.).



This project is funded by the European Union



North America: There is no grid code valid for all regions in North America. The North American Electrical Reliability Corporation (NERC) has four isolated interconnection fields: West, East, ERCOT (Texas Electrical Reliability Council) and Quebec Connections. In addition, there are nine independent system operators (ISO): Alberta, Ontario, Midcontinent, Southwest Power Pool, California, PJM Interconnection, ERCOT, New York and New England.

There are several regulatory agencies in the U.S. that affect and shape national and local grid code requirements. According to 661A, the Federal Energy Regulatory Commission (FERC) specifies location-specific reactive power requirements to TSOs, which must be conformed to by region-specific wind power plants. NERC applies applicable standards for voltage and reactive power control to ensure reliable operation. ISO / RTO (Regional Transmission Operator) envisages network-specific requirements such as undervoltage trip, voltage regulation, dynamic reactive power control and reactive power requirements. In addition to these requirements, local system operators can specify their interconnected system requirements. Finally, the Public Utilities Commission (PUC) of each state approves renewable energy contracts for Government agencies, sets the state's renewable goals, and evaluates reviews. The recent trend has been to close coal-fired power plants and add more renewable generation such as wind and sun. As a result, ISOs are evaluating technologies such as energy storage to achieve frequency regulation due to the increasing mismatch between energy supply and demand. In the future, it is difficult to predict how grid codes will develop in the USA.

Significant expansion of renewable energy raises a number of technical and economic issues that need to be resolved. It can even prove necessary to develop new technologies. It is clear that for the wind power industry, wind farms will have to make their own contribution to the stable and therefore reliable grid operation. The technical development of wind turbines is closely related to the development of international standards and grid codes, and this will continue to the future.

2.6.9 Relationships between Distribution and Transmission System Operators

Today, ancillary services such as congestion management are mostly provided by large synchronous power plants connected to the transmission grid. In the future, due to the transformation in energy generation, generation capacities will shift from transmission to distribution level. Thus, the role of the operators of the transmission and distribution system will change, especially with regard to the provision of ancillary services. Therefore, distribution system operators are questioned about how system stability and total system responsibility can be assumed by distribution system operators and therefore they can actively contribute to the transmission system. The economic effects of changing roles in the energy market and the impact of higher coordination between distribution and transmission operators to provide ancillary services are being examined. The results show that a stronger collaboration between system operators has positive effects for both players and significant cost savings can be achieved.

As a result of the transformation in energy resources, more and more renewable energy sources have gone online especially in the distribution level with the increase in capacities installed through the distribution grid. The future shows that this trend towards increasing distributed renewable generation will continue. On the one hand, there are differences in the total system responsibility and divergence from ancillary services of the TSO, e.g. frequency restoration or re-dispatch distribution, keeping the line frequency or thermal load of electrical equipment within certain parameters, etc.

Today, these services are mostly provided by generation units directly connected to the transmission grid, and therefore TSO can make it easier to schedule the most cost-effective option, since almost all relevant information is available for the TSO. On the other hand, the distribution system operator (DSO) is responsible for the reliable



This project is funded by the European Union



operation inside its control area and must support TSO for the reliability of the transmission system. In the past, it was not necessary for DSO to use re-dispatching measures, as congestion in the distribution network was unlikely to occur.

It may be necessary to develop the relationship and regulatory legislation (traditional or new) between DSOs and TSOs to provide effective system solutions that meet the needs of a sustainable energy system. Below is a summary of the principles that CEER¹⁷¹ believe that should determine the path of future DSO-TSO relationship and related regulatory legislation.

1. Comprehensive principles: It sets the framework in which more specific principles and approaches on governance, network planning and system operation are developed. At the centre of this framework, DSOs and TSOs need to build a constructive and collaborative relationship and leadership with mutual respect. Coordination and cooperation between network operators will support effective segregation of activities and achieve optimal system output in competitive retail and wholesale markets.
2. The increased need for governance and coordination should not create any confusion in allocating relevant roles and responsibilities. Relevant tasks should be carried out in appropriate consultations between DSOs and TSOs and other stakeholders. It is essential that in this process, DSOs and TSOs' revenue regulations create incentives to optimize the results of the system, rather than focusing on minimizing the costs of DSOs and TSOs. Cross-sectoral interactions between electricity, gas and heat should also be considered in the development and management of grids and networks.
3. Grid planning: In a rapidly changing environment, transparency of state of the grid and shared convictions are crucial in defining the minimal cost solutions and creating the opportunity for innovative products and services. What matters is the need to avoid low or excessive investments (e.g. the costs incurred). In order to realize long-term scenarios and grid development plans of the increased DSO-TSO collaboration, there is a need for cooperation and collaboration between DSO-TSO as well as all stakeholders which may have a potential impact (for example, urban planning bodies and electric and gas powered vehicles).
4. Operation of the system: The changing system will make the task of overall system security increasingly difficult. However, there are also important opportunities for the DSO-TSO collaboration to gain greater effectiveness in the entire system operation. More information is needed to help DSOs and TSOs better anticipate and manage developments in their grids and to determine where one side can and should take action to support the needs of the other and the system as a whole. Regulatory legislation should not only support effective market coordination and access to flexible resources, but also create the right signals and framework that allows the competitive market to meet system needs and minimize the efforts needed by DSO and TSO.

The next step for National Regulators, DSOs and TSOs will be to consider how these principles can best be applied in the context of their country, in order to achieve maximum benefits for customers.

The overall transformation of the energy system, and significant changes in the distribution level in particular, require a critical consideration; whether it is necessary to reorganize regulatory goals and if so, in which direction and how. The National Regulators' challenges are to integrate new goals into existing goals and incentivize system operators with appropriate tools for them to strive for these goals. In this context, CEER¹⁷² identifies key areas where regulators and other stakeholders can take action to achieve the most appropriate outcome for the system.

¹⁷¹ CEER Position Paper on the Future DSO and TSO Relationship, Ref: C16-DS-26-04, 21 September 2016

¹⁷² CEER Position Paper, Incentives Schemes for regulating DSOs, including for Innovation, Ref: C16-DS-28-03, Final version 24 January 2017



This project is funded by the European Union



For these areas, approaches such as choices, innovations and best practices for balancing the entire system are presented.

The balance of options is related to the impact of the national regulators' choices, the conditions in which they operate and the participating stakeholders, in order to balance different goals and incentives against each other. Thus, defining regulatory incentives must follow an interactive process with stakeholders. In this process, regulators should openly submit their proposals, as well as support the impact assessments on incentives. Monitoring tools and indicators should be developed later and should be presented to stakeholders, where necessary, so that regulatory tools can be evaluated and adapted properly and timely.

Innovation is an important aspect when considering the effectiveness of any regulatory framework. Incentives for innovation are essentially means to achieve greater goals and can be direct or indirect. Achieving several key goals, such as innovation, service quality, cost effectiveness and security of supply is an increasingly important and widespread conviction.

When designing incentive plans for DSOs in order to help them deal with new regulatory challenges, a holistic approach, the "whole system approach" should be considered. The whole system approach focuses on the "system" concept that tries to determine the net benefit that regulatory decisions will bring to the entire electrical system. For this reason, it is vital to recognize the duties and responsibilities of DSOs and TSOs; for example, to clarify whether benefits in distribution grids have an impact on transmission system operations. While adopting a forward-looking perspective, regulators may think that DSO's regulated grid activities have an impact beyond their distribution network, it should not be forgotten that this only applies to the sectors and areas where there is no competition present.

2.7 As-Is Policy and Regulatory Framework in Turkey for Electricity Distribution

2.7.1 Overview of Energy Sector Strategic Plan

Regulatory framework for the electricity distribution sector is highly aligned and influenced by the national energy strategies and laws. The national regulatory authority, Energy Market Regulatory Authority (EMRA) acts as the oversees and regulates the market for electricity, natural gas, petroleum and LPG, ensure effective and fair competition, protect the interests of consumers, ensure safety, quality, competence, continuity, reliability in energy supply and encourages the sustainability of energy at all levels.

The regulatory framework in Turkish electricity market includes the Laws, Regulations, Communiques, Board Decisions and other related Principles and Procedures as well as strategy documents published by the Ministry of Energy and Natural Resources. In the following figure, the most important and related legislation is listed as below, with respect to the definitive order from high-level strategic papers to existing regulations that determine the framework for electricity distribution sector.

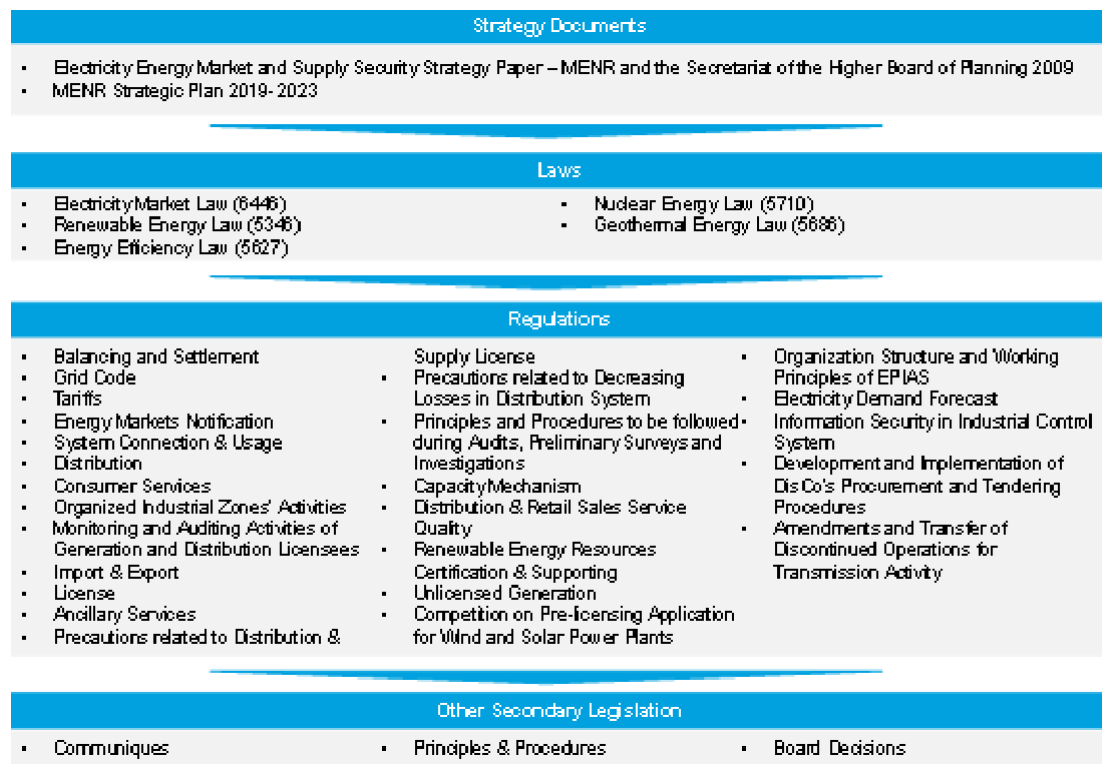


Figure 34: Overview of electricity sector regulations

Regarding the future steps of electricity sector reforms, there has been a series of strategic efforts and documents that has been mainly driven by Ministry of Energy and Natural Resources (MENR).

The main document that summarizes the current perspective for the energy industry overall is the '2019-2023 Strategic Plan' that was published by the MENR in January 2019. This strategy document is an update and continuation of the previous strategic plan, that covered the time interval between 2015-2019. "2019-2023 Strategic Plan' particularly focuses on the goals below:



This project is funded by the European Union



1. Security of Sustainable Energy Supply
2. Prioritization of Energy Efficiency
3. Enhancement of Institutional and Sectoral Capacity
4. Increase in Regional and Global Activity in Energy and Natural Resources
5. Technology Development and Localization in Energy and Natural Resources Domain
6. Increase of Predictability for Energy Markets
7. Increase of Production Capacity Through Sustainable Mining Practices

Under the strategic goals, a number of targets are emphasized in order to continue with the reforms and boost the positive transformation of national energy industry in all related sub-domains. These targets, which are clustered under the strategic goals are given in the table below.

Strategic Goal	Target
Security of Sustainable Energy Supply	- Level of installed electrical capacity based on local and renewable resources will be increased from 59% to 65% in comparison to total installed capacity. - Nuclear energy will be included in the national energy mix and efforts will be shown to increase its share in energy supply. - Natural gas and electricity infrastructure will be strengthened. - Exploration activities for petroleum and natural gas will be continued, prioritizing offshore activities. - Technological transformation activities will be implemented in electricity sector.
Prioritization of Energy Efficiency	- Efforts will be continued to increase energy efficiency. - Market infrastructure will be formed for demand side participation in electricity and natural gas markets. - Works will be undertaken to increase public awareness regarding energy efficiency. - Energy system planning will be done for electric vehicles.
Enhancement of Institutional and Sectoral Capacity	- Career management system will be developed to enhance technical capacity of employees. - Cloud, digitalization and governance systems will be developed in an integrated manner. - Strategic communication plans will be developed to increase public awareness with respect to mining, domestic coal and nuclear energy. - Regulations and human resource will be developed for nuclear energy. - Institutional and sectoral capacity will be enhanced for energy and mining industries.



This project is funded by the European Union



Strategic Goal	Target
Increase in Regional and Global Activity in Energy and Natural Resources	- Efforts will be continued to position Turkey as an energy trading hub. - In prioritized areas, strategies will be realized to improve cooperation and investment opportunities with countries of interest.
Technology Development and Localization in Energy and Natural Resources Domain	- Efforts will be continued to increase share of locally manufactured equipment in the domain of energy and natural resources - R&D projects that have strategic importance for energy and natural resources domain will be increased. - Clustering projects will be realized. - National Systems will be implemented for national energy infrastructures. - Underwork for digital transformation will be delivered for the mining industry.
Increase of Predictability for Energy Markets	- Activity and scope of energy markets will be enhanced. - Bureaucratic processes will be reduced in energy and mining investments. - Supply planning will be made in alignment with medium and long-term demand projections. - Improvements and simplifications will be made in favour of electricity and natural gas consumers. - Transparency and financial predictability of markets will be enhanced.
Increase of Production Capacity Through Sustainable Mining Practices	- Mining potential of the country will be assessed and known reserves will be evaluated. - Industrial raw materials, mining products with strategic and critical importance will be channelized to national economy. - Projects focusing on local processing of mined material into end-products will be realized. - Development of new boron products and increase in boron sales volume will be realized. - Mining activities will be continued in an effective, efficient and secure manner with respect to international standards.

Among the strategic goals and targets declared by this document, it can be stated that electricity distribution activities are central to the national energy strategy due to an enabling role in sustainable energy supply, energy efficiency, technology development and increase of market predictability. It is also clear that development trends in Turkish electricity distribution sector have direct impact on enhancement of institutional and sectoral capacity, although sectoral capacity of electricity distribution sector has already been developing in a rapid manner especially since the liberalization and privatization efforts that re-shaped the structure of the whole sector.



This project is funded by the European Union



2.7.2 Review of Secondary Legislations and Tariff Methodology

The “backbone” of regulations is mainly formed by licensing and tariff regulations, market rules (in this case “Electricity Market Balancing and Settlement Regulation - BSR”), distribution regulation and grid code and that are issued by the regulatory authority.

Licensing Regulation set forth the principles and procedures regarding the licenses to be granted to the legal entities such as license application, evaluation and issuance procedures.

Tariffs Regulation consists of principles and procedures regarding preparation, monitoring, evaluation, amending and approval of regulated tariffs in the electricity market. It also defines the criteria to prepare tariff proposals by TEİAŞ, EUAS (Wholesale), EDCos and retail sales companies as well as regulating income and/or average price caps of these legal entities. Together with the regulation, a new structure is established in order to provide more effective use of the network, reflect costs to the owners of these costs and determine new multi-period tariffs considering load profiles. Tariff types are defined within the scope of the regulation; one of them being LRT. Different tariffs can be applied by customer segment basis and considering the socio-economic structure of consumers.

Balancing and Settlement Regulation consists of detailed information and procedures on day-ahead market, intraday market, balancing power market, financial settlement of these markets, payment and collateral mechanism, procedures to be applied to eligible suppliers as well as the roles of EDCos and TSO in relation to balancing and settlement.

The **Distribution Regulation** sets forth the principles and procedures related to the reliable, low cost planning and operation of the distribution system, for the implementation of the market model set in Law No. 6446. It covers the principles, procedures and obligations of the EDCos, and users of the distribution system including facility design, operating rules, and issues pertaining to the planning and operation of the distribution system, in accordance with non-discrimination principles.

The **Grid Code** sets forth the principles and procedures regarding the standards applicable for reliable and low-cost operation of the transmission system, ensuring system stability and energy quality. The Turkish Grid Code is a technical document that is aligned with the market model and describes the required technical and operating aspects of the transmission network, ensuring stability and energy quality.

Electricity Market Consumer Services Regulation was published in May 2018 and replaced the old Regulation that was published on 8 May 2014. Consumer Services Regulation includes minimum standards, principles and procedures for the transactions between consumers, suppliers and/or distribution companies for electrical energy and/or capacity sale and those providing services regarding the same. The Consumer Services Regulation categorizes eligible consumers based on their consumption amounts as eligible consumers with high consumption amounts (more than 100,000 kWh) and eligible consumers with low consumption amounts (less than 100,000 kWh).

Regulation on Electricity Demand Forecasts was published on 7th May 2016 in the Official Gazette, bringing the following rules:

- As a result of unbundling, RetCos and EDCos have to submit demand forecasts, for a period of 5 and 10 years, respectively.



This project is funded by the European Union



- RetCos shall perform demand forecast for last resort, retail sales and eligible customer's consumption using scientific methods, considering official economic targets and taking opinion of public or private sector companies, if necessary.
- The usage of statistical models and scientific methods is emphasized, as compared to the existing regulation.
- Rules for evaluation and verification of the model is stretched and 10% confidence interval is removed. However, the model shall be verified economically and scientifically with generally accepted tests in literature.
- Forecasts, together with the data set used, are submitted to EMRA until the end of June and December each year (which was previously March) for EDCo and RetCo, respectively.
- If required EMRA can undertake demand forecasts on their own.

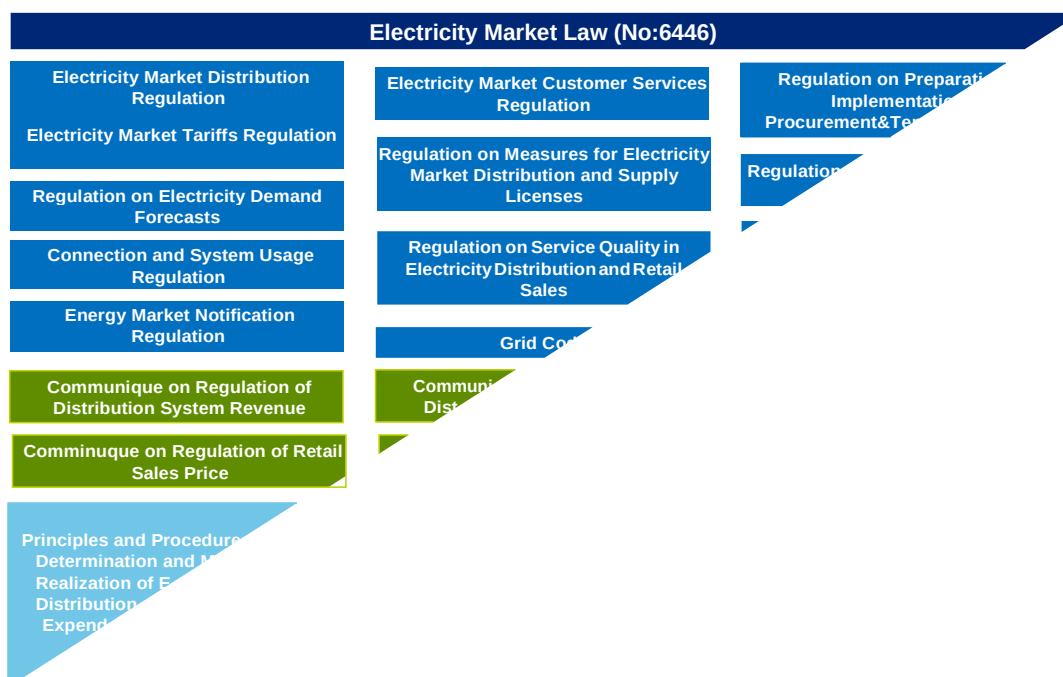


Figure 35: Overview of Electricity Distribution and Retail Legislation

Provisional Article 18 of the Electricity Market Law is related with the precautions that shall be taken to decrease Theft and Losses (T&L) in the distribution system and distribution regions whose T&L ratio is above Turkey's average T&L level. **Regulation on Precautions to Decrease Distribution System Losses**, which was published on 31.12.2015, defines the precautions that shall be taken by related EDCo, responsibilities and exemptions of these companies and adjustments that will be different from other EDCos.

EDVARS (Electricity Distribution Data Warehouse and Reporting System) Regulation aims to determine the rules and procedures in order to enable EMRA to have remote access to DSO IT systems so that EMRA can have the capability of real-time monitoring of data that DSOs are mandated to report. 'EDVARS' is used as a Turkish abbreviation for the data warehouse and reporting system that enables DSOs to perform all the reporting actions that are required by EMRA and allows EMRA to have real-time access to DSO information systems. Systems that



This project is funded by the European Union



are included in EDVARS regulation can be listed as; customer information systems, meter data management systems, asset management systems, recording / remote monitoring systems for continuity of supply, outage management systems, maintenance management systems, geographical information systems, call-centre information systems, investment-related systems, accounting systems, electronic document management systems, etc. The regulation also requires DSOs to provide detailed recordings to enable tracking of reporting business processes and requires asset management systems to provide data analytics based on geospatial information and related business processes.

Quality Factor Regulation introduces the ‘quality factor’ parameter that is used as an overall indicator of DSO performance with respect to regulations. Quality factor score, that is calculated through a series of provided formulas, is used to determine the impact of distribution activities to the DSO revenue cap. In calculations of quality factor scores, several factors are taken into account; focusing on the continuity of supply (establishment of outage recording systems, reporting requirements, performance realizations and improvements), technical quality parameters (measurement, data and reporting requirements, performance improvements), customer satisfaction performance and HSE-related performance.

Investment Regulation covers the rules and procedures for determination and monitoring of capital investment expenditures (CAPEX) by DSOs within the scope of distribution system revenue regulations. Investment planning process, including the preparation, acceptance and revision of investment plans, and the principles of investment plans and master plans are regulated under this document. Distinction of investment characteristics are recognized and rules of acceptance by EMRA are determined. Monitoring and reporting requirements for grid investments are also stated within the scope of this regulation.

A draft regulation is published by EMRA in August 2020 in order to revise and enhance the existing investment rules and procedures and is expected to become effective in the coming period. Notable changes that are revised or included within the scope of draft regulation are as follows:

- Allocation of CAPEX for R&D Dissemination Investments (Allocation of an amount of capped with 0.2% Network CAPEX for R&D Dissemination Investments)
- Non-project (‘Other’) IT investments are considered in Technological Investments category, which amounts to 5% of network CAPEX.
- ‘Smart Grid Planning’ is included and obliged as part of DSO Master Plans, including cost-benefit analysis for related investment projects.
- Flexibility in the cap for Technological Investments (Grid Management Systems CAPEX) based on DSO’s application to EMRA and justification of increase in smart grid investments

Service Quality Directive covers the regulations for DSOs, RetCos and end-users in terms of supply continuity, commercial and technical quality of electrical energy provided through the electricity distribution grids. This regulation aims to ensure that electrical energy is supplied in an economic optimum, with minimum duration and frequency of interruptions, in alignment with standardized commercial agreements and within acceptable technical power quality parameters. This regulation also indicates the cases of exemption for DSOs as well as the monetary penalties and compensations in breach of the regulation.



This project is funded by the European Union



2.8 Gap Analysis and Regulatory Recommendations for Electricity Distribution

2.8.1 Barriers and Challenges

In the highly regulated distribution sector, obstacles related to legislation and regulations are determining the ways of doing business and implementation strategies of smart grid solutions.

The main problem with smart grid legislation in many countries is the lack of published and accepted legislation on this issue, the evaluation of smart grid solutions within current market mechanisms, social pressure on electricity prices and limited investment revenues, uncertainty about how the prepared national action plans will be directed, settlement process and payment methodologies, data protection laws, lack of clarity regarding the roles and responsibilities of stakeholders, lack of standardization and different implementation practices. Considering that the generation from renewable energy sources will increase in the future, while there will be more energy in some hours, there will be an energy constraint in some hours, which makes it necessary to develop a market structure that enables flexibility. Although there are currently ancillary service mechanisms such as spare capacity and frequency controls within the scope of existing market mechanisms, they support traditional generation facilities such as gas power plants. Another obstacle is the need to provide reserve capacity over a period of time (e.g. 4 hours in Germany), which causes the flexible load approach, which can be offered for a shorter period, especially on the demand side, falls outside the scope of the legislation. In order to overcome this situation, in countries that practice in this way, market access requirements are made possible to introduce fewer or shorter loads.¹⁷³

Another obstacle encountered in the implementation process of smart grids is economic difficulties. Some of the recommended methods to overcome economic challenges are the exclusion of investment cost and elimination of risks with appropriate agreement or service models. In these cases, an external operator may carry out the planning, installation and operation of the smart grid. For example, there are independent companies that carry out the marketing of flexible potentials in Germany. However, with this method, there is a possibility of reducing profitability as the economic benefit is divided between the system operator and 3rd party service provider. Another method to overcome economic difficulties is to provide incentives such as investment support, tax reduction, and reduction in energy costs for smartgrids.

It is important that policies regarding smart grids support investments in this area. For example, there are different options such as time-of-use based tariff for the active participation of customers in the legislation, net and open cost repayment policies that will contribute to the reduction of investment risk, giving various incentives to organizations, more preferable conditions and social benefits related to depreciation. .

According to research by CEER, 79% of EU Member States use price regulation mechanisms to promote smart grid, and 63% use performance indicators. In addition, it has emerged that 76% of countries need to develop regulatory tools for smart grid development. The smart grid legislation arrangements recently made or foreseen in some European countries can be summarized as follows:

¹⁷³ Report on Non-Technical Barriers for Smart Energy Solutions, Hamburg University of Applied Sciences (HAW Hamburg), March 2013



This project is funded by the European Union

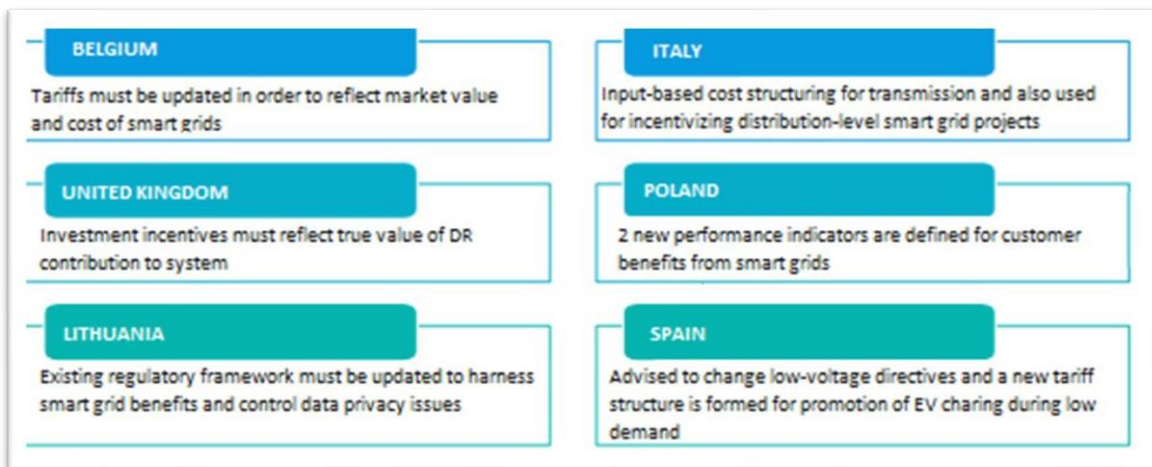


Figure 36: Example Smart Grid Legislation Regulations

Stakeholder Management



There are many stakeholders from policy makers, service providers, electricity customers, financial institutions in the process of establishing and expanding smart grids. According to the analysis by CEER, distribution system operators play a role in the development of smart grids in majority of EU member countries (84%). In a smaller number of countries, it was observed that regulatory agencies (44%) and transmission system operators (40%) played an important role, while suppliers (52%), Government (56%) and technology providers (56%) played a major supporting role. Some institutions, such as universities, research institutes, independent consultants, manufacturers, local authorities, are among stakeholders.¹⁷⁴

Many customers do not have detailed information about electricity procurement, but mainly focus on electricity cost, and some research has revealed that power outages and quality of electricity are less important than expected for consumers, especially for residential consumers. On the other hand, there is little incentive to change consumer habits. The main reason for this is the low awareness of smart grid solutions and their effects.

All stakeholders need a clear vision for the smart grid development process to function properly. It is necessary to have stakeholders in concord, have a win-win situation for each stakeholder, and end-customers should be considered in all cases. In order to achieve all this, it is important to increase the education and awareness of smart energy solutions and an important communication and change management effort is required in this process. It is necessary to explain the vision to stakeholders, to explain the advantages of smart grids (enabling the power grid to stabilize at a lower cost, no need to build any new facility for demand side participation, the advantages of distributed generation, reducing CO₂ emissions and its contribution to sustainability, etc.), to inform the consumers

¹⁷⁴ CEER Status Review on European Regulatory Approaches Enabling Smart Grids Solutions ("Smart Regulation"), 2014



This project is funded by the European Union



about the urgency and importance of the issue, to have the stakeholders agree on vision, to develop criteria for monitoring the process and to activate the leadership by regulatory agencies.

On the other hand, with practical thinking, with the introduction of smart energy solutions and automation of processes, organizations may experience concerns that they will lose control and experience potential problems with quality and interruptions. However, experience shows that these problems can be avoided by careful planning of smart energy solutions., testing and training of the personnel.

Standards and Interoperability

The absence of rules regulating technical and security standards and standards about information and communication technologies in the development process of smart grids is the main problem currently faced in many countries. Existing rules for data protection may not be specific to smart grid operation. In this regard, national institutes, industry collaborations and national standardization institutions in many countries have created road maps. In the EU, there has been a visible progress in legislation on the standardization process. The following is the EU's steps towards standardization.¹⁷⁵:

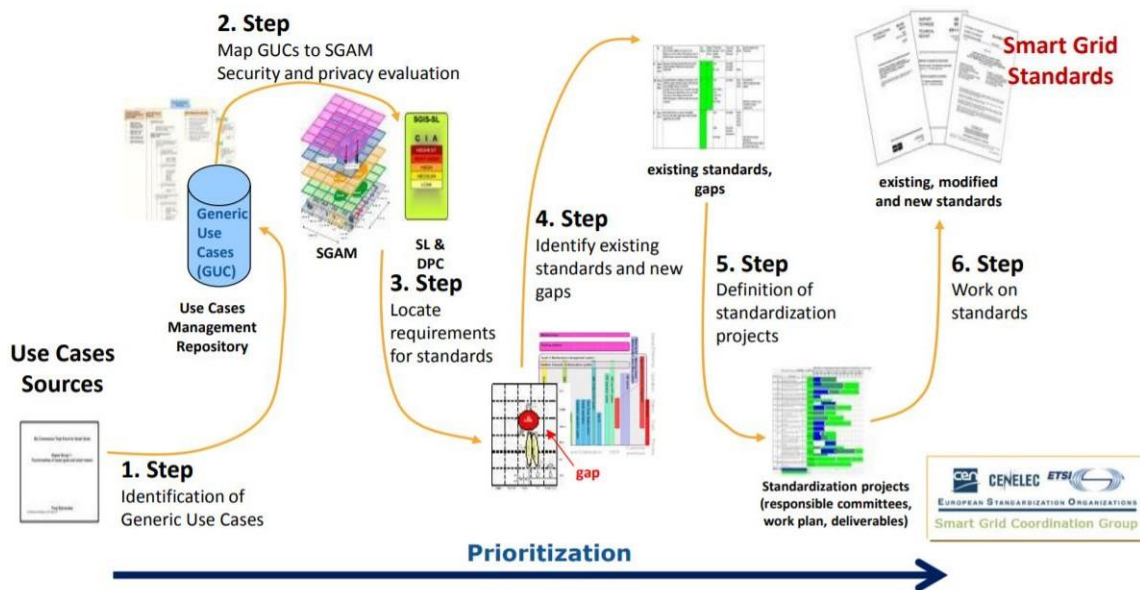


Figure 37: EU Smart Grid Standardization Steps

Another issue that may be included in the scope of standardization is data protection, security and cyber security. As a result of the establishment of smart grids, it is inevitable to create large-scale data and increase the data exchange between the parties. In this context, some countries have started to work on data protection and data security. As an example, the European Commission, dated October 10, 2014, [Data Protection Impact Assessment Template](#) for Smart Grid and Smart Meter Measurement Systems was published. It is a guide to providing basic rights to protect personal data and ensure privacy in smart grid applications and systems and smart meter setup.

¹⁷⁵ Challenges & Actions for Smart Grid Deployment in the EU Internal Energy Market



This project is funded by the European Union



This guide provides an assessment and decision-making tool that helps organizations plan and run smart grid investments, identifying risks on data protection, security and privacy.

Resource & Business Model Alignment

In addition to the identified barriers mentioned so far, in the development of smart grids, competent human resource deficiencies and difficulties such as keeping up with new business models and rapidly changing technology should also be considered.

Overall landscape for smart grid solutions and technologies is in constant development and this requires for all the involved stakeholders to strongly align their business scopes, operational perspectives and available resources to technological innovations and adapt to the ideas of new business models that are enabled by smart grid deployments. Inclusion of bi-directional data flow and intelligence, strong emergence of prosumers and EV owners and overall potential of heavy growth in the number of independent actors and interactions are some of the key changes that need serious considerations and planning in transition management practices, especially by electricity DSOs.

EREG Consultation Paper on Smart Grid Barriers:

Some of the barriers identified by EREG are: uncertainty, lack of clear roles and responsibilities, data management, security and privacy issues, political will, regulatory structures and alignment of incentives, market requirements, ineffective implementation of unbundling, insufficient supporting schemes for RES, lack of definition of smart grids functionalities, safety and more. EREG believes that some of these tentative barriers can be solved through the European Commission's task force for the implementation of smart grids in the internal energy market, as this task force plans also to deal with definition of roles and responsibilities and issues related to data handling, data protection and data safety. EREG agrees that possible barriers should be identified and considered. Their impact will differ across Europe; however, EREG still considers that there are no fundamental barriers to the deployment of smarter distribution and transmission systems where necessary and cost-efficient.

One other barrier, not mentioned in the Consultation Paper, referred to the availability of skilled workforce (especially with reference to the knowledge of innovative solutions). Indeed, one respondent mentioned as a possible performance indicator the percentage of time / human resources devoted to training activities. EREG agrees that sufficient trained, educated and available personnel are necessary now and, in the future, however, the means to achieve this need to be further elaborated and discussed by relevant parties, mainly at national level.

Engagement of grid operators with their network users was mentioned as an important item for the deployment of smart grids. In addition, the need for the engagement of suppliers (and more generally, players acting in competitive markets) with their customers was mentioned. EREG believes that this is an important issue for an effective user-centric deployment of smart grids. EREG believes that a possible regulatory approach to promote user and customer engagement is carefully to address the regulation of commercial quality (i.e. information, customer treatments, etc. provided by regulated parties to their users and customers).

- Whereas the four responding TSOs observed no risks (or do not explicitly reply), mainly due to unbundling provisions, all six DSOs which explicitly replied envisaged risks of cross-subsidies.
- Industry Associations did not seem concerned that cross-subsidising between TSOs and DSOs would be any problem; to the extent this is necessary due to the nature of their businesses. However, they have some



This project is funded by the European Union



more concern towards new services and non-regulated companies. One respondent emphasises that it should be prevented that users and especially vulnerable users are charged for expenses and developments they will hardly benefit from.

The research/consultant group see that cross-subsidies can happen, but the risk can be reduced by regulatory measures, inter alia a more efficient unbundling also of distribution system operators. One of the respondents in this group answers clearly that there are no risks of cross-subsidies, another one that intelligent regulatory rules can prevent any cross-subsidising between stakeholders.

As anticipated, ERGEG believes that TSOs and DSOs are the prime movers for the deployment of smart grids, also by allowing new marketplaces and opportunities for suppliers and energy service companies. With respect to the latter, it is evident that grid tariffs do not pay expenses by actors in competitive markets.

In addition to a careful implementation of unbundling provisions, a thorough evaluation of the distribution of costs and benefits related to smart grids across the whole supply chain and a clear identification of roles and responsibilities of the different stakeholders were mentioned as instruments to avoid future cross-subsidies. With respect to the latter, the ongoing activities within the task force on smart grids promoted by the European Commission focus on roles and responsibilities and can contribute regarding these matters.

Apart from the barriers outlined by ERGEG, a number of additional challenges are listed below that are related to smart grids for electricity distribution:

- Lack of EU-wise technical standards for individual technologies, as well as for the interoperability of smart grid solutions for electricity distribution,
- Smart grid deployments in electricity distribution networks are wide in EU, in this context considerable lessons learnt is available that can serve as best practices for the deployment of smart grid solutions for DSOs,
- Lack of active participation of electricity distribution companies in the development of smart grid technologies,
- Strict data protection laws and the new General Data Protection Regulation (GDPR) can be, in some cases, a barrier for the exploitation of the full potential of the deployment of smart grid solution (e.g. In the case of smart meters for electricity),
- Lack of clear regulatory framework and/or existing complex regulation constitutes a barrier for the fast deployment of smart grid solutions for electricity distribution,
- The existing regulatory framework does not provide the necessary incentives to electricity DSOs to invest in innovative smart grid technologies that will generate benefits for the end-customer in the long run,
- Lack of a performance-based regulatory framework that will encourage electricity distribution companies to increase the efficiency of their networks via the deployment of smart grids solution, and
- Lack of clear roles and responsibilities for the regulated entities to encourage the introduction of new services or markets.



This project is funded by the European Union



2.8.2 Overarching Principles

In the electricity distribution industry, legislation and regulations have a direct impact on the way they do business and to determine the implementation strategies of smart grid solutions. In the process of smart grid transformation, the regulatory framework should be supportive and encouraging the activities of distribution companies in this area. In this context, price regulation mechanisms or performance indicators can be used to encourage smart grids.

While developing legislation for smart grids, the following topics should be considered as main objectives:

Improved System Operations	Increased Economic Efficiency	Increased Resources for Customers
• More effective and efficient usage of network • Improved customer service, reduced cost	• Creation of situational awareness: more information on system usage and costs • Increased confidence in dynamic pricing	• End-use efficiency • Distributed generation and active end-user system

Figure 38: Main Objectives in the Development of Smart Grid Legislations

There are many stakeholders from policy makers, service providers, electricity consumers, financial institutions in the process of establishing and expanding smart grids. In order for the smart grid development process to function properly, it is essential to harmonize all stakeholders, to establish a win-win situation for each stakeholder, and to consider end consumers in all circumstances. It is of great importance that all these are taken into account in the development of smart grid legislation.

Main principles for the development of smart grid regulations are briefly described below:

Overarching Principles for Smart Distribution Grids
OP1: Output and input regulation EMRA should focus on outputs in their regulation of distribution companies, by designing the regulatory framework taking into account both the economic and technical aspects, as well as the fact that developing a smart grid is not a goal in itself, but is a means to an end, i.e. a regulatory approach towards smart grids alone, is not envisaged. However, since the deployment of a smart grid is a heavy technical endeavour, input regulations cannot be neglected. Input regulations may be related to the preparation and approval of the network codes, as well as to standardization issues which fall under the input regulation.
OP2: Effects and benefits expected by smart grids The application of smart grid technologies and services for the distribution companies, should have clear effects and benefits towards both the DSOs, as well as towards the consumers. Such benefits may include: • Increased sustainability,



This project is funded by the European Union



- Adequate capacity of distribution grids for providing to consumers,
- Adequate grid connection and access for all kinds of grid users,
- Satisfactory levels of security and quality of supply,
- Enhanced efficiency and better service in supply and grid operation,
- Coordinated grid development through regional and local grid planning to optimize distribution grid infrastructure; and
- Enhanced consumer awareness and participation in the market by new players.

OP3: Performance indicators and output measures for smart grids

EMRA should have in place a clear and straightforward approach for the evaluation of smart grid projects, based on performance indicators and output measures. The evaluation framework should be based upon transparent Key Performance Indicators (KPIs), so that all targets are measured and evaluated in an observable, quantifiable, and verifiable manner. Moreover, these indicators should be supported by a complete regulatory framework and a long-term reasonable rate of return to avoid the sub-optimization for some of the indicators. Additionally, wherever the performance targets and the corresponding indicators are associated with economic effects, they should be decoupled from external effects outside the control of the DSOs. Finally, the evaluation process should be implemented in a form of reward/penalty compensation mechanism based on the best output measures.

OP4: Encouraging innovation along research, development, demonstration chain

EMRA should foster innovation and research and development (R&D) activities related to smart grids for distribution. KPIs for innovation and demonstration projects should differ from the performance indicators for large-scale and/or rollout projects. This differentiation is justified by the fact that the innovation and R&D activities include also additional elements, such as the dissemination of the results and the required training, as well as they should also take into account the replicability of the projects. Moreover, according to ERGEG, KPIs for demonstration will also depend a lot on what is actually being trialled. It was remarked, and ERGEG fully agrees, that the performance-based approach could fit well the deployment phase, whereas different approaches for incentivizing the demonstration phase might be opportune.

Smart grid technologies for distribution networks, as well as potential demonstration and large-scale projects, should be evaluated according to a nation strategic roadmap for smart grids for energy networks to be developed by EMRA in collaboration with the energy network operators. This evaluation needs to take into considerations the following aspects:

- Identification of what it is research, development, demonstration and deployment,
- Ex ante and ex post assessment of benefits,
- Ensure market participants as point of contact to the customers assuring that independent market operators are involved in measuring benefits,
- Replicability and openness of projects,
- Transparent validation procedures,
- Well-defined and transparent criteria for monitoring of demonstration projects,



This project is funded by the European Union



- Evaluation of project indicators tailored to each demonstration allowing to measure projects' results; and
- Ensure proper coordination among research projects, including avoidance of overlapping and duplication.

It remains at EMRA's responsibility to assess the benefits and the costs of the possible large-scale or demonstration projects for smart grids, according to national priorities and in coherence with the applicable national regulation systems.

OP5: Standardization, harmonization and interoperability

Interoperability is a key requirement for smart grid projects. It should be mentioned that even though some technological domains are already covered by a sufficient number of standards, there are cases where interoperability standard are missing. Moreover, there technical domains where a large number of standards are available, thus making the selection of the appropriate standards by the DSOs a complicated process.

It is highly recommended that EMRA establishes a task force for the implementation of smart grids in the internal energy market. The purpose of this task force is to deal with inter alia services and functionalities for smart grids and smart meters, as well as a standardisation strategy for smart grids.



This project is funded by the European Union



2.8.3 Regulatory Recommendations

The following table provides the detailed regulatory recommendations for smart grids for electricity distribution.

ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R1	Tariff Methodologies and Incentives	Incentivizing Strategic Smart Grid Projects	Additional premium might be added to CAPEX in case electricity DSO makes expenses for strategic smart grid projects. EMRA may select a few projects for each tariff period that will receive pre-defined incentives. This selection can be performed through an application/competition process and the incentive is recommended to be approved based on a systematic evaluation of KPI-realization for individual projects.	Incentivization of a selected number of Smart Grid projects that go through a competitive stage will catalyse the Smart Grid transformation in the distribution industry. Competitive process for additional incentives will result in strategic project concepts with higher quality and more ambitious goals, and a transparent competition process will motivate DSOs to improve quality of their project applications. KPI monitoring of incentivized projects will ensure stricter monitoring, higher regulatory engagement and increased possibility of high-impact project results for the industry. A good example can be found in Italy, based on ARERA Resolution No. ARG/elt 39/10. On the basis of a competitive process, the resolution provides an additional 2% extra on Weighted Average Cost of Capital (WACC) remuneration for a period of 12 years on the part of the distribution RAB associated with investments needed for the demonstration project.	This methodology is not applied by EMRA for Smart Grid CAPEX or R&D projects. Application/evaluation stages exist for biannual R&D project applications.	EMRA, DSOs
R2	Tariff Methodologies and Incentives	Allocated CAPEX for Smart Grid and Technology Investments	10% of the Network CAPEX + ad-hoc application to EMRA for further budget with strict justification of additional projects	Following the initial phases of Smart Grid system investments, an enhanced Smart Grid management requires implementation and integration of several systems and components within a single framework. Increase in the number and scope of Smart Grid systems require a higher portion of overall CAPEX as the investment scope should slide towards high technology system deployments. Turkish DSOs' smart grid roll-out/maturity level is relatively lower than EU standards, so it is recommended that to be encouraged via increased allocated smart grid/technological budgets. This allocation will increase focus of DSO managements on the technology investments and provide leverage for Smart Grid transition.	5% of the network CAPEX is allocated for Smart Grid and Technology Investments, with ad-hoc application to EMRA for further budget	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R3	Tariff Methodologies and Incentives	Allocated CAPEX for R&D Dissemination Investments	2% of the network CAPEX + ad-hoc application to EMRA for further budget	Although only R&D projects may successfully result in ready-to-use outcomes, a certain ratio will deliver usable products and solutions that can have direct positive impact on real-life operations and business processes and practices. Allocation of a significant R&D dissemination budget will allow focus and create initiatives for widespread usage of R&D outputs and speed up the financial returns for DSOs and the funding mechanisms. Dissemination of Smart Grid R&D solutions is also strongly recommended by ERGEG/CEER in their Smart Grid position papers and regulatory reviews.	0.2% of network CAPEX is allocated for R&D dissemination investments in the draft legislation for investments (as of August 2020)	EMRA, DSOs
R4	Tariff Methodologies and Incentives	Incentives for Extension of Network Assets Lifetime	Development of indirect incentive methodologies to increase network asset performance and extend operational lifetime through advanced asset management practices.	Practices for extension of asset lifetime require lower budget amounts in comparison with costly grid reinforcement and renewal projects. Incentives for advanced asset management practices will provide flexibility in investment planning and create a culture of advanced and pro-active maintenance on existing network components. Smart Grid monitoring capabilities and management practices such as using data analytics for predictive maintenance have significant potential for avoiding failures, increasing savings on OPEX and CAPEX and extending asset lifetimes.	Indirect incentive mechanisms for network assets' lifetime extension is not included in existing practices.	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R5	Tariff Methodologies and Incentives	IT/OT System Licenses and After Sales Services to be Considered as Uncontrollable Component of OPEX	• Yearly license fees regarding database, operating system and other related software solutions • Maintenance agreements for all the technological systems and infrastructure that complete their warranty periods • Expenses in this category are not expenses that are directly controlled by the DSOs and mainly dependent on vendor pricing policies, thus vendor dependency exists. (Competitive environment is very limited or non-existent) • It will be useful to specify these expenses as 'Uncontrollable OPEX' component and provide income allocation with respect to realized expenses (through invoices) of DSOs within the Tariff Period. • Certain conditions may be defined in order to ensure that invoices regarding the license and maintenance agreements are provided directly by the related system supplier or re-seller company. • A estimated budget can be determined before the Tariff Period with respect to this cost item and can later be revised according to realized figures.	Deployment and operation of IT and OT systems are dependent on after-sales vendor support as the software component in these systems requires fixes, improvements and upgrades to remain effective in operation. Majority of IT/OT system vendors place additional pricing on periodic software licenses regarding database, operating system or other features/components. Pricing policy behind these items are not controlled by DSOs and are difficult to precisely estimate for upcoming years of system usage. Thus, this expense item is 'uncontrollable' by its definition and should be registered as an 'Uncontrollable Component' in OPEX considerations.	These OPEX items are not considered as Uncontrollable Component	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R6	Tariff Methodologies and Incentives	Methodology to Define OPEX Requirement for IT/OT Hardware	- Expenses related to all hardware (RTU, IED, modem, smart meter, backbone router, server, etc.) which do not complete their useful lifetime but require partial or complete replacement due to malfunctions or similar reasons. - There may be several approaches for OPEX budget calculations. Each IT/OT hardware type's repair/replacement need can be evaluated through their MTBF values, assuming that certain percentage of all hardware will be annually replaced or repaired (using spent and planned CAPEX values for same hardware categories).	IT and OT hardware are critical components in daily grid operations, especially when DSOs are adapting the transition to Smart Grid management philosophies and deploying technologies with IT/OT components. Unexpected problems with IT/OT hardware require fast solutions in terms of repair or replacements in order to avoid any negative impacts and potential economic losses in grid operations. Definition of an OPEX allocation for this purpose will ensure proper responsiveness for sustaining IT and OT systems.	No as-is methodology.	EMRA, DSOs
R7	Tariff Methodologies and Incentives	Economic Lifetime of IT/OT Assets/Systems	It is recommended that the minimum period of time for acceptance of technology infrastructure renewal investments as CAPEX should be accounted in accordance with the useful lifetime periods as stated in Tax Procedure Law, instead of accepting it as 10 years. For example; - Server: 4 years - Software: 3 years - Network Router: 5 years - Tele-control systems: 5 years - Etc.	Technological equipment that can be considered as IT/OT assets are generally used as subcomponents of a larger, more complex system or solution. Depending on asset type, function and capacity, expected/estimated lifetimes of such equipment are various. Manufacturers of these components are also delivering warranty periods of much shorter times in comparison to accepted 10 years interval. It is therefore necessary to acknowledge this situation and evaluate renewal periods according to asset types and expected lifetimes in CAPEX. EURELECTRIC acknowledges this situation and recommends that smart grid investments such as ICT investments should be accepted with shorter lifetime periods.	In effective legislation, minimum period of time for acceptance of technology infrastructure renewal investments as CAPEX is accepted as 10 years. However, in the recent draft legislation for 'Rules and Procedures for Determination of Electric Market Distribution System Investments', this period is revised as 5 years for computers/PCs, tablets, indexer devices, mobile phones ve printers under the scope of Technological Systems'.	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R8	Tariff Methodologies and Incentives	CAPEX Category for IT Expenditures without a Project	It is suggested that all technological investments such as PCs, server/network hardware, tablets, etc. and all software and hardware components that are required for testing technological infrastructure should be evaluated under the scope of 'Grid Management Systems' and not under the scope of 'Other Expenses In Form of Investment Expense' (%1).	Due to the increased level of technology components and usage in transition to Smart Grid, IT systems are a major part in reliable grid management activities. IT expense items such as PCs, servers, network hardware, tablets and other IT equipment that are in direct use for grid management purposes by central or field teams. It is beneficial to evaluate IT expenditures in the same context with 'Grid Management Systems' and allow DSOs to manage that budget according to operational requirements and priorities.	In effective legislation, IT expenditures are considered under the scope of 'Other Expenses in Form of Investment Expense'. Recommended change is in alignment with the Draft legislation, which foresees inclusion of IT expenditures (computers/PCs, tablets, indexer devices, mobile phones, monitors, printers and similar assets) under 'Technological Systems'.	EMRA, DSOs
R9	Smart Grid Planning	Identification of Targets of Achievements for DSOs about Smart Grid Roll-out	EMRA is advised to determine the principle guidelines, targets, achievement targets and evaluation criteria for DSOs about Smart Grid roll-out projects, digitalization, technology deployment and practices within the IV. Implementation Period	Introduction of identified achievement targets and KPIs for Smart Grid roll-out projects will ensure performance-based monitoring of DSO activities by EMRA. As part of common regulatory processes and project management practices, KPIs are widely used in notable Smart Grid programs in EU. In some European examples such as the UK, NRAs request business plans, including smart grid targets and achievements, from DSOs and monitors the progress according to the statements given in these plans.	Guidelines, performance objectives and KPIs are used in conventional regulatory framework for DSOs. Relevant performance objectives and indicators for Smart Grid projects have not been particularly identified but widely discussed in preparatory projects such as TAŞ2023.	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R10	Smart Grid Planning	Smart Grid Master Plan	Include Smart Grid Planning in DSO Master Plans as a Regulatory Requirement	Inclusion of Smart Grid Planning as a component within DSO Master Plans for each regulatory period will ensure harmonization between the regular network planning and related Smart Grid projects. This will also allow scope and KPI standardization for DSO targets in the tariff period. Several EU countries develop smart grid and smart meter roll-out plans and NRAs encourage DSOs to comply with the national roadmaps in their planning efforts. In the UK, DSOs present their smart grid roll-out plans embedded within their business plans.	Already in draft "Rules and Procedures for Distribution Investments"	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R11	Smart Grid Planning	Minimum Requirements for Smart Grid Master Plan	- Smart Grid Master Plan must contain information on the as-is status of Smart Grid components. - Actions for more effective usage of functionalities in existing infrastructure or systems and improvement of activities must be included in the planning. - Smart Grid Master Plan must have details in 'Project' granularity - There must be CBA studies completed for each project proposal and a prioritization must be made in scope - Minimum requirements for the project definition in planning phase must be: project name, scope, objectives, targets, qualitative and quantitative benefits, related technologies, anticipation of hardware and software components, as-is status related to project concept, project period, anticipated calendar and budget requirements - A separate section covering regulatory recommendations must be included in the Master Plan, including new business models, new service definitions and market re-structuring plans	A multi-year Smart Grid Master Plan is the core strategic document (or a set of documents) that will guide the transition process for DSOs and ensure alignment of Smart Grid projects while tracking the progress. This roadmap plan is especially useful in the beginning phase of a widescale Smart Grid portfolio investment, but also continue with updates throughout the transition management. Many national or regional examples can be found such as UK (DSO Business plans) Ireland (SEAI - Smart Grid Roadmap), Germany (BDEW-Eurelectric SG Roadmap) etc.	Our recommendation is in line with the amendments in draft "Rules and Procedures for Distribution Investments"	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R12	Smart Grid Planning	CBA as a Complementary Tool of Decision Making in Planning	Inclusion of cost-benefit analysis (CBA) with respect to smart meter and grid monitoring/control/automation roll-out planning; prioritization of all projects that are included in the planning with respect to CBA outcomes.	Usage of CBA as a complementary decision-making tool is useful in objectively evaluating a large number of Smart Grid projects with various sizes and complexity levels. This method is embedded in decision making processes for Smart Grid projects and many guideline documents have been published by key institutions such as EU JRC, CEER and IRENA as well as academic and industrial papers. Deployment of smart metering systems are recommended to be subject to cost-benefit analysis in EU Directive in accordance with the Commission Recommendation 2012/148/EU. CEER recommends that (Smart Grid) projects shall be disseminated, societal cost-benefit assessment shall be performed and output regulation (value for money of users) shall be introduced. In the UK, business plans presented by DSOs to NRA includes CBAs for Smart Grid projects.	CBA is selectively used in evaluating significant Smart Grid investments or used in evaluation discussions for future projects but is not a common practice applied by all DSOs yet. Draft "Rules and Procedures for Distribution Investments" require DSOs to implement CBA in their smart grid planning activities.	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R13	Smart Grid Planning	Smart Meter Roll-out Planning	Roll-out planning with a detailed design and selection of smart meter locations in the resolution of neighbourhood and implementation of DSO-specific CBA studies	Smart meter roll-out projects are highly complex and large in scale due to large number of metering points, variety in grid and geographical topology, customer types and distribution. Roll-out planning is essential in order to handle a cost-effective procurement, logistics and installation phase without unexpected technical or administrative problems. Due to level of common characteristics, technical constraints and ease of implementation; roll-out planning is suggested to proceed at a resolution of neighbourhood. Roll-out planning had been done with all large-scale smart meter projects in leading countries such as Italy, Sweden etc. Inclusion of CBA is recommended as supported by EU Directives, CEER and as practices by multiple European NRAs for Smart Grid projects including smart-metering roll-out projects.	Nationwide decision for full-scale smart meter roll-out has not been given yet and there is no regulation for planning activities of a roll-out project. Existing AMR metering projects ('OSOS') are limited in terms of metering points and has been implemented for high-consumption customers with scattered nature. The concept of roll-out planning has been discussed in 'Smart Metering' part of one of the key projects such as 'TAŞ2023' but no further action is taken by EMRA yet. A project that spinned off from the results of TAŞ2023 project that is related to AMI is named 'MASS (National Smart Metering Systems) Project'. This project aims to develop technical requirements and roadmap for implementation of smart metering solution nationwide. All DSOs and ELDER (Industrial Association of Electricity DSOs) are stakeholders in this project.	EMRA, TEDAS, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R14	Smart Grid Planning	Harmonization of Smart Grid Planning Activities of Different Energy Sectors	Harmonization of electricity distribution smart grid planning with electricity transmission and gas distribution	Electricity distribution has points of connections or overlaps with electricity transmission (TSO-DSO interconnections) and gas distribution networks (customer interface). Harmonization in deployment of Smart Grid systems will provide benefits for TSO, Electricity DSO and Gas DSO in leveraging their grid management capabilities. For TSO-DSO interconnection, provision of grid services and monitoring/control capabilities can be enhanced through harmonized investments. For Electricity-Gas DSOs, harmonized efforts in smart metering and customer engagement can reduce project expenses and create mutual benefits. There are R&D projects and guideline studies for TSO-DSO interoperability in Smart Grid domain in EU, under EC, EDSO and H2020 projects.	Technical criteria for TSO-DSO interaction exist in conventional grid operations but Smart Grid harmonization is not within discussion scope due to lack of clarity and consensus in Smart Grid visions of state-owned TSO, 21 private DSOs and EMRA. Gas DSOs are privatized at a later period than electricity DSOs and many of them are not developing their Smart Grid visions and investment plans in alignment with electricity DSOs. There does not exist a comprehensive platform that brings all parties under a unified Smart Grid vision.	EMRA, TEİAŞ, Electricity DSOs, Gas DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R15	Smart Grid Planning	Harmonization of Smart Grid and Smart City Efforts	Harmonization with other urban infrastructure operations such as telecommunication, water, municipal services, etc.	Urban infrastructure management is comprised of multiple services and layers, including electricity, gas, telecommunication, water and municipal services. Harmonization of Smart Grid and Smart City efforts for certain urban environments is essential to renovate and modernize the overall perspective on the urban infrastructure and the intelligence level of urban services. Many benefits are expected at urban level, such as reductions in CAPEX or OPEX requirements, increased revenue streams, increased service level quality, increased data/information sharing and development of city-level intelligence for continuous monitoring and control. There are several R&D projects and academic studies in development of urban innovation for urban infrastructure management.	There is no regulation with respect to urban infrastructure management in Smart City context and harmonization among relevant urban infrastructure operators. Municipalities are primary authorities in local level whereas many infrastructure operators are regional or national service providers. Smart City vision is discussed in different contexts and no comprehensive legislation is present.	MENR, MEU, MTI, EMRA, ICTA, Electricity DSOs, Gas DSOs, Telecommunication Operators, Municipalities
R16	Monitoring Requirements	Yearly Reporting Requirement of Smart Grid Realizations	Monitoring of realization percentage of DSO plans on Smart Grid roll-out. Specific report template may be identified by EMRA for this reporting item.	In order to keep track of project-based and overall progress of Smart Grid Master Plan, reporting on an annual basis to EMRA is recommended, similar to annual reporting for annual CAPEX and OPEX realizations. This is a common practice for countries following Smart Grid programs and several EU NRAs monitor the progress of DSO investments through their business plans which also include Smart Grid projects.	Yearly reporting is within current practice in terms of CAPEX and OPEX realizations within each Implementation Period. Smart Grid Master Plan is advised to align with this reporting practice.	EMRA, DSOs
R17	Monitoring Requirements	Identification of KPIs for Monitoring the Success of Smart Grid Projects	Implementation of concrete methodologies for evaluating, monitoring and auditing Smart Grid projects and their benefits	Determination of KPIs is necessary to provide objective assessments of Smart Grid goals and achievements. Studies for common frameworks of Smart Grid KPIs have been conducted by EU initiatives, such as EU JRC. EU JRC recommends definition of suitable metrics and KPIs in order to measure impact of services and benefits of Smart Grid projects to ideal Smart Grid vision. All Smart Grid programs in leading countries are monitored within objective KPIs, in alignment with expected benefits such as revenue generation, lowering CAPEX or OPEX or increasing system performance.	Distribution business is regulated by EMRA through KPIs, but no Smart Grid related KPI has been set yet. Some Smart Grid components like OMS, EDVARs, GIS, etc. are included in the obligatory implementations by DSOs.	EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R18	Standardization and Interoperability	AMI Interoperability	- Minimum technical requirements of smart meters - Standard OBIS codes - Communication protocol interoperability	Due to privatized nature of Turkish electricity distribution sector (21 DSOs) and large number of metering points, smart meter roll-out throughout the nation will result in various smart metering products and solutions deployed in field and in back-office applications. Identification of minimum technical requirements, standardization guidelines and interoperability requirements are significantly required to align smart metering projects by different DSOs. This has been a common practice for large-scale smart meter roll-out projects, in countries such as Italy, Denmark, Sweden etc.	MASS (National Smart Meter) project is ongoing for this purpose.	EMRA, DSOs, Meter Manufacturers
R19	Standardization and Interoperability	Cyber Security Standardization	Adaptation and implementation of cyber security measures in compliance with the information security management guidelines of ISO/IEC 27002 and SO/IEC TR 27019	Effective management of cyber security measures require company- wide and industry-wide attention and practices according to latest standards and guidelines. It is recommended that DSOs must adapt to existing set of guidelines in globally accepted cyber security / information security standards.	ISO27001 standard certification is mandated for all DSOs.	EMRA, DSOs
R20	Standardization and Interoperability	Identification of Minimum Requirements for Certain Smart Grid Systems	Recommended at minimum for; - Asset Management Systems - Smart Meters - Meter Data Management - Network Management Systems (SCADA, DMS, DERMS, etc.) - Reporting and Data Management (EDVARs)	Smart Grid systems have different purposes, scales and complexity that require specific attention for achieving seamless integration and flawless operation. Minimum acceptable criteria must be identified for each specific system type in order to gain a standardized Smart Grid system portfolio within each DSO and throughout the electricity distribution industry. This issue is generally addressed in standardization efforts by IEC, ETSI etc. or national authorities; and a similar standardization roadmap can be developed with TSE (Turkish Standards Institute).	Available for; - GIS - AMR - OMS (TSKS)	EMRA, DSOs, TSE
R21	Standardization and Interoperability	EV Charging Points - Requirements for Grid Integration	Technical requirements for grid integration	Due to presence of multiple technical standards (CCS, ChaDeMo, Tesla Supercharger, Guobiao) and difference in charging power requirements of different EV charging station equipment, it is highly important to provide nationally accepted technical requirements for grid integration of EV charging points. In general, countries opt for a certain standard and aim to set criteria for connection points. Many European countries (France, Germany, Netherlands, Norway etc.) have standardized preferences of technology and require grid compliance for accessible charging stations in their domestic markets.	No criteria are determined for EV charging point integration to distribution grids.	EMRA, DSOs, EV Charging Equipment Providers, Potential EV Charging Operators



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R22	Standardization and Interoperability	Grid Integration Requirements for Energy Storage	Technical requirements for grid integration	Energy storage systems have the capability to act as an enabling tool in active distribution grid management due to their controllable design for energy flow management. Either as isolated or aggregated, many services (flexibility, grid support, voltage/frequency regulation etc) can be extracted via intelligent and coordinated usage of energy storage systems; but integration criteria to the distribution grid must be in place and audited accordingly in order to enable such services and maintain grid operations without issues. Countries such as Germany have initiated regulations for energy storage integration according to local targets and constraints, such as renewable-coupling or grid reliability.	Legislation for facility acceptance procedures of electrical energy storage facilities was drafted in October 2019 and published in February 2020. However, legislation does not cover any issues related to grid integration criteria and operational regulations.	EMRA, DSOs, DG Plant Owners, Aggregators
R23	New Services and Business	EV Charging Infrastructure	Definition of roles, responsibilities and revenue streams for regulated entities (DSOs)	DSOs have a key role in enabling EV charging infrastructure and definition of roles and business models is key to the discussion. There are multiple studies and publications (EDSO for Smart Grids, EURELECTRIC, IEA etc.) that focus on DSO role in EV business value chain, such as smart charging services, V2G implementations, infrastructure operations etc.	Draft regulations have been released in 2017, but not become effective yet.	EMRA, DSOs, EV owners, 3rd party charging operators, ESCOs
R24	New Services and Business	Distribution Ancillary Service	Definition of roles, responsibilities and revenue streams for regulated entities (DSOs)	Provision of innovative ancillary services that depend on Smart Grid management by DSOs is an upcoming issue that needs regulations on technical and commercial aspects for the DSOs and energy markets in general. Renewable-energy or battery oriented ancillary service provision has been allowed at TSO level in countries such as Germany, the UK and Ireland; and DSO-level service provision is under consideration in parallel with adoption of aggregator roles in energy markets.	Ancillary services are only provided at TSO level. EMRA-supported pilot R&D projects are ongoing for inclusion of renewable-energy based DG units at DSO-level ancillary service provision.	EMRA, DSOs, Energy Storage System Owners/ Operators, DG Plant Owners, Aggregators
R25	New Services and Business	Energy Storage	Definition of roles, responsibilities and revenue streams for regulated entities (DSOs)	DSOs are expected to handle energy storage integration at LV or MV levels, especially in combination with renewable-based distributed generation units. Effective management and integration of energy storage for creation of new service definitions must be defined in regulatory legislations. Leading EU examples can be found in Germany and Denmark where the regulation defines new responsibilities and business models for DSOs.	No regulation on energy storage integration to electricity distribution grids and related business models/services for DSOs (Draft regulation has not yet become effective).	EMRA, DSOs, ESCOs, Aggregators, DG Plant Owners



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R26	New Services and Business	Demand Response	Definition of roles, responsibilities and revenue streams for regulated entities (DSOs)	Demand response services at MV or LV (aggregated) level (including smart meter flexibility services) can be a critical tool for managing local or grid-wide flexibility requirements of the DSO. Regulations are required to define the allowed business models, interactions, contract conditions, execution principles and energy market integration. Leading examples for DR regulations for distribution grids can be found in Europe, by organizations such as European Commission (EC Smart Grid Task Force) or countries such as France, Belgium, Ireland and the UK. Countries such as Germany, Netherlands, Austria are also in regulatory reviews for DR and aggregation services.	Pilot projects and studies are conducted in EMRA-supported R&D projects. No draft or approved regulation regarding demand response services in Turkey. Potential role of DSOs is unclear.	EMRA, DSOs, DSO Customers
R27	New Services and Business	Energy Efficiency Services	Definition of roles, responsibilities and revenue streams for regulated entities (DSOs)	Improving and maintaining nationwide energy efficiency measures is critical for effective usage of country's energy resources. DSOs with Smart Grid capabilities are expected to be in the centre of managing or supporting energy efficiency services in built environment, electric mobility and industrial uses. There are multiple examples within of energy efficiency regulations within Europe that DSOs play a key role in, such as Denmark, Belgium (Flanders region)	A recent regulation has been published in Turkey, focusing on 'Energy Performance Contracts for Public Buildings/Facilities', but the role of DSOs is not significantly included and an ESCO role perspective is strengthened. Energy efficiency targets for DSOs are evaluated in reduction of technical & non-technical energy losses and grid investments. There is a lack of focus for DSOs' potential role in leveraging nationwide energy efficiency and provision of energy efficiency services.	EMRA, DSOs, ESCOs, Aggregators, Facility Owners as Grid Customers (Household, Industrial or Commercial)



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R28	New Services and Business	Enabling Construction of DSO's Own Telecommunication Infrastructure	- Special provision of radio frequency allocation for electricity DSO smart grid applications - Definition of possible revenue streams for allowing joint use of the infrastructure amongst different sectors	This is a cross-regulatory issue that both energy market and telecommunication regulatory authorities are concerned. Increasing telecommunication requirements due to Smart Grid systems require reliable, isolated telecommunication infrastructure that are exclusive to the DSO operations. Collaborative usage of telecom infrastructure is under discussion in both domains, especially in countries such as Germany, UK, Finland etc.	Allowed RF communication in 169.4-169.475 MHz frequency range. There are several DSOs that use RF communication (proximity of 444 MHz) and fibre optics for SCADA backbone communication, but through acquiring services from approved RF service providers or existing national telecommunication operators.	ICTA, EMRA, DSOs
R29	Other Recommendations	Identify High-Priority Technology Areas for Domestic Industry	Supporting target areas for technology development and export (storage, IoT, data analytics, network management software, smart meters, solar panels, etc.)	Development of domestic Smart Grid ecosystem is important in order to develop and maintain a sustainable business environment and enhance economic value. Identification and prioritization according to industry requirements and capabilities is essential to initiate ecosystem planning.	An ecosystem of equipment manufacturers, software and hardware developers, service providers and re-sellers (local branches of international companies) exist in the industry. However, this ecosystem needs significant growth in size and technological capabilities to enrich and sustain Smart Grids in Turkey. New generation technology providers must be identified, supported and aligned with other industrial partners through Smart Grid projects and other related incentive mechanisms.	MENR, EMRA, ICTA, MIT



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R30	Other Recommendations	Public Awareness and Consumer Acceptance	EMRA and the DSOs should promote mechanisms for improved consumer awareness of technology use and market opportunities.	In order to reach success for Smart Grid projects, awareness and acceptance levels of energy consumers must be high so that the Smart Grid transition can continue successfully, and benefits can be created through better consumer engagement processes. This is one of the key topics that is suggested by European (EDSO, EURELECTRIC) authorities for Smart Grid projects through events, publications and strategy papers. Many countries such as France, Netherlands etc. have developed consumer engagement strategies according to local conditions and requirements in this perspective.	Consumer engagement and awareness for Smart Grid transition is very limited and not initiated by DSOs or public authorities. Recent disseminations of industry-wide projects such as TAŞ2023 and triggering events in electric mobility and renewable energy has started to attract consumers' attention to a certain level and presents an opportunity for more structured planning for higher engagement.	MENR, EMRA, ICTA
R31	Other Recommendations	Regulations for Disaster Recovery Plans	Establishment of advanced emergency and system restoration plans using smart grid technologies to ensure network resilience in case of disasters and large disruptions	Smart Grid technologies and management philosophy has significant potential to contribute to disaster recovery actions, especially in natural disasters such as earthquakes that are frequent in Turkey, due to capabilities of continuous real-time monitoring and control over the grid segments. Regulations must be revised in the light of Smart Grid capabilities of DSOs, especially in potential disaster zones, to enhance disaster recovery plans and give DSOs certain responsibilities to act in case of disasters. Smart Grid concepts such as smart metering and micro grids are crucial in this context. Countries outside Europe such as Japan and Canada are progressive in implementation of such concepts with disaster awareness.	Disaster recovery plans are made according to existing capabilities and expected role of DSO is mainly to re-organize its central and field teams to energize disaster region to a possible extent via grid or via temporary solutions (such as diesel generators). SCADA systems are also available for disaster recovery purposes but not included in the disaster recovery regulations as a mandated system.	AFAD, MENR, EMRA, DSOs



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R32	Other Recommendations	Revised Rules for More Efficient Reactive Energy Regulation	Revision of existing rules and regulations on reactive energy management in alignment with new concepts and technologies in reactive energy management and flexibility services	Existing set of rules and regulations for reactive energy management are not completely sufficient to capture and organize Smart Grid capabilities and flexibility potential that can be reached by DSOs. New or revised regulations are recommended to include concepts like aggregated flexibility services, reactive energy support from distributed generation etc. to provide better grid management.	Existing reactive energy management regulations are mainly focusing on ancillary services market at larger scale and they are not related to DSOs and distribution grid management. EMRA-supported pilot R&D projects are ongoing to analyse benefits of distribution level flexibility services and to provide regulatory suggestions to EMRA.	EMRA, DSOs, DG Plant Owners, Aggregators
R33	Other Recommendations	Encourage Establishment of Sector Smart Grid Platform	Establishment of Smart Grid Information Exchange Platform and active working groups under the platform for industry-wide standardization and exchange of Smart Grid experiences	A Smart Grid platform with active working groups per focus area is recommended to form a collaborative structure among the DSOs and other key stakeholders in sharing Smart Grid experiences, benefit from lessons learned by other entities and contribute to industry-wide standardization efforts for Smart Grid transition.	There had been several attempts at initiating a Smart Grid platform or working group, but lack of definitions and regulations for roles, responsibilities and benefits caused discontinuation. DSOs have limited amount of information exchange on Smart Grid projects through R&D collaboration (mutual projects), dissemination events (fairs etc.) or direct communication in formal or informal platforms.	ELDER, EMRA, DSOs, Smart Grid Vendor Ecosystem, Academia



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-is Status in Turkey	Key Stakeholders Involved
R34	Other Recommendations	Communication and Dissemination Activities	DSOs should make sure that results and lessons learned from smart grid demonstration projects are disseminated.	Smart Grid projects' content and outputs are relatively unknown to stakeholders outside the electricity distribution industry. In order to attract interest, increase awareness and highlight the importance of Smart Grid transition, demonstration projects need to be planned and managed carefully, supported accordingly by EMRA and properly disseminated to relevant stakeholders and public audience.	Dissemination efforts are limited and partially insufficient in terms of reaching to stakeholders and public outside the industry ecosystem. Social benefits, technological scope and modernization processes through Smart Grid transition require higher dissemination efforts.	EMRA, DSOs, Industry Stakeholders, Local/National Press, Public



This project is funded by the European Union



2.8.4 Recommendations for Smart Grid Planning

With regards to the plans for smart grid activities of the distribution companies, DSOs are recommended to prepare and submit to EMRA their “Digitalization and Smart Grid” master plans. A multi-year Smart Grid Master Plan is the core strategic document (or a set of documents) that will guide the transition process for DSOs and ensure alignment of Smart Grid projects while tracking the progress. This roadmap plan is especially useful in the beginning phase of a widescale Smart Grid portfolio investment, but also continue with updates throughout the transition management.

Inclusion of Smart Grid Planning as a component within DSO Master Plans for each regulatory period will ensure harmonization between the regular network planning and related Smart Grid projects. This will also allow scope and KPI standardization for DSO targets in the tariff period. Several EU countries develop smart grid and smart meter roll-out plans and NRAs encourage DSOs to comply with the national roadmaps in their planning efforts.

Before DSOs develop and submit their smart grid master plans, EMRA is advised to determine the principle guidelines, targets, achievement targets and evaluation criteria for DSOs about Smart Grid roll-out projects, digitalization, technology deployment and practices within the IV. Implementation Period. Introduction of identified achievement targets and KPIs for Smart Grid roll-out projects will ensure performance-based monitoring of DSO activities by EMRA. As part of common regulatory processes and project management practices, KPIs are widely used in notable Smart Grid programs in EU. Guidelines, performance objectives and KPIs are used in conventional regulatory framework for DSOs. Relevant performance objectives and indicators for Smart Grid projects have not been particularly identified but widely discussed in preparatory projects such as TAŞ2023.

In the following, a guideline is provided with best practise recommendations related to the sections and subsections of the “Digitalization and Smart Grid Planning” master plan in terms of their scope and contents.

Objectives of the Smart Grid Master Plan

- **Supporting sustainable, reliable (resilient) electricity network structures by identifying the smart grid investments that distribution companies will realize during the next implementation period**
- **Making technological investments in optimum conditions (with efficiency, cost, technology selection, competence, application points, etc. perspectives)**
- **Basing the planning of technological investments on prioritization and cost-benefit principles**
- **Enabling optimal usage of resources through planning efforts**
- **Developing a sustainable and effective planning for digitalization and smart grid transformation and mobilizing stakeholders inside and outside the company**
- **Developing IT/OT projects required by the regulations**
- **Development of project planning for new services**
- **Determining the smart grid needs specific to DSO by prioritizing them through analysis**

Minimum requirements for the Smart Grid Master Plan can be summarized as follows:

- Smart Grid Master Plan must contain information on the as-is status of Smart Grid components.



This project is funded by the European Union



- Actions for more effective usage of functionalities in existing infrastructure or systems and improvement of activities must be included in the planning.
- Smart Grid Master Plan must have details in 'Project' granularity
- There must be CBA studies completed for each project proposal and a prioritization must be made in scope
- Minimum requirements for the project definition in planning phase must be: project name, scope, objectives, targets, qualitative and quantitative benefits, related technologies, anticipation of hardware and software components, as-is status related to project concept, project period, anticipated calendar and budget requirements
- A separate section covering regulatory recommendations must be included in the Master Plan, including new business models, new service definitions and market re-structuring plans
- Inclusion of cost-benefit analysis (CBA) with respect to smart meter and grid monitoring/control/automation roll-out planning; prioritization of all projects that are included in the planning with respect to CBA outcomes.

The proposed structure for the “Digitalization and Smart Grid Planning” to be prepared by the DSOs is shown below.

“Digitalization and Smart Grid Planning” Master Plan	
1. Executive Summary	
2. Introduction	
2.1. Digitalization and Smart Grid Planning Process	
2.2. Stakeholder Involvement	
2.3. Assessment of Effective Regulatory Framework for Smart Grids	
3. As-is Status of Smart Grids in the DSO	
3.1. Overview of Status-quo	
3.2. Smart Grid Innovation Activities	
3.3. Detailed As-is Status for Smart Grid Technical Domains	
3.3.1. Smart Grid Planning	
3.3.2. Advanced Network Monitoring, Control and Management Systems	
3.3.3. Asset Management and GIS	
3.3.4. Enterprise IT and Data Analytics	
3.3.5. Integration of Distributed Generation and Energy Storage	
3.3.6. Electric Vehicles and Charging Infrastructure	
3.3.7. Telecommunication Infrastructure	



This project is funded by the European Union



“Digitalization and Smart Grid Planning” Master Plan

3.3.8. Advanced Metering Infrastructure

3.3.9. Enterprise Application Integration

3.3.10. Cyber Security

4. Company Vision and Strategy for Smart Grids

4.1. 2035 Vision

4.2. 2025 Strategy

4.3. Priority Areas

4.4. Success Targets

3. Innovation for [Gas DSO]

3.1. Scope of Digitalization and Smart Grid

3.2. Stages of Digitalization and SmartGrid

3.3. Digitalization and Smart Grid Objectives

3.4. Funding Digitalization and Smart Grid Projects

3.5. Approach to Innovation

3.6. Selecting and Prioritizing Smart Grid Areas

3.7. Developing Plans for Digitalization and Smart Grid

3.8. Stakeholder Engagement

3.9. Collaboration Between DSO and TSO

4. Planning for Better Utilization of Existing Systems/Functionalities

5. 2021-2025 Smart Grid Planning (Project Based)

5.1. Smart Grid Planning

5.2. Advanced Network Monitoring, Control and Management Systems

5.3. Asset Management and GIS

5.4. Enterprise IT and Data Analytics

5.5. Integration of Distributed Generation and Energy Storage

5.6. Electric Vehicles and Charging Infrastructure

5.7. Telecommunication Infrastructure

5.8. Advanced Metering Infrastructure

5.9. Enterprise Application Integration

5.10. Cyber Security



This project is funded by the European Union



“Digitalization and Smart Grid Planning“ Master Plan

6. Prioritization Based on Cost-Benefit Assessment

7. Governance Arrangements

- 6.1. Partners and Supplier Arrangements
- 6.2. Managing Risk and Future Uncertainty
- 6.3. Tracking Benefits
- 6.4. Keeping the Strategy Up to Date

8. Planning for New Services, Business Models and Market Structures

9. Regulatory Recommendations of the DSO for Implementation of the Master Plan

2.9 Smart Grid Road Maps in Different Countries and Regions

2.9.1 Sweden - 2030 Road Map

Sweden-2030 Road Map is a study conducted by the Coordination Council and National Knowledge Platform for Smart Grids¹⁷⁶ and was implemented in Sweden for smart grid transition by creating a road map for 2015-2030¹⁷⁷.

Vision:

The vision of the study is to make Sweden a world leader in smart grids that will strengthen customer participation, sustainable development, supply continuity and industrial growth. The purpose of the study is to help creating clear market rules, to strengthen the participation of customers, to create beneficial development conditions for smart grids and to promote smart grids as a growing industry in Sweden according to the action plan that will be created by the development and dissemination of broad cooperation and knowledge.

Smart Grid Components and Stakeholders:

The transmission system voltage level in Sweden consists of 400kV and 220kV. Besides, 40-130kV grid is defined as a regional system and there are 4 regional system operators. Local grids are defined for below the 40kV voltage level and there are more than 170 local network operators. There are around 5.3 million subscribers in total. 3 out of 170 local operators provide service to approximately half of all subscribers.

The figure below shows smart grid stakeholders and the factors that affect them in this road map.

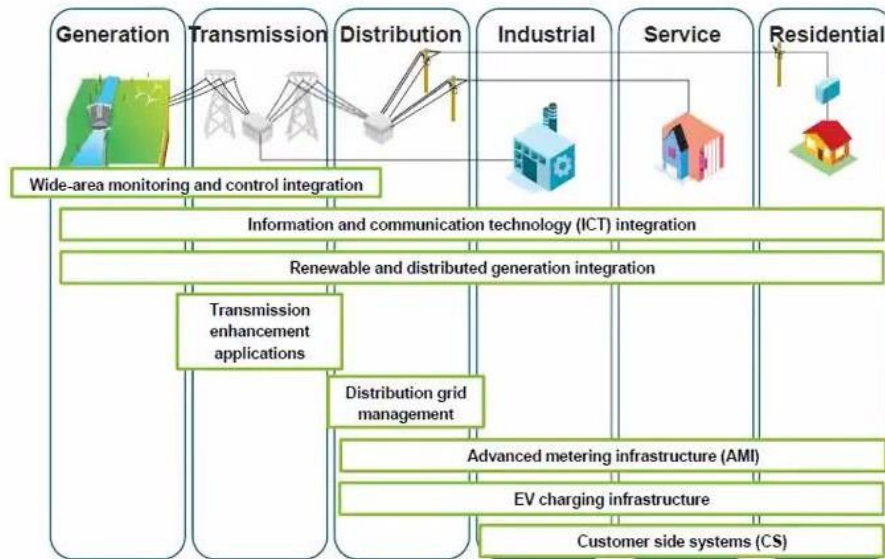


Figure 39: Sweden-2030 Road Map Stakeholders and Components¹⁷⁸

The integration of information technologies (IT) and communication technologies (ICT) and the integration of renewable/distributed generation into the grids are considered as the most important topics in the process from

¹⁷⁶ Coordination Council and National Information Platform for Smart Grids

¹⁷⁷ <http://swedishsmartgrid.se>

¹⁷⁸ The Swedish Action Plan for Smart Grid



This project is funded by the European Union



electricity generation to the end consumer. In addition, wide-area monitoring and control integration, transmission strengthening applications and distribution system management in the generation, transmission and distribution grids are other important components. There is an advanced metering infrastructure (AMI) and electric vehicle charging infrastructure components in the industrial/residential consumer connections to the distribution system. Regarding consumers, consumer side systems (CS) were evaluated.

The focus points considered to be important for the development of smart grids in Sweden are:

- Smart grids as part of a larger energy system
- Electricity market design and strengthening of customer participation
- R&D and information supply
- Security and privacy
- Economic growth and business development
- Standards and collaboration
- Communication and wide roll out

Within the framework of this project, the following activities have been carried out for the participation of stakeholders:

- Dialog Fora (broadly attended workshops on specific topics)
- Expert groups (entered the Council for each focus and to provide feedback)
- Information platform (swedishsmartgrid.se)

Smart Meters:

Hourly metering for customers with a fuse input of 200A and above was made compulsory with Electricity Act¹⁷⁹ in 1999 in Sweden. After 2003, Vattenfall Distribution Company started to use smart metering applications, Electricity Act was updated in 2006 and hourly metering lower limit was reduced to 63A. Again in 2006, EU Directive 2006/32/EC¹⁸⁰ made it necessary to use meters that show real-time consumption of consumers. As of 2009, 99% of meters across Sweden were replaced with smart meters.

The figure below shows the historical development of smart metering regulations in Sweden.

¹⁷⁹ Electricity Law

¹⁸⁰ European Union Directive 2006/32/EC



This project is funded by the European Union

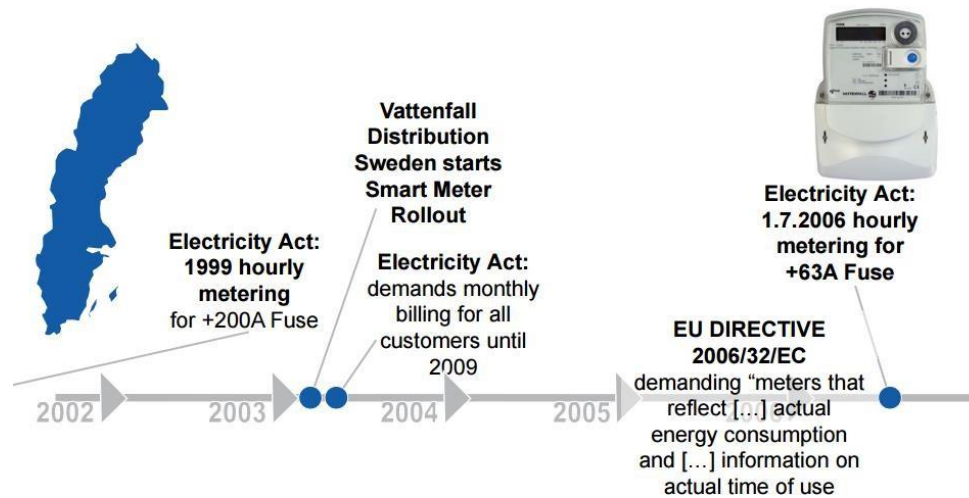


Figure 40: Historical Development of Smart Meter Applications in Sweden¹⁸¹

Development of the National Action Plan:

The development stages of road map and action plan that are prepared for 2015-2030 are as follows:

- Aim of the study
- Future scenarios
- Potential outcomes
- Key points
- Suggestions and proposals

As can be seen from the steps, first of all, the objectives of the project have been determined. Then, different scenarios were created for the future and the possible results of these scenarios were estimated. In line with these results, key points and measurement needs have been determined, and ultimately, suggestions and proposals have been developed.

The critical points within the framework of the project are:

- Political framework and market situation
 - Basic rules about electricity markets
 - New status framework for the grid
 - Cooperation with other participants of the grid
 - Long-term strategy framework and market conditions
- Customer involvement and social aspects
 - Smart grids from a customer point of view
 - Customers' access to metering data and information

¹⁸¹ The Swedish Action Plan for Smart Grid



This project is funded by the European Union



- Synergy between smart grids and other social elements (social planning and products/services)
- R&D, innovation and growth
 - Knowledge and skill development
 - Research priorities and collaboration
 - Integrated smart grid innovation strategy
 - Requirements for pilot and implementation projects
 - Smart grids in global markets
- Legal measures and regulation
 - Customers' right to access hourly measurement data without a contract or extra charge
 - Regulatory barriers related to energy storage in the distribution grid

However, risk reduction possibilities of grid operators' investments to smart grid investments that have not been proven useful yet, were investigated by within the framework of the road map study. The innovation strategy for integrated smart grids includes new and supportive funding forms for the entire value chain.

A proposal plan was prepared for the thematic research study and it was considered to be included in the national research fund. Priority has been given to information security and technology integration in electricity infrastructures and development programs have been established in these areas.

In terms of energy efficiency, smart grid solutions and demand management integration have been investigated. In addition, sharing knowledge about the potential of smart grids has been taken into account in sustainable social planning.

As can be seen in the image below, the smart grid road map prepared for Sweden consists of 3 main phases: Initial Phase (1-3 years), Development Phase (3-7 years) and Maturity Phase (7-10 years). It is considered that the most important point to be noted here is the continuation of the transition, which is planned to start with transforming smart meters, mostly through R&D projects.

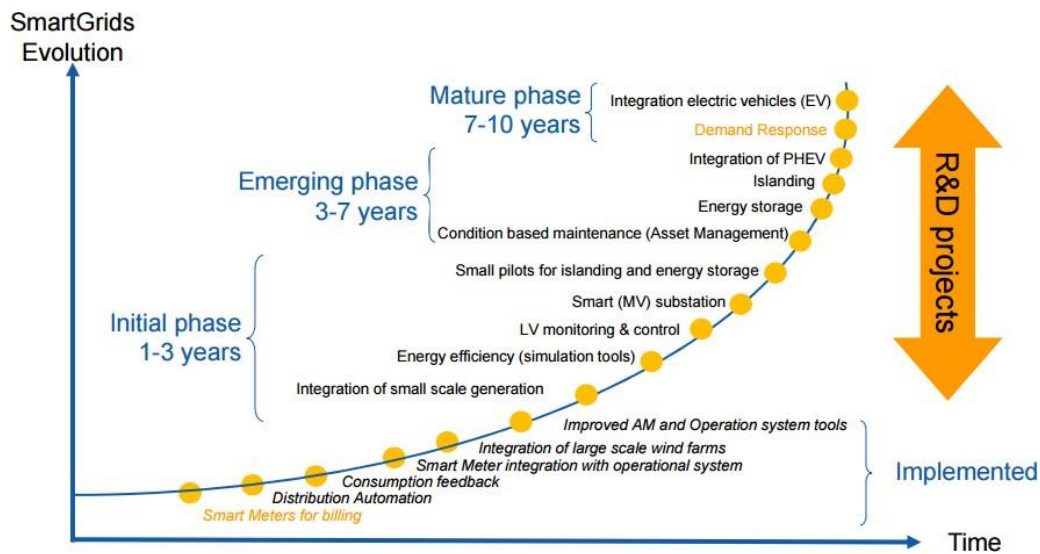


Figure 41: Sweden - 2030 Smart Grid Road Map¹⁸²

2.9.2 Germany - Standardization Road Map for “E-Energy/ Smart Grids”

With the study carried out by DKE (German Commission of Electric, Electronics, and Information Technologies) and VDE (Electric, Electronics, and Information Technologies Authority) in 2010, the current situation of smart grid technologies in Germany was examined and a road map was created for the standards. Later in 2012, targets were updated and v2.0 was published¹⁸³.

Vision:

The vision of German smart grids has been determined within the framework of the 2022+ Road Map study implemented by BDEW and is given in this report's heading of 2.9.3. The work of DKE and VDE aims to create a road map related to the standardization of smart grid technologies within the framework of this vision.

Smart Grid Definition and Components:

Smart grids (smart energy supply systems), as defined by DKE consists of monitoring and communication of smart generation facilities, storage systems, loads and grid operation equipment with the help of Information and Communication Technologies (ICT) in power transmission and distribution systems. At this point, the main goal is to provide sustainable and environmentally friendly energy supply through an open, energy efficient, financially sound, safe and reliable system operation. In the figure below, smart grid components are shown under headers of smart grids, markets and gridoperation.

Smart Grid Architecture and Its Stakeholders:

Multi-dimensional Smart Grid Architecture Model (SGAM) was used for smart grid architecture, which is one of the most important cornerstones of road map study, as realized in many other countries. The model in question consists

¹⁸² The Swedish Action Plan for Smart Grid

¹⁸³ <https://www.dke.de/resource/blob/778304/96de7a637009007d65182df8c4d1a9aa/the-german-roadmap-e-energy-smart-grids-version-2-0-data.pdf>



This project is funded by the European Union



of layers of business, function, informatics, communication and equipment and requires interoperability between these layers.

While regulatory agencies across Europe use the European Smart Grid Technology Platform (ETP Smart Grid) definitions and vision, the ETP Smart Grid approach also serves as a guide for cost/benefit studies. However, only direct effects of smart grids on consumers and other stakeholders are included in cost/benefit studies and indirect effects are not taken into account.

At the same time, IEC TR 62357 Seamless Integration Reference Architecture (SIA), which defines the integration needs and standards between smart grid components, has also been used to determine integration needs. The figure below shows the SIA architecture.

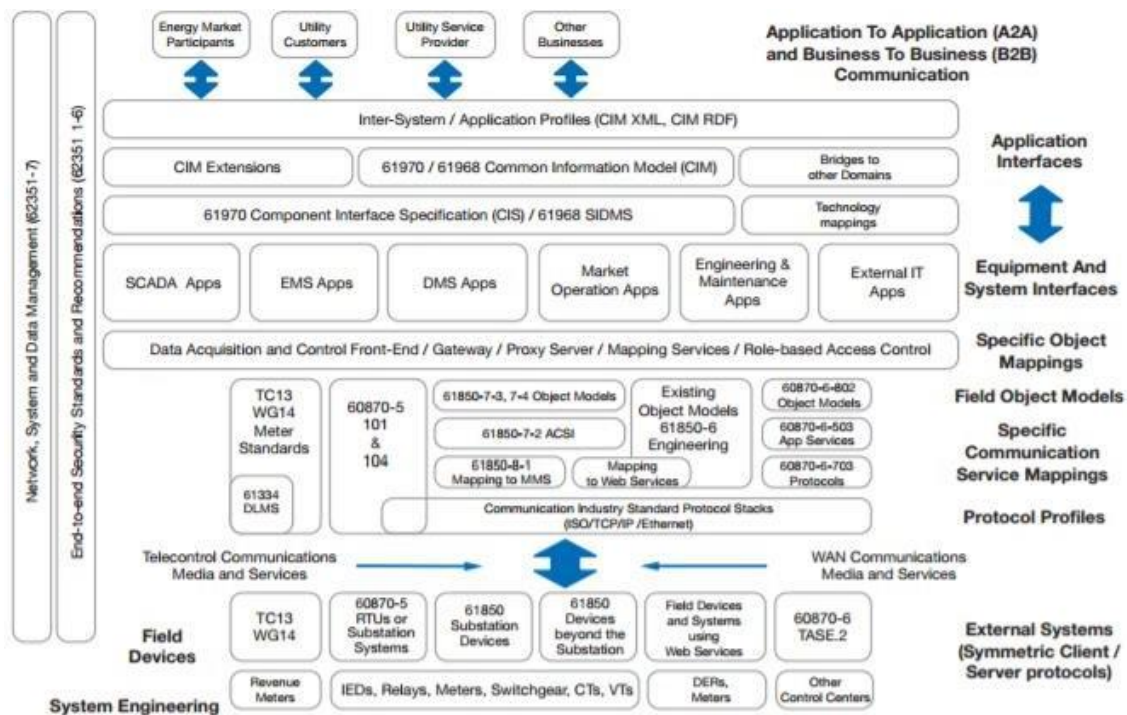


Figure 42: IEC TR 62357 Smart Grid Integration Architecture¹⁸⁴

Road Map Methodology:

In version 1.0 of the study, international standards, their integration with each other and reflections on smart grids, technology or industrial road maps or standards related to smart grids of other countries are examined. In the more current version, version 2.0, a systematic methodology based on the work done in the previous version is described. The methodology in question is shown as follows:

¹⁸⁴The German Roadmap E-Energy/Smart Grids 2.0



This project is funded by the European Union

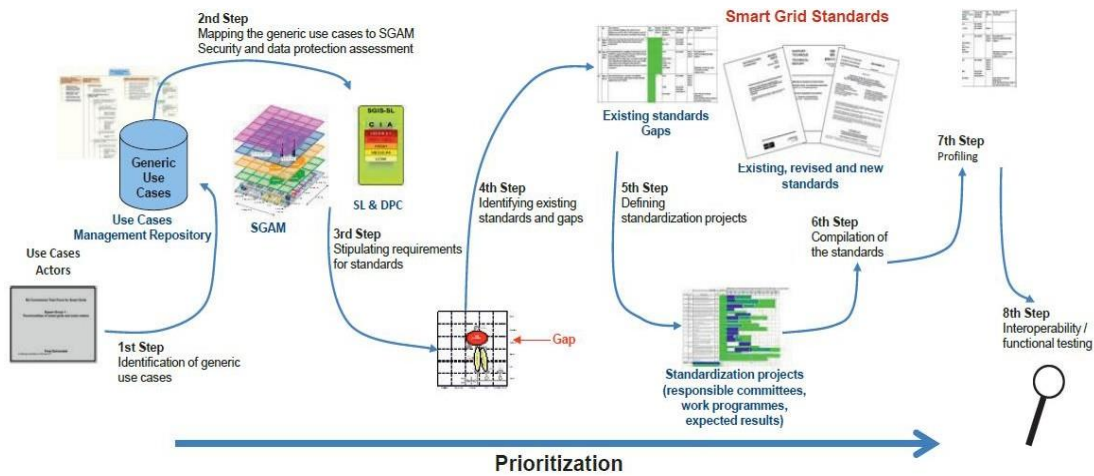


Figure 43: Sustainable Workflow of Smart Grids Standardization (DKE)¹⁸⁵

The basis of the methodology is to develop Use Cases, a system engineering approach. 9 steps have been planned out in the process and each step is explained below:

1st Step: It consists of creating the “World of the Future” concept through Usage Scenarios by determining functionality definitions and security needs. The Usage Scenarios to be created at this step are the basis of the upcoming steps that are determined as a result of collaboration with smart grid stakeholders.

2nd Step: In this step, it is planned to determine which layers, components and stakeholders of SGAM will be affected by the Usage Scenarios defined in the previous step and, moreover, data protection and security requirements are included in this step.

3rd Step: In this step, the minimum standard requirements for information and communication protocol layers have been determined. Continued studies for standardization are targeted to be based on the minimum requirements mentioned.

4th Step: Completion of situation analysis and gap analysis studies are planned in this step.

5th Step: It is aimed to determine the standardization projects by evaluating the differences between the current situation and the targeted structure.

6th Step: In this step, realization of the projects that are determined within the previous step is planned. At the same time, the first versions of the standards will be created.

7th Step: It consists of completing the profiling studies on the basis of steps 1 and 2.

8th Step: In this last step, it is aimed to complete the road map by performing integration and functionality tests.

¹⁸⁵The German Roadmap E-Energy/Smart Grids 2.0



This project is funded by the European Union



2.9.3 Germany - BDEW 2022+ Road Map

“Realistic Steps for Smart Grid Applications in Germany” study was launched by BDEW in 2013 aiming for year 2022 and after¹⁸⁶.

Vision:

As of 2022, at least 35% of energy sources in Germany are expected to be renewable sources. However, it is considered that energy efficiency and energy savings will contribute to the Federal Government's objectives of reducing CO₂ emissions.

The fluctuating structure of energy generation will increase significantly due to renewable penetration, but it will be balanced with network and user flexibility. Flexibility is seen as the most important factor for stability.

Germany's smart grid vision can be stated as such: Smart grid applications and technologies such as virtual power plants, energy storage units, demand management applications, customer participation should be established as a connected system in a reliable, efficient and sustainable manner, and the transmission and distribution grids interacting flexibly and all these components are connected with central/distributed communication and control systems.

Definition of Smart Grid:

BDEW has defined smart grids as an energy grid that allows integration of consumption and supply behaviour of all market-related market participants. Smart grids also represent goals such as economically efficient, lowered energy and system losses, sustainable energy supply systems and high availability.

BDEW predicts that smart grids will generally focus on the electricity market in the short term, and in the medium and long term, electricity, gas, heating and transport networks will form hybrid networks with an increasing integration.

Road Map Methodology:

In line with the goal of shaping the road map, the 10-year period up until 2022 is divided into 3 phases:

- Development and pioneering phase (2012-2014)
- Installation and configuration phase (2014-2018)
- Comprehension and market phase (2018-2022)

The figure below shows roadmap steps.

¹⁸⁶ [https://www.bdew.de/internet.nsf/id/816417E68269AECEC1257A1E0045E51C/\\$file/Endversion_BDEW-Roadmap_englisch.pdf](https://www.bdew.de/internet.nsf/id/816417E68269AECEC1257A1E0045E51C/$file/Endversion_BDEW-Roadmap_englisch.pdf)

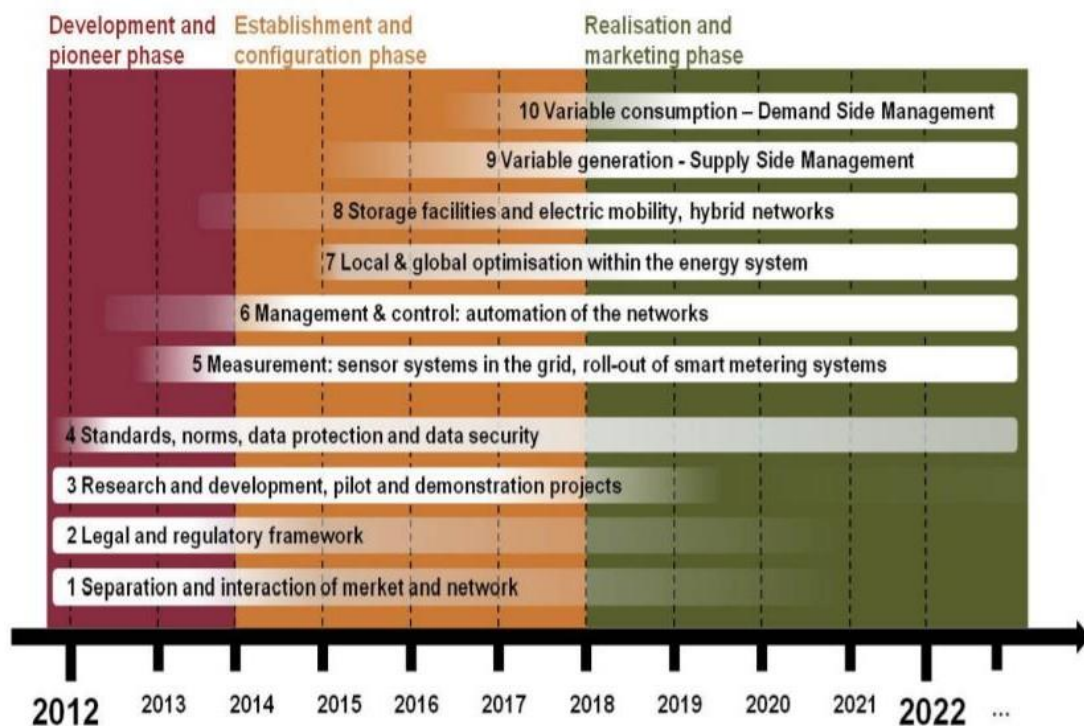


Figure 44: BDEW, Germany 2022+ Road Map¹⁸⁷

- 1- Separation and integration of the market and network
- 2- Legal framework
- 3- R&D, pilot and demonstration projects
- 4- Standards, norms, data protection and data security
- 5- Metering: sensor systems within the network, wide roll out of smart meters
- 6- Management and control: grid automation
- 7- Local and global optimization
- 8- Storage systems and electric vehicles, hybrid network
- 9- Variable production - supply side management
- 10- Variable consumption - demand side management

2.9.4 United Kingdom - Ofgem 2030+ Road Map

The work was carried out by the United Kingdom Smart Grid Forum¹⁸⁸. Founded by the Ministry of Energy and Climate Change and the regulator Ofgem, the Smart Grid Forum brings together electricity companies, consumer groups, energy suppliers and a wide range of industrial organizations.

¹⁸⁷ BDEW Roadmap, Realistic Steps for the Implementation of Smart Grids in Germany

¹⁸⁸ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/285417/Smart_Grid_Vision_and_RoutemapFINAL.pdf



This project is funded by the European Union



Vision:

It is the development of an intelligent electricity grid that will support the transition of United Kingdom to an efficient and timely low carbon economy that will meet the goals of reducing carbon emissions while minimizing the prices reflected on the consumer, ensuring energy security and reaching wide energy targets. Smart grid will support flexible, efficient grids while modernizing our energy system and will create new businesses, innovation and growth for 2020 and beyond. It provides and encourages consumers to manage their demands, adopt new technologies and minimize prices to benefit their own interests and the entire electrical system.

Definition of Smart Grid:

From a technical point of view, it is realized that smart grids are modernized electricity grids that provide real/recent monitoring and active control functionality from generation to consumption with the help of information and communication technologies.

Scope and Focal Point of Study:

In order to fully realize the potential of smart grids, the entire electricity system, including distribution and transmission system operators, suppliers, generators, consumers and the market, needs to evolve. While this study reflects the effects of smart grids on the system as a whole, the primary focus is on the challenges faced by electricity distribution grids. Distribution grids are the part of the electricity system with the greatest opportunity for smart applications and the place to invest, in order to ensure increasing demands and new requirements are met. Smart Grid Road Map is not a project plan and does not set strict rules for achieving smart grid goals. It can be predicted that renewable energy will grow, and demand will increase with increased usage of electricity for heating and transportation; however, the exact course of the distribution system is far from predictable. For these reasons, Smart Grid Road Map should be flexible and new developments and information should be adapted into existing applications. Therefore, Smart Grid Road Map will guide its applications and will be renewed as the nature of energy system improves.

Smart Grid Benefits:

With the introduction of smart grids, smart meters and other smart products and increasing demand-side management, allow consumers and communities to control their energy consumption and shift their consumption from peak hours. This means saving grid costs and decreasing prices reflected to the customer.

Thanks to the faster and cheaper connection to the grid, economic growth and employment growth will be supported. It is predicted that it will provide employment opportunities for 9000 people for smart grids by 2030, gross value added of 13 billion pounds and an increase of 5 billion pounds by 2050.

Thanks to the advanced display and control systems to be applied in the system, energy security and low carbon technologies will be integrated. This will allow grid companies to identify and differentiate problems more quickly, while managing the supply-demand balance at the local level.

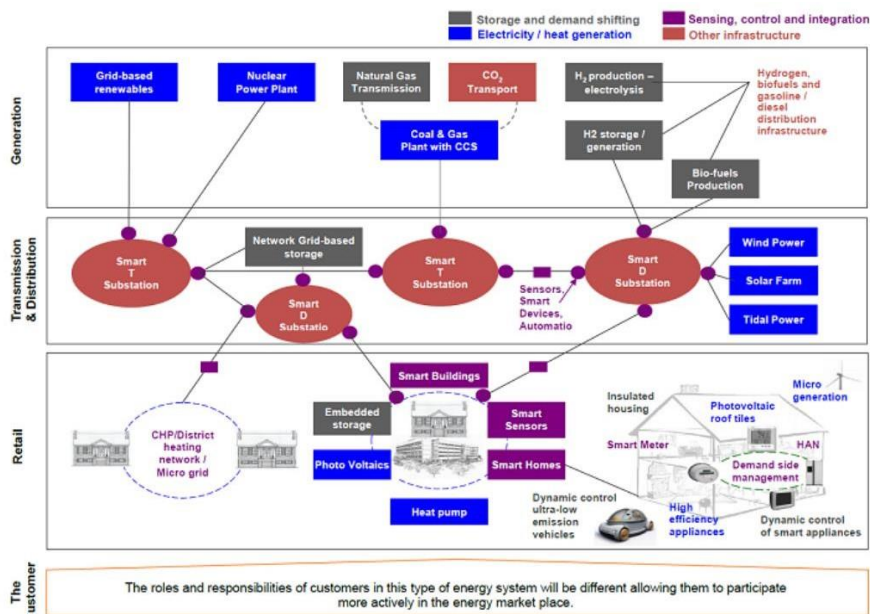
Smart grid components and stakeholders:



This project is funded by the European Union



The interaction between the smart grid and its stakeholders in United Kingdom is shown in the figure below. The European Smart Grid Architecture Model (SGAM) is based on smart grid architecture and has been updated according to UK-specific situations.



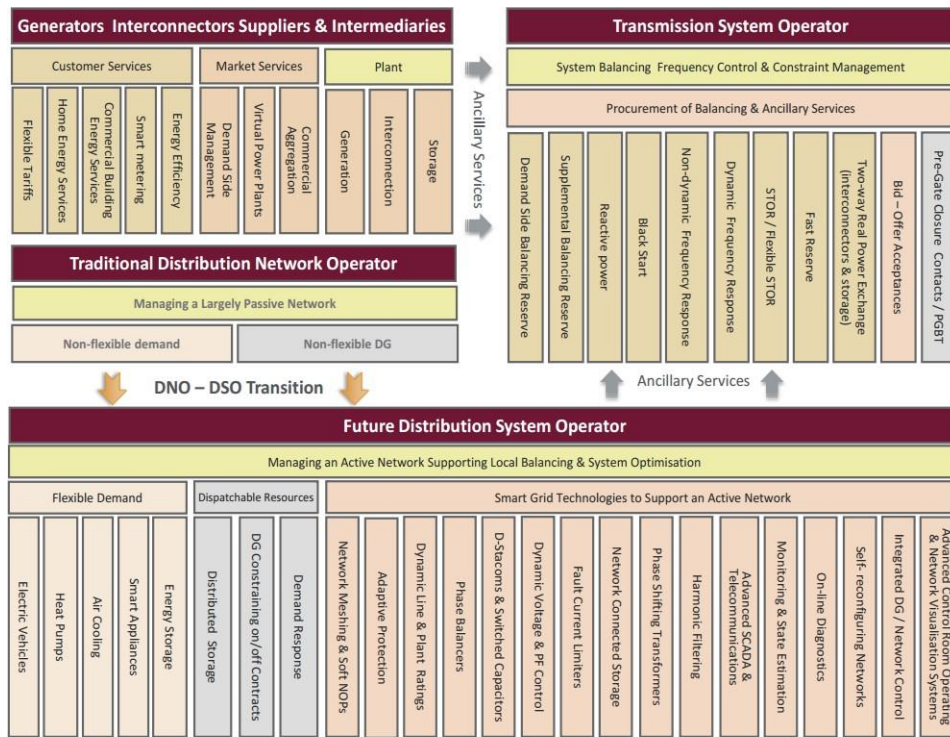
Source: DECC

Figure 45: BDEW, Germany 2022+ Road Map¹⁸⁹

¹⁸⁹ BDEW Roadmap, Realistic Steps for the Implementation of Smart Grids in Germany



This project is funded by the European Union



Source: UK Power Networks

Figure 46: Smart Grid Components of Generation, Transmission and Distribution System Stakeholders

Road Map Methodology:

The study carried out by the Smart Grid Forum included the following phases:

- **Phase 1 - Creating assumptions and scenarios:** This phase was completed under the leadership of the Ministry of Energy and Climate Change. It involves the establishment of assumptions and scenarios that the Forum will be based on in the road map study, in line with the Ministry's low carbon emission targets.
- **Phase 2 - Establishing the evaluation model:** Ofgem (Office of Gas and Electricity Markets) conducted this study with a high-level generalized view to evaluate alternative grid development options. The model is based on the philosophy of comparing the direct costs and benefits of smart grids. The costs and benefits to be compared are as follows:
 - Investment cost
 - Change in generation and transmission cost
 - Losses and changes in supply reliability
 - Customer discomfort cost
 - Direct CO₂ emission change
- **Phase 3 - Development of low carbon emission grids:** Distribution system operators examined the impact of planned system installations on the grid within the framework of the assumptions and scenarios defined in Phase-1.



This project is funded by the European Union



- Phase 4 - Closed doors: Under this phase, smart grid stakeholders were brought together and studies for determining possible risks and necessary legislative arrangements were carried out.
- Phase 5 - Working methods: Ways of ensuring the healthy communication of the Forum with smart grid stakeholders were investigated.
- Phase 6 - Commercial and legal problems: Stakeholders came together and planned the necessary commercial and legal problems and actions to overcome them.
- Phase 7 - Whole system design: Under this phase, distribution grid architectures and specific roles and duties of each stakeholder that can be created for more reliable and more efficient operation of electricity distribution grids are defined in 2030.
- Phase 8 - Vision and road map: Under the control of the Ministry of Energy and Climate Change, a smart grid vision and road map were created within the framework of the conclusions drawn from the previous phases.

Road Map Steps:

The figure below shows a summary of the road map for UK and short, medium- and long-term goals.

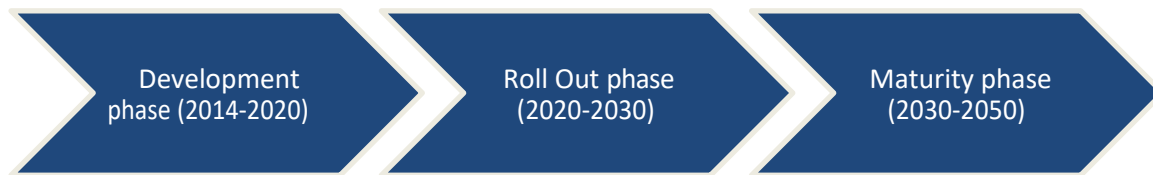


Figure 47: United Kingdom – 2030+ Road Map¹⁹⁰

- Development Phase (basis for post 2020)
 - Transition from projects to the usual activity structure
 - Establishing regulatory and commercial framework
 - Developing standards and strengthening the supply chain
 - Transition to smart meters throughout United Kingdom begins
- Roll Out Phase (reinforced consumer)
 - Roll out of smart meters
 - Commercialization of smart applications and other devices
 - Potential DNO-DSO conversion to occur
 - Establishing on-site supply chain
- Maturity Phase (realization of vision)
 - Creating an integrated energy system
 - Empowering consumers

¹⁹⁰ OFGEM Smart Grid Vision and Route Map



This project is funded by the European Union



- Growing supply chain with export

2.9.5 Spain - FutuRed 2030 Electricity Network Vision

In 2005, the FUTURED Technology Platform for Spanish Electricity Grids (FUTURED) was established in line with goals such as meeting of official institutions and sector companies on a common platform and sharing ideas, developing a common vision and identifying potential cooperation opportunities.

Accordingly, 2030 Electricity Network Strategic Vision document was published by FutuRed¹⁹¹. In this study;

- Technological targets for 2030,
- Evaluation of the existing network,
- Vision of electricity grid for 2030 and beyond,
- Barriers and strengths for 2030 targets

subjects were investigated.

Moreover, potential research and application issues were identified, projects were selected and planned for the period up to 2025, with another study by FutuRed (2025 Research Plan)¹⁹².

Vision:

The main vision of the study is to strengthen the technology transformation of the Spanish transmission and distribution grids in order to achieve technological leadership, ensure sustainable development and increase competition.

Targets:

The goals set for the year 2030 are as follows:

- Developing more stable and efficient electricity transmission and distribution infrastructures, managing a larger amount of energy with wider advanced operational functionality, saving energy, reducing losses and promoting lower costs
- Ensuring safe, reliable and flexible operation by strengthening the active roles of all system stakeholders
- To provide the right reliability, quality and cost levels of energy supply for industrial and residential consumers while meeting the increasing demand
- Ensuring efficient integration of renewable energy sources and distributed generation with conventional power plants, without compromising system stability and supply continuity.
- Increasing the potential of financial profit by providing integration of service providers and consumers, and implementing demand-side control programs by making use of smart devices on the customer side

¹⁹¹ <http://www.futured.es/wp-content/uploads/2016/09/Strategic-Vision-2030.pdf>

¹⁹² <http://www.futured.es/wp-content/uploads/2016/01/SRA-2025.pdf>



This project is funded by the European Union



- Establishment of an environmentally friendly transmission/distribution grid while taking into consideration the goals of sustainable development and reduction of environmental impacts at infrastructure planning and implementation stages.
- Strategic technology, computer infrastructures, power electronics, storage and roll out of new sensors/materials

Definition of Smart Grid:

The electricity grid of 2030, in other words, the smart grid, is defined as the system where energy flows are managed and optimized in real time in line with the decisions made by consumers, providers, operators and other stakeholders.

Study Scope and Methodology:

The research plan was created in line with the needs arising as a result of situational assessments, gap analysis, and 2025 targets. This plan includes short to medium and medium to long-term plan actions and evaluates certain barriers and opportunities.

Moreover, Spain has taken SGAM as an architectural model in smart grid applications as did many other European countries.

In line with the objectives determined within this plan, projects were divided into different sub-groups within the framework of their functionality:

- Control and operation
- Electricity grid planning and design
- Maintenance and equipment life management
- Measurement, efficiency and demand management

The most important aspect that requires attention is that manufacturers, technology centres, and universities with their knowledge and experience are also included in the process in order to enrich the target determination and planning stage and not to miss the technological developments.

Furthermore, the projects targeted to be studied are classified into the following categories according to their strategic importance:

- Top Priority
- Important
- Complementary

Although a full cost/benefit analysis has not been carried out within the prioritization studies of the projects, they are considered subject to parameters such as their time horizons (short to medium or medium to long-term), total cost of the project, whether direct field application is required etc. In addition, after a joint study conducted by



This project is funded by the European Union



FutuRed and Boston Consulting Group (BCG), a cost/benefit analysis covering smart grid was conducted¹⁹³, but this study was not used as a parameter in project prioritization.

Road Map:

As mentioned in the previous topic, the projects are divided into functional categories first, and then, into prioritization categories using costs and other parameters. As a result of these studies, the research topics planned to be included in the action plan are as follows:

- Control and operation
 - Short to Medium Term
 - Advanced electrical equipment
 - Improving the access standards of electrical equipment
 - Development of power electronic control equipment
 - Development of predictive and self-diagnosis systems
 - Communication and automation
 - Development of communication solutions for wide area control
 - Development of communication standards and automation equipment protocols
 - Medium to Long Term
 - Fault detection, fault elimination and service quality
 - Smart fault detection equipment and service restoration systems
 - Electronic wavelength quality control and improvement devices
 - Wide area protection systems based on WAMS (wide area monitoring system)
 - Distributed energy sources
 - Demand and micro-production management
 - Micro-grids
 - Technologies for the integration of new energy sources
 - Business support tools
 - Real-time applications for grids
 - Simulation and optimization tools
 - Reliability of the control structure
 - External connection to the controlsystem

¹⁹³ Development of Smart Grids in Spain, FutuRed & BCG, November 2012



This project is funded by the European Union



- Integration of businesses with customers and control systems
 - Managing large databases and interoperability
- Maintenance and equipment life management
 - Digital exchange of signals
 - Optical/digital transformers
 - Sensors with self-diagnosis
 - Monitoring of the dynamic properties of the equipment (temperature, loading, wind speed, etc.)
 - Real-time traceability of partial discharges
 - Use and dissemination of IEC61850
 - Asset life management-based maintenance plan
 - Reducing maintenance cost by applying SF6 solutions
 - Standardization of external communication protocols of the distribution centre
 - Grid monitoring and asset management optimization
 - Asset life, reliability and risk reduction-based maintenance plans
 - Advanced decision-making mechanisms
 - Intelligent decision-making system
 - Intelligent decision support system-based maintenance planning
- Grid planning and design
 - Short to Medium Term
 - Alternative development of the grid
 - Line and distribution centre designs with low socio-environmental impacts
 - High temperature and other special conductor types
 - Use of flexible alternating current transmission devices
 - Creating grid development models
 - Improvement of determination tools for generation plant location
 - Storage systems to strengthen the integration of renewable energy sources
 - Creation of grid planning models with high uncertainty
 - Electrical equipment
 - Dynamic short-circuit current controller
 - Wave quality monitoring devices
 - Development of auxiliary equipment for superconducting systems



This project is funded by the European Union



- Development and implementation of energy storage systems
- Design and implementation of mobile charging points
- Medium to Long Term
 - Distribution grid development alternatives
 - Micro-grids
 - Integration of distributed generation
 - Use of power electronics devices
 - Switching based static protection devices
 - Transportation grid development alternatives
 - Direct current applications
 - Extra high voltage applications
- Metering and meters
 - Metering and control equipment/technologies for grid-consumer interface
 - Short Term Projects
 - Integration of metering and control devices for distributed generation control and demand-side management
 - Development of standards for communication between metering/control equipment and demand management centres
 - Defining the relationship between consumer equipment and metering/control devices
 - Demand management
 - Short to Medium Term Projects
 - Demand flexibility study by sector/usage
 - Developing social awareness projects
 - Demand management programs
 - Medium to Long Term Projects
 - Use of storage systems for demand management
 - Energy efficiency research



This project is funded by the European Union



2.10 Smart Grid Roadmap for Turkish DSOs

Smart Grid is an emerging concept in electrical networks along with the developments on advanced measurement, intelligent monitoring, automatic control, information and communication technologies. There are several definitions describing characteristics of the smart grids proposed by various authorities, such as International Electrotechnical Commission (IEC), International Energy Agency (IEA), European Commission (EC) and the US Office of Electricity Delivery & Energy Reliability.

The purpose of the smart grid concept can be summarized as modernizing electrical networks to provide a live system improving security, reliability, flexibility and efficiency. A smart network can be determined by the features of observability, controllability, intelligent decision-making, self-adapting/healing abilities and renewable energy integration. Being a smarter grid is an evolutionary process depending on the integration and acceptance level of new technologies in the existing infrastructure within a holistic approach.

Smart Grids are basically considered as a global imperative that triggers change and transformation to help efforts to tackle energy and environmental issues and improve service quality worldwide. Environmental concerns, rapid increase in energy demand, emphasis on electrified transport, aging infrastructures, and strengthened and more demanding consumers are the main factors that require this change.

Energy markets in all developed countries are working hard to keep up with the paradigm shift they face. The main dynamics of this change can be listed as follows:

- Reducing the carbon footprint as quickly as possible,
- To meet the market participation demands of the consumers,
- Keeping up with rapidly developing renewable energy, IT and analytics, telecommunication and cyber security technologies,
- Designing and commissioning transmission and distribution grids that can meet these developments
- To meet the financial and regulatory requirements needed on time

For Turkey, support to national domestic energy generation target to remove foreign dependency can be added to this list which requires transferring technology and knowledge in energy.

In the transformation of smart grid, the future of electricity distribution systems can be defined very basically by the following three characteristics:

- **Millions of manageable active endpoint equipment:** Substations (distribution centres, circuit breakers, etc.), distribution transformers, lines and feeders, distributed generation facilities, storage units, electric vehicles, micro-networks, etc. and sensor networks, relays, smart electronic devices, communication switches, meters and communication equipment installed in many different points; a grid management, characterized by creating value for all stakeholders.
- **Hundreds of thousands of market stakeholders:** Operating the electricity system and the market supported by information and communication technologies while having stakeholder participation (consumers, supply companies, generators, producer-consumers (prosumers)).



This project is funded by the European Union



- **Flexibility management:** System capacity management that will be required in a flexible and distributed structure, which will be needed due to the increase in the share of renewable energy sources (solar, wind, etc.) connected to the electricity grid, and inclusion of new load types with different characteristics such as electric vehicles, heat pumps, manageable loads.

In the grid of future, some of the connected endpoints will go beyond showing passive load characteristics as they do today and will have features such as generation (distributed energy sources), response, detection, communication, calculation and adaptation.

Distributed generation and new load types at hundreds of thousands of points will start to cause rapid and random changes in frequency and voltage parameters and in real-time supply-demand balance of the electricity grid. Thanks to the advanced control and optimization technologies that smart grids will bring; it will be possible to benefit from renewable energy sources as much as possible by eliminating the problems created by their distributed energy generation. DSOs will play a key role in sustaining this.

2.10.1 As-is Status of Smart Grids in DSOs

After the privatizations, the operators of the electrical distribution companies have been obliged to undertake the necessary investments and improvements in the networks. Primarily, distribution companies were expected to perform network master plan studies for 5- and 10-years horizon. Besides Energy Market Regulatory Authority (EMRA) started to update loss & theft target values for each distribution region for every year; to reduce technical and non-technical losses.

In addition to the initiation of implementation Smart Grid systems (including SCADA, distribution automation, OMS, AMR, GIS, etc.) which started mainly with the 2nd Tariff Period (2010-2015) of the sector, R&D and pilot projects have also been initiated on topics such as advanced measurement infrastructures, demand side management, smart meters, and communication within the scope of R&D activities that intensified after 2014. This approach of encouraging innovation within DSOs, which is followed in different countries in the development of smart grids, is important in terms of examining the benefits of new systems/technologies.

In Turkey, several secondary legislations oblige DSOs to implement certain systems; either implicitly or explicitly. These systems include SCADA, OMS, AMR, GIS, reporting systems, etc. DSOs efforts so far has been concentrated in these systems mainly.

Further findings about the as-is status of smart grid deployment in Turkish DSOs are summarized below:

- **Different Smart Grid maturity and technology deployment levels amongst 21 EDCo:** Comparing 21 distribution companies based on technical components of smart grids, maturity levels were observed to be quite different from each other. This reveals that the activities shown as targets in the upcoming periods should be carried out by each distribution company carefully, taking into account their own planning and needs. As a different reflection of the level of heterogeneous maturity observed in distribution companies, there is a great variety in the prevalence levels of similar technologies used under technical components. For example, one distribution company has launched telecontrol applications in substations that has expanded for more than 1000 substations, while another distribution company has only a few dozens of substations that has been integrated to SCADA system.
- **Lack of a systematic approach to track the results, lessons learned and real-life experience for SG projects:** Lack of systematically track the results, field experiences and benefits of smart grid projects



This project is funded by the European Union



stands out as another major problem. Distribution companies cannot systematically monitor and evaluate the results obtained from smart grid projects; therefore, they cannot use their gains in the dissemination or further development of smart grids. This also leads to the absence of tracking systematics, being unable to reveal real benefit and determine the correct application areas within the smart grid architecture.

- **Functionalities that have been implemented but not used:** It has been observed that some distribution companies have installed some of the systems/modules, but do not or cannot use several functions of these technologies due to reasons such as lack of competent personnel or lack of business process adaptation.
- **Insufficient pilot implementation and trials on the field for new technologies:** The fact that the smart grid pilot applications carried out by the distribution companies are mostly small-scale, which causes insufficient field experience and knowledge on new technologies.
- **Lack of cross-sectoral know-how sharing platform:** The lack of an effective interaction and information sharing platform to share the best practices and experiences in the industry draws attention as another problem. Such a platform enables distribution companies to realize their own shortcomings while transferring the knowledge and experience they have gained from projects in their region.
- **HR requirements that can harmonize power system and ICT technologies:** The lack of human resources who are advanced in power systems operations and also has the skills of digital technologies and is able to harmonize these two areas, emerges as a problem that must be overcome in the distribution sector as soon as possible.
- **Challenges to realize IT-OT convergence:** Due to the silo approach regarding operations of certain software solutions, the actual data transfer requirements between IT and OT systems cannot be realized, and therefore enterprise application integration (EAI) is not fully achieved.
- **Problems with transforming data asset to value and lack of analytics-based decision making:** After the implementation of smart grid projects, a large volume of data is accumulated in databases. Data management is important to increase operational efficiency. However, it has been observed that some distribution companies have room to improve in managing the quality of the big data that can be used in various analysis. For this reason, it is not possible to contribute to the decision support processes by making use of these big data, namely data analytics studies.
- **Solutions that do not comply interoperability requirements:** It is observed that some of the solutions/ systems do not meet international interoperability standards. While such solutions benefit distribution companies in the short term, it is inevitable that problems arise with the integration with other systems in the medium and long term. These systems, which are not designed in the framework of smart grid concept, either have to meet smart grid and interoperability standards, or they have to be replaced with internationally accepted software.
- **Overdependency to public infrastructure for SG communication needs:** In order to meet the communication needs of IT/OT systems, it has been observed that the distribution companies use 3rd party Telecom infrastructures (Telecom and GSM). IT and OT systems of companies with critical infrastructure, such as electricity distribution companies, should have their own communication infrastructure as the main communication system. This is very important for the safety and reliability of communication. In a disaster scenario, intensive use of Telecom or GSM networks may limit OT/IT communication in the region. Or some communication problems may arise because of different practices of the 3rd party provider. (For



This project is funded by the European Union



example, GSM Company can invest in 4G in an area with large population and no communication problem, instead of investing in a zone with a small population and communication problem).

2.10.2 Needs Assessment

Smart Grid itself is a big idea. The total concept does not end with the modernizing the electrical or communication network. The idea of modernizing electricity network includes the ability to reduce power consumption at the consumer end during peak hours (Demand side management), enabling grid connection of distributed generation, incorporating grid energy storage for distributed energy, providing opportunity to integrate renewable energy and eliminating failures such as widespread power grid cascading failures. The increased efficiency and reliability of the smart grid is expected to save consumers money and help reduce CO₂ emissions by establishing an efficient network.

For Turkey, the main expectations from smart grids can be listed as follows:

- Reducing the technical and non-technical loss levels throughout the country and reducing the carbon footprints of distribution companies,
- Improving supply continuity and energy quality,
- Increasing grid resilience,
- Increased awareness through the use of advanced, near real-time measurement and metering infrastructures,
- Ensuring consumer/demand side participation,
- Increasing connection capacity for renewable generation and reducing foreign dependency in energy supply,
- Optimum use and management of grid assets,
- Transformation from static networks to dynamic, live infrastructures with bidirectional energy and information flow,
- Ensuring harmonization with the EUacquis,
- Supporting R&D, domestic technology and market development



This project is funded by the European Union



Figure 48: Turkey's Expectations from Smart Grids

In order to realize all these high expectations, the operation of a well-designed transition and transformation process from smart grids is critical. Planning phase must consider many parameters as it is the only way possible to benefit from advantages of smart grid technologies while incurring high costs. While determining the implementation strategies and the road map; technology maturity, experiences in different countries, international standards/interoperability principles, cost-benefit approaches, legislation and regulations, consumer behaviour and habits, and competence levels of distribution system operators' existing systems should be studied as important inputs.

Smart Grid roadmap developed for Turkey in this study considers the following needs and achievement targets as basis and project recommendations have been developed on top of these considerations.

Smart Grid Planning

- Implementation planning for smart grid and digital transformation
- Adaptation of organization and business processes for IT-OT convergence
- Strong engagement of academia for development of Smart Grid-ready HR
- Collaborations for new business models, lessons learned exchange

Advanced Grid Monitoring, Control and Management

- Start network management utilizing SCADA/ADMS/OMS and DERMS systems
- Proper capture and management of network data, data-driven decision making in network management, advanced grid analytics



This project is funded by the European Union



- Roll-out of grid automation systems to improve situational awareness and remote control & management capabilities, automation work-force management
- Large-scale pilot projects for concepts including self-healing networks, (ANM), D-ancillary services, closed-loop networks, WAM for distribution and DC networks.
- R&D projects to harmonize the data and infrastructure of different type of utilities (gas, telecoms, water, etc.)
- R&D and trial projects for future network components including amorphous metal transformers, superconductors and power-electronics based switches.

Asset Management and GIS

- Properly capture and manage network, customer, and geospatial data in GIS
- Asset performance and life-cycle management via IoT and IT
- Risk and reliability-based maintenance plans
- Long-term asset management and strategical investment decisions based on APM

Enterprise IT & Analytics

- Enhance customer interactions enabling enterprise applications, mobile apps, social media integration and next generation analytics
- Develop enterprise IT architecture and properly manage
- Digitalization roadmap, plan to deploy advanced analytical capabilities and platforms
- Implement data quality control & assurance systematics and tools
- Automate regulatory reporting
- Accurate short-term load forecasting
- Include OT and telemetry data in enterprise analytics

Enterprise Application Integration (EAI)

- Realtime synchronization of network model and telemetry data
- Design integration architecture and develop the implementation plan
- Complete all major integration work for IT and OT systems for key data exchange
- Start implementation of interoperability standards (CIM/IEC 61968)

Integration of Distributed Energy Resources (DG & ESS & DSM)

- Real time monitoring and remote control of DGs
- Initiate distribution ancillary services capabilities for voltage/reactive and congestion management support from DGs
- Standardize and automate DG connection permission processes



This project is funded by the European Union



- Large-scale pilot projects to evaluate the effects of hybrid rooftop PV and ESS
- Pilot projects for implementation of utility-scale storage systems
- New network components (voltage regulators, OLTC DTRs, etc.) to increase connection capacity of RES
- Integration with aggregator Systems for better utilization of DSM
- Adapt network expansion planning processes considering DERs

Integration of Electric Vehicles and Charging Infrastructure

- Enabler role to proliferate of EVs via standardization/automation of connection process
- Implementation of systematics for smart management of LV&MV network capacity
- Explore potential use of EVs for grid services (V2G) via pilot projects
- Cross-regional interoperability and plug & play practices for EV charging

Smart Grid Communication

- Design, plan and implementation of own communication infrastructure
- Collaborate with telecommunication operators for better network utilizations
- Interoperable environment for SCADA, AMI and IoT
- New capabilities for tighter communication capabilities with field crew
- Pilot implementations for testing and adaptation of new generation communication technologies for smart grid components
- Start to manage smart grid telecommunication networks and nodes

AMI/Smart Meters

- 80-80 principle for deployment of smart meters: 80% of total consumption by 2025 and 80% of the estimated 50 million customers by 2035
- Develop minimum standard requirements for smart meters and relevant standards
- Large-scale smart meter pilot projects
- Develop deployment plans for AMI and communication infrastructure
- Implementation of MDM (Meter Data Management) systems and meter analytics
- Advanced invoicing applications for energy efficiency
- Trial studies for blockchain technologies in energy trade

Cyber Security

- Cyber security audits for compliance check of IT and OT environment
- Action plans to mitigate vulnerabilities and risks
- Track CS maturity level and progress



This project is funded by the European Union



- Establish of cyber security operationcentre
- Implement cyber security test laboratories
- Nationwide cybersecurity certification program for smart grid components

2.10.3 Smart Grid Roadmap for DSOs

Building on the assessment of current situation and requirements, a successful transition to a ‘Smart Grid’ framework requires certain steps in certain directions within the relevant technical domains. It is crucial to track and maintain the progress towards this goal in order to ensure realization of Smart Grid benefits and transform DSOs as future-proof entities.

In this perspective, a total number of 31 concrete recommendations are presented in this section with conceptual framework and relevant sub-topics that can be handled as projects within the context. Technical domains that are considered for enlisting project recommendations can be listed as below:

- Smart Grid Planning
- Advanced Network Monitoring, Control and Management Systems
- Asset Management and GIS
- Enterprise IT and Data Analytics
- Integration of Distributed Generation and Energy Storage
- Electric Vehicles
- Telecommunication Infrastructure
- Advanced Metering Infrastructure
- Enterprise Application Integration
- Cyber Security

Projects enlisted under the given technical domains are suggested for each DSO in order to create a diversified Smart Grid project portfolio and secure tangible results from its efforts and investments through a structured path of progress.

2.10.3.1 Smart Grid Planning

Transition towards Smart Grids is a cumbersome task for DSOs due to the level of complexity and multitude of work steps that require high level of coordination, alignment, and monitoring for certain success. Planning phase is therefore a crucial step in laying out the foundation for efforts and projects that will follow. It is also highly important to monitor the progress using project management methodologies and develop business-oriented frameworks and strategies for expected outcomes of managed project portfolio. In this context, following projects are recommended within the ‘Smart Grid Planning’ technical domain:

- Smart Grid Master Plans
- Establishment of a PMO Structure for Smart Grid Roll-out
- New Services, Business Models and Market Blueprints



This project is funded by the European Union



Following tables will provide further explanations on recommended projects.

Recommendation 1 Smart Grid Planning Activities

Planning the deployment of smart grid technologies is a challenging process due to highly complex environment of information (IT) and operational technologies (OT). The first step towards realization of Smart Grids is the initial planning activities that will lay out the conceptual foundation for future projects. Therefore, it is essential for DSOs to start with developing their Smart Grid Master Plans and build up their entire Smart Grid project portfolios and implementation strategies according to the basis provided in the Master Plans. Certain steps recommended for successful progress are as follows:

- **Smart Grid Master Plan**

DSOs must initiate an overall effort to develop their Smart Grid Master Plan with committed involvement of all their central and operational units. An overall strategy is required that incorporates analyses of current situation, key stakeholders, business KPI's, operational requirements, technological gaps, improvement areas as well as roadmaps for implementation strategies and a detailed cost-benefit analysis for Smart Grid investments in all technical domains.

- **Smart Grid R&D and Pilot Implementation Planning**

A major part of Smart Grid deployments begins with early research and demonstration efforts that require diligent planning and prioritization. Development of research strategies, R&D project portfolios, demonstration sites and pilot implementation strategies are key components of successfully managing Smart Grid R&D efforts, which will eventually guide the Smart Grid strategy and wider-scale Smart Grid deployments.

- **Harmonization/Revision of Grid Master Plans with the Smart Grid Master Plan**

As a regulated entity, each DSO regularly prepares and follows Grid Master Plans within its conventional operational framework. It is essential for a Smart Grid Master Plan to successfully align with existing Grid Master Plans in order to capture the existing DSO strategy, incorporate Smart Grid elements and transform it successfully without completely detaching from existing planning efforts but instead re-directing them towards a more technologically advanced set of goals.

As-is Status in Turkey: Turkish electricity distribution sector has developed a detailed smart grid roadmap defining the achievement targets and implementation recommendations till 2025. EMRA has recently added a clause in the draft version of "Procedures and Principles for the Determination of Investments in Electricity Distribution" to oblige DSOs to include Smart Grid planning as part of their 5 and 10-years Master Plan studies.

Prioritization: Short-term

Technical Domain: Smart Grid Planning



This project is funded by the European Union



Recommendation 2 Establishment of a PMO Organization for Managing Smart Grid Roll-out

Due to the wide-scale technical and administrative complexity of Smart Grid implementations, it is recommended for DSOs to establish a 'Project Management Office (PMO)' structure within their organizational frameworks. Main function of a PMO will be to handle the strategic project management; continuously track progress of Smart Grid roll-outs in multiple technical domain, coordinate projects and resources, provide coaching and training for Smart Grid Project Managers and ensure that certain project management methodologies are put into standardized, high-quality use across the organization. A series of tasks are required to establish and maintain a healthy PMO structure that will handle the project portfolio of Smart Grid rollouts.

- **Establishment of Smart Grids Project Management Office (PMO)**

Planning and establishment are recommended, starting with the general structure of a project management office. Structural setup process includes but is not limited to its definition of organizational structure, human resource and technical capacity requirements, functional tools, services, methodologies and standards.

- **Establishment of Smart Grid Projects and Systems Management, Tracking and Performance Evaluation Systematics**

It is crucial for a PMO to objectively track and manage its project portfolio. This task covers the development of a systematic and standardized approach to successfully manage, track and evaluate Smart Grid projects within the portfolio, and determination of key performance indicators (KPIs) for a healthy project monitoring.

- **Transformation of Network Operation, Management and Optimization Organization**

Setup of an internal organization for network operation, management and optimization is recommended. Network operation processes and network management & optimization processes should be segregated from each other to establish two distinct units with specific focus points.

- **Establishing Data Management and Quality Control/Assurance Organization**

In Smart Grid transition processes, it is important to establish a data management and quality control/assurance organization for enterprise systems, both in IT and OT domains. Management of enterprise data is an interdisciplinary issue and requires strong coordination between multiple units in the corporate structure for effective handling. Setup of an internal organization is recommended, including a detailed description of unit resource commitments, roles and functional responsibilities for data management and quality assurance in Smart Grid projects.

- **Establishment of Big Data Analytics Organization**

An important aspect of Smart Grid transition is the heavily increased volume of data that will begin to flow from deployed Smart Grid systems in multiple domains. It is essential for a large corporate organization to adopt a data-driven approach in order to capture and create the value from its systems and operations. Setup of an internal organization is recommended for systematic management of big data generated from Smart Grid systems.

- **Business Process Transformation and Adaptation**



This project is funded by the European Union



Recommendation 2 Establishment of a PMO Organization for Managing Smart Grid Roll-out

Transformation and adaptation of existing business processes is necessary to achieve efficient and high-performance Smart Grid operations. It is recommended that all business processes must be reviewed and re-structured in detail to incorporate functional requirements and outputs of Smart Grid technologies in existing operations.

- Establishment of IT and OT Communication Operation and Management Organization**
 Due to the fact that information technology (IT) and operational technology (OT) infrastructures have different requirements and priorities, setup of a cross-functional team is recommended that will focus on development, improvement and maintenance of Smart Grid systems in both IT and OT perspectives.
- Establishment of Distributed Energy Sources Connection Management and Planning Organization**
 Distributed energy resources are among the key drivers of the Smart Grid transition and it is essential for a Smart Grid PMO to involve an organization that provides expertise and handles this topic. It is recommended that a team should be set up with a focus on grid integration of renewable energy based distributed generation units and energy storage systems. This will enable the PMO to involve a key factor in its strategic planning and management efforts.
- Planning Training and Competence Development Activities**
 Due to the fact that all Smart Grid systems will be delivered to a larger base of employees that will handle the future routine, it is highly important that the DSO's human resource to be continuously educated, trained and coached for higher competence in Smart Grid system management and project management activities.
- Establishment of Smart Grid Cyber Security Management Organization**
 Deployment of Smart Grid systems can also be translated as modernization and digitalization of grid management in various aspects. In order to operate the Smart Grid without any malign external interference, a Cyber Security organization must be set up that will continuously analyse cyber security risks, develops contingency plans, develops system and data protection strategies and prevents potential cyber security threats.

As-is Status in Turkey: Most of Turkish DSOs have not yet implemented a PMO structure to properly monitor and manage their progress in smart grid domains. In general, alignment of company organization and business processes are in good shape but triggered via establishment of new systems and infrastructure, the approach is generally reactive. On the other hand, there is still room to improve about IT-OT convergence from business process and organizational perspectives.

Prioritization: Short-term

Technical Domain: Smart Grid Planning



This project is funded by the European Union



Recommendation 3 New Services, Business Models and Market Blueprints

Transition to Smart Grids provides new perspectives and business opportunities for DSOs that had not been available with the conventional grid management philosophies and systems. It is recommended for DSOs to develop and execute a project on market-oriented transformation around Smart Grid technologies and their value chain. Each factor driving the Smart Grid transition also holds various business opportunities that will benefit all the involved stakeholders, but extraction of the added value requires elaborate assessments of business value chain, consumer orientation, market models and mechanisms.

- **Comparing Different Models and Establishing Market Structure for Ancillary Services Market** Together with the increase in the grid integration rate of distributed energy resources, ancillary services become more important in smart distribution grids in terms of the added value that can be provided to maintain more stable and reliable network operations. It is recommended for DSOs to evaluate the potential contribution of distributed generation in provision of ancillary services and analyse alternative business models in quantitative comparison and cost-benefit analyses. This would also trigger regulatory revisions and expansions of ancillary services regulation scope.
- **Evaluation of Different Market Models for Demand Side Participation**
Demand side participation is expected to be one of the key aspects of Smart Grid operations and one of the primary interactions between the DSO and energy consumers. This recommended task includes analysis of the demand side value chain including but not limited to demand resource providers, demand aggregators, load curtailment entities and supplies, consumers and DSOs. Existing market models and tariff structure should also be investigated. New models should be developed with local constraints and conditions considered.
- **Establishment of Market Mechanisms for Sustainable Expansion of User-Sized Renewable Energy Generation**
Energy consumers are the prime owners of small-scaled renewable energy generation units (distributed generators) and it is important for this segment to have a sustainable growth for a sustainable energy future. Assessment of international market models are recommended in order to form cost-efficient growth strategies and incentive mechanisms, develop new definitions in Turkish energy market mechanisms (dayahead, intraday, balancing), capacity mechanisms and capacity incentive applications.
- **Comparison of Different Market Balancing Mechanisms**
It is recommended that various market balancing mechanisms should be compared through an extensive international literature and industrial research. Long-term agreements, spot market mechanisms, intraday markets, real-time balancing services and ancillary services are key topics for investigation. Definitions and criteria for balancing mechanisms in Turkey are included.
- **Transformation Studies of Grid and User Oriented Open Market Structure for the Expansion of Electric Vehicles**
Integration of electric vehicles is one of the transformative factors that possess challenges for grid management strategies. In order to develop mechanisms that will enable higher integration rates of electric vehicles in addition to distributed energy resources, it is recommended to investigate alternative market models foresee usage of electric vehicles as energy storage units in the grid and define extensive services that Smart Grid operators and electric vehicle owners can provide in exchange.



This project is funded by the European Union



Recommendation 3 New Services, Business Models and Market Blueprints

Incentive, compensation and payment methodologies must be defined in line with local regulations, constraints and user preferences. Technological and legal regulation requirements must be determined.

- Evaluation of Different Market Mechanisms for Blockchain and Peer-to-peer (P2P) Energy Trade** Blockchain technologies can be considered as a prime candidate for enabling and catalysing distributed resource management and distributed intelligence. A multitude of Smart Grid applications (such as P2P energy trade, grid services, distributed resource coordination, meter data management, EV integration) would eventually require Blockchain technology as an important factor. It is suggested that a task incorporating market mechanisms that evolve around blockchain technologies and P2P energy trade must be handled within this project.

As-is Status in Turkey: Turkish DSOs are executing (or completed) numerous R&D projects for trials of different smart grid components including Distribution Ancillary Services, Demand Response, EV Charging, etc. R&D and Innovation mechanisms of EMRA is quite encouraging for this kind of studies. However, we would like to note a few potential improvement points about these activities:

1. Incorporation of other stakeholders (customers, prosumers, other system/infrastructure operators, market operator, etc.) of Smart Grid ecosystem should be considered in these innovation activities in order to better test future business models, new services and market structures.
2. Portfolio of smart grid innovation projects so far lack large-scale demonstration projects, which in return results of deficit of real-life experience of about end-to-end operation of smart grid services including all stakeholders.

Prioritization: Medium-term

Technical Domain: Smart Grid Planning



This project is funded by the European Union



2.10.3.2 *Advanced Network Monitoring, Control and Management Systems*

‘Advanced Grid Monitoring, Control and Management Systems’ is one of the most critical smart grid technical components that should be considered as one of the focus areas of sustainable service quality and should be extended in the short and medium terms.

Rapid global digitalization along with urban and industrial growth means that societies' dependence on electrical energy is heavily increasing. Thus, malfunctions in the expanding power system cause social and financial losses for the end users. Therefore, distribution companies are required to continuously conduct new investment, improvement and maintenance works in their systems to improve supply reliability and continuity.

However, failed attempts to completely eliminate discontinuity arising from the nature of the current system raises the need to modernize conventional system operation processes and transform them into more efficient and reliable structures. To meet this need; grid monitoring, protection, control and management systems and technologies, which are important components of smart grids, should be planned and deployed in the short and medium terms.

Technologies that provide real-time data at decision points for grid interventions are gaining importance day by day in grid management. The use of monitoring and automation systems, which were abundant in transmission grids since they were more critical in the past, has also become widespread in distribution networks. Particularly, with **expectations regarding the supply continuity and service quality requirements** are increasing and **distributed (embedded) generation sources become more integrated into the grid every day**, distribution grids start to turn into a structure that allows **bidirectional energy flow**, which increases the need for these technologies. It will become increasingly important to equip distribution grids with more remote intervention and automation capabilities, especially in terms of control.

Other motivations for distribution automation investments in the short and medium term include:

- Improved distribution grid operation and repair processes with rapid fault positioning and fault analysis
- Managing more complex power streams, stemming from inclusion of distributed energy sources, as much and as transparent as possible; and achieving higher levels of reliability for both loads and generation facilities
- Basing distribution grid operations on an active and dynamic load/source dispatch
- Managing more complex power streams, stemming from inclusion of distributed energy sources, as much and as transparent as possible; and achieving higher levels of reliability for both loads and generation facilities

In order to achieve advanced grid automation functions in the long term, basic grid automation functions to be carried out in the short and medium terms are of great importance. Distribution companies are expected to carry out roll out and pilot implementation projects for the following basic and advanced functions in the short and medium terms:

- **Data Communication Infrastructure:** The communications infrastructure is the backbone of advanced grid management functionality. Developments in communication technologies which support the network monitoring, control/command and protection functionalities and lack of current systems inability to ensure communication needs encourages distribution companies to carry out pilot applications in the medium



This project is funded by the European Union



term in terms of innovative communication technologies in order to incorporate functionalities that cannot be met under these circumstances.

- **Distributed Intelligence Applications:** Thanks to the use of existing automation competencies of distribution or transformer centres in the grid and advanced distributed smart applications that will be used in the medium term, it will be possible to fully automate the system thus eliminating human intervention. The autonomous manoeuvres of the stations upon failure situations by evaluating the local conditions is one of the most important application areas of the “*self-healing*” grid. **Self-healing grids, which will be indispensable for smart grids in the long term**, can be defined as the capacity of the system to repair itself automatically and efficiently after failure.¹⁹⁴ Thanks to this feature, it will be possible to isolate the defective area in the narrowest possible space within the minimum time frame after the failure, to re-energize the maximum number of end users with the minimum switching manoeuvre and to operate the remaining grid under stable conditions during all these actions. While performing these operations, real-time data will be obtained from the embedded sensors in the grid, and control equipment will protect the system against internal and external malfunctions of the system.

Although the self-healing network concept is expected to remain at low acceptance rates for short-term electricity distribution systems; innovative methods in network failure intervention processes and adaptation of developing technology in grid processes will become important for the future especially with introduction of large-scale pilot applications. In order to access this network structure, it is important that large-scale pilot applications are carried out by many distribution companies in the upcoming investment period.

- **Grid Control Technologies:** Modern grid control technologies include applications based on advanced mathematical algorithms. For example, performing failure analysis with the data received from smart devices in the grid and determining the location of the fault, isolating the defective region, re-feeding the remaining network regions, returning the network to its normal operating state after the fault is eliminated, and making advanced analysis for maintenance and investment processes after failure are the competences provided by modern grid control technologies.

Another function provided by advanced grid control technologies is the optimization of MV and LV lines in terms of voltage ranges and power flows. It is envisaged that modern control technologies and applications will start to be used, especially for critical grid components, in future electricity distribution systems.

- **Voltage and Reactive Control Technologies:** Recently, the number of distributed generation facilities (solar, hydro etc.) connected to the distribution grid has increased in some transformer centres (TM). In these regions, balancing the voltage level and reactive power has become more complex. In the long term, increase in the concentration of photovoltaic power plants/generation facilities and other embedded generation is an important risk for the stability of distribution grids due to the problems it will cause in terms of voltage and reactive control. In order to overcome these problems, for example, tap changing distribution transformers, voltage control systems, and controllable inverters that can supply reactive power must be used as part of distribution system automation. Experience from pilot projects shows that the use of controllable distribution transformers makes it possible to correct approximately 90% of all voltage limit excesses in the MV network. Using new inverters especially for roof type PV applications and

¹⁹⁴ Sardina, D. ve Järventausta, P., “Fault Location, Isolation and Network Restoration as a Self-Healing Function”, Tampere University of Technology, 2015.



This project is funded by the European Union



smarter automation of transformer centres (MV/LV) might help in both improving the utilization factor of distribution transformers and overcoming the voltage problems in MV and LV grids.

A number of projects are recommended in this perspective, which can be listed as below:

- SCADA/ADMS
- Roll-out of Distribution Automation Systems
- Advanced Grid Analytics
- Adaptation to New Operational Philosophies
- New Grid & Automation Technologies
- Outage Management

Following tables will provide further explanations.

Recommendation 4 SCADA/ADMS and Network Management Systems

An ADMS platform contains software modules that automate grid re-energization processes and optimize grid performance in the event of downtime. ADMS developed for electricity distribution companies includes functions such as fault location detection, isolation and restoration, Volt/VAr reactive optimization, voltage management, peak load management, micro-grid operation and grid integration of electric vehicles and embedded production. According to the IntelliGrid definition, generally accepted 10 ADMS functionalities can be listed as follows:

- Real Time Distribution Operation Model and Analyses (DOMA)
- Fault Location Detection, Isolation and Re-Energization (FLISR/FDIR)
- Volt/VAr Control and Optimization (VVC/VVO)
- Distribution Congestion Analysis (DCA)
- Optimal Feeder Restructuring (OFR)
- Relay Protection Coordination (RPRC)
- Large Area Restoration (LAR)
- Coordination of Emergency Actions (CEmA)
- Coordination of Re-Energizing Steps (CRA)
- Intelligent Alarm Processing (IAP)

In alignment with the given functionalities, a series of project are recommended for implementation.

- Grid Management and Load Dispatch Centre Structure
- ADMS Operational Integration Design
- TEİAŞ SCADA Control Centre ICCP Integration
- ADMS Establishment and Application -NMS



This project is funded by the European Union



Recommendation 4 SCADA/ADMS and Network Management Systems

- Mobile NMS Application
- Advanced Distribution Management Systems (ADMS) Design, Application or Improvement Planning
- Starting Actively Using Existing Advanced Distribution Management System (ADMS) Modules
- ADMS Establishment and Application – (DPF + SCA + SE, FLISR, VVC, OFR + LAR)
- Inclusion of LV Grids in ADMS (NMS + DPF + SCA + SE)
- Innovative ADMS Functions Pilot Application

As-is Status in Turkey: In general, Turkish electricity DSOs have robust progress and maturity in terms of SCADA systems.

In general, DSOs supplying the western parts of the country are in higher maturity level since the total demand and quality expectation of the customers in these areas are higher than the rest of the country. Several utilities have been investing in centralized SCADA/DMS solutions, besides some utilities preferred to meet current operational needs by providing limited monitoring and control capabilities.

There are also problems about the functionalities that have been implemented but not used in real operations in Network Management Systems.

Almost all utilities have a connection model of their MV service area in several different platforms.

Prioritization: Medium-term

Technical Domain: Advanced Network Monitoring, Control and Management Systems

Recommendation 5 Roll-out of Grid Automation Systems

Modern grid control and automation technologies include applications based on advanced mathematical algorithms. For example, performing failure analysis with the data received from smart devices in the grid and determining the location of the fault, isolating the defective region, re-feeding the remaining network regions, returning the network to its normal operating state after the fault is eliminated, and making advanced analysis for maintenance and investment processes after failure are the competences provided by modern grid control technologies.

Investments in monitoring and automation systems should be designed in the light of the difficulties encountered in the relevant grid section (regional conditions such as accessibility, grid topology, meteorology, critical loads). This planning should be based on service quality requirements of the grid, reliable assessments of distributed energy roll out, and modular concepts for automation.

Due to differentiating characteristics of medium and low-voltage grid portions, roll-out of grid automation systems within this project recommendations are clustered under two segments, namely 'MV Grid Monitoring / Control' and 'LV Grid Measurement / Monitoring' in order to provide a clearer view of required tasks.

- **MV Grid Monitoring/Control**
 - TEİAŞ-DSO Interface Points (TransformerCentres)



This project is funded by the European Union



Recommendation 5 Roll-out of Grid Automation Systems

- Primary Distribution Stations and Lines
- Secondary Switching Stations and MVOutputs
- Distribution Transformer Buildings and MVInputs/Outputs
- **LV Grid Measurement/Monitoring**
 - Monitoring Pilot Application
 - Distribution Transformers and LV Outputs Monitoring and Measurement (Analog and Digital)
 - LV Grid Control/Command Pilot Application

As-is Status in Turkey: Remote-control function is mostly supported on primary substations in MV networks while generally not being provided in secondary MV and LV level.

Prioritization: Short-to-Medium Term

Technical Domain: Advanced Network Monitoring, Control and Management Systems

Recommendation 6 Advanced Grid Analytics

Existing ADMS solutions provide advanced reporting and post-event analysis capability, integrated with commercial BI (business intelligence) systems. This allows distribution grid operators to perform analyses for improving different business processes with high yields. However, some ADMS solutions have included data analytics functionality and complex event handling into the operational environment, in order to meet exclusive real-time analytical needs for business operations. In the coming period, advanced analytical functionality can be expected to be implemented (including in-memory processing and in memory database technologies) within ADMS solutions. Grid data and connection models are essential to establish a fully functioning “advanced grid analytics” systems which also requires a sound plan for pilot implementations and dissemination activities.

In this context, a series of projects are recommended in order to develop, sustain and benefit from advanced grid analytics to full extent in real-life operational processes.

- Grid Data Model Design
- Improvement/Verification of Grid Connection Model
- Grid Data Management and QA&QC Management System Design
- Implementation of Grid Data Management and QA&QC Management System
- Grid Analytics Concept Proof and Pilot Application Project
- Grid Analytics Application and Dissemination Project

As-is Status in Turkey: In most of the DSOs, efforts to realize the business transformation of “analytics-driven decision making” have either not started or at very preliminary stages.

Prioritization: Medium Term

Technical Domain: Advanced Network Monitoring, Control and Management Systems



This project is funded by the European Union



Recommendation 7 Adaptation to New Operational Philosophies

Emergence of new generation energy technologies are significantly challenging and changing the conventional grid structure and pushing the grid operation towards a 'Smart Grid' philosophy, that is not necessarily limited to planning and deployment of several systems that enable DSOs to tackle the challenge. Transition to smart grids require an important change in perspectives and philosophies so that DSOs are completely able and aware of the new possibilities and limitations of Smart Grid systems that they deploy and use.

Integration of distributed generation units, electric vehicles, energy storage units and inclusion of demand side practices (such as demand response) mandate a bi-directional grid management due to the fact that not only energy but the information and communication requirements in the Smart Grid are also bi-directional. Active grid management philosophy becomes highly important and there are several steps to consider and execute in order to successfully change grid management philosophies into a data-oriented, pro-active and comprehensive nature. List below present a number of tasks and sub-projects in this perspective.

- Advanced Emergency and System Restoration Plan (Grid Resilience)
- Active Grid Management (Active Grid Management - AGM) Design
- Active Grid Management (AGM) Pilot Application
- Managing Reactive Energy with New Monitoring Algorithms at All Levels of the Distribution System
- Live-Line Working Pilot Applications in Electricity Distribution
- Pilot Practice for Integration of Building Energy Management Systems and Grid Management Systems for Load Management
- MV Grid Closed Ring Large Scale Pilot Applications (Protection, Control and Monitoring)
- Self-Healing Network - Large Scale Pilot Applications
- Distribution Grids Flexibility Resources and Ancillary Services Feasibility and Legislation Study
- Distributed Generation Ancillary Services Voltage Regulation and Capacity/Congestion Management Support Study
- Distributed Generation Ancillary Services Secondary Frequency Support Pilot Application
- Pilot Application of Distributed Generation Control, Manageable Loads and Storage Systems Transmission and Distribution Ancillary Services
- Establishment of Ancillary Services Monitoring and Management Systems
- Creating Micro Grid Optimal Connection Criteria Project
- Development of Smart and Distributed Management Systems for Hierarchical Coordination of Individual Micro-Grids
- Individual Micro-Grid Hierarchical Control and Coordination Pilot Application Project
- Micro Grid Dissemination Forecasts and Connection Planning



This project is funded by the European Union



Recommendation 7 | Adaptation to New Operational Philosophies

- Grid Resilience Pilot Project with Micro-Grids
- Micro-Grid Pilot Application for Increasing Distributed Generation Connectable Capacity

As-is Status in Turkey: There are several conceptual and small-scale trial studies for the advanced solutions, technologies and operational practices, especially through R&D funding of DSOs.

Prioritization: Medium-to-Long Term

Technical Domain: Advanced Network Monitoring, Control and Management Systems

Recommendation 8 | New Grid & Automation Technologies

Together with the increased usage of consumer electronics in the last decades, a significant portion of end-user electricity consumption has started to become direct current (DC) appliances, due to the fact that DC applications are standard in consumer electronics. In addition to DC consumption requirements, all the new generation Smart Grid components, such as solar photovoltaic panels and batteries (whether in energy storage units or electric vehicles) are integrated in the LV grid through AC/DC inverters. DC applications are also gaining attention in high-voltage applications, especially in establishment of long-distance transmission lines due to lower technical loss rates and operational economy.

Such developments and necessities have been triggering questions regarding the widespread usage of AC systems in MV and LV grids. Prospects of easier, more seamless integration of small-scaled renewables, electric vehicles, energy storage units and controllable DC loads for demand response activities make the R&D and pilot implementation efforts on DC distribution grids an important aspect to consider.

In addition to DC grids, a number of emerging grid and automation technologies are considered to have significant impacts on the future of Smart Grid operations, such as augmented reality, wide area monitoring, LED lighting and amorphous transformers. In this regard, a number of sub-projects are recommended for gaining valuable insight on the future of Smart Grids, as listed below.

- Feasibility Study and Roadmap for LV DC Distribution Grids
- Pilot Applications Related to LV DC Distribution Grids
- 'Augmented Reality' Pilot Applications in Electricity Distribution Grids
- Wide Area Monitoring Pilot Application in Distribution
- MV Innovative Distribution Automation Field Solutions Pilot Application
- LV Innovative Distribution Automation Field Solutions Pilot Application
- Amorphous Transformer and Super Conductor Pilot Application Studies
- Pilot Application Study of Switching Equipment Based on Semi-Conductor and Power Electronics Technologies



This project is funded by the European Union



Recommendation 8 New Grid & Automation Technologies

- Pilot Applications of LED in Street Lighting

As-is Status in Turkey: There are several conceptual and small-scale trial studies for the new grid and automation technologies, especially through R&D funding of DSOs.

Prioritization: Medium-to Long Term

Technical Domain: Advanced Network Monitoring, Control and Management Systems

Recommendation 9 Outage Management

Outage management functionality is one of the critical components in management of Smart Grid infrastructure and systems. Outages are the primary reflection of grid failures and have significant impact on social and economic activities of end-users at various scales. Improved handling and mitigation of outages is therefore one of the key aspects that DSOs must focus on in their Smart Grid roadmaps and investments.

An outage management system is required to perform critical tasks; such as fault localization, resource prioritization for grid restoration after outage incidents, outage impact assessment, restoration time assessment and assistance to field crew organization for restoration activities.

Although some of the DSOs have already implemented an OMS within their SCADA systems, several other DSOs do not have any capability of outage management due to a lack of OMS. Thus, a major Smart Grid functionality remains inactive and prevents these DSOs to provide reliable and uninterrupted energy delivery to their customers in MV and LV grids. Tasks below are recommended for DSOs without any OMS implementation within their Smart Grid framework and operational capabilities.

- Outage Management System Design and Construction Studies
- Establishment of Outage Management System
- Outage Management System - Social Media Integration
- Launching the Outage Notification Mobile Application
- Mobile OMS (Field) Project
- Pilot Project for Integration of Telecom Service Outage Data to Outage Management System
- Dissemination Project for Integration of Telecom Service Outage Data to Outage Management System
- Work Force Management (WFM) Business Rules Definition and Construction Studies
- Establishment Project of Advanced Workforce Management System (WFM)
- Mobile WFM Design and Construction Studies
- Establishment Project of Mobile Workforce Management System



This project is funded by the European Union



Recommendation 9 Outage Management

As-is Status in Turkey: Per regulatory obligations, all DSOs have implemented continuity of supply recording and basic outage management systems. Furthermore, many DSOs have implemented basic work order management systems. There are also a few DSOs that have implemented some of the aforementioned advanced OMS and WFM functionalities.

Prioritization: Short to mid-term

Technical Domain: Advanced Network Monitoring, Control and Management Systems

2.10.3.3 Asset Management and GIS

In all distribution companies, almost all processes are run in a similar way, and grid elements are made up of the same components. After the installation of the grid components, they are continued to be used without any monitoring and management until a malfunction occurs except for the basic maintenance activities.

Faults and outages in distribution grids can increase according to environmental changes and loading conditions. Depending on the increase in air temperature and demand, more density occurs in weak points in the grid and the probability of failure increases.

Even if periodic maintenance works are carried out, priority should be given to the points where failure or outages may occur depending on various parameters such as physical condition of lines and equipment, loading profile and weather. First of all, the current weakness points and the physical and electrical condition of the equipment should be determined.

Maintenance works should be prioritized and planned according to the current condition of the lines and equipment and according to the techno-economic analyses of grid performance and reliability after previous maintenance. Use of Reliability & Efficiency Centered Maintenance approach is recommended for cost and performance concerns.

In many developed countries, healthy grid management practices include predictive or reliability-based maintenance management with analytical approaches as a widespread implementation. Similarly, with the implementation of asset management applications in our country, maintenance prioritization or grid investments can be planned according to the current condition of the lines and equipment and according to the techno-economic analyses of grid performance and reliability after previous maintenance.

In order to provide a sustainable distribution service, distribution companies must maintain the optimum balance between the operating expense ceiling and the investment ceiling which are the two main elements of the electricity distribution tariff model. In some countries that apply the revenue cap methodology, this balance is tried to be achieved by using the concept of TOTEX (OPEX+CAPEX), which forces both budgets to be evaluated together.

In order for the limited investment budgets to be used efficiently, the distribution assets must be managed properly, and the working life of the assets must be extended. The status data of the assets should be retrieved upfront and constantly updated with remote data collection or on-site retrieval. For the TOTEX concept, the most appropriate balance is achieved through extending lifetimes of assets that are nearing the end of their lifetime or that need maintenance as much as possible with on-site interventions and fixing problems with planned maintenance instead of waiting for malfunction.



This project is funded by the European Union



A total of three projects are recommended within the technical domain of 'Asset Management & GIS', listed as below:

- Data Management and GIS Improvement
- Advanced Asset Management
- Situational Awareness of Asset Performance

Further details are provided as following.

Recommendation 10 Data Management and GIS Improvement

Management of asset data through geographical information systems (GIS) is one of the key topics that enables the DSO to possess extensive knowledge of its asset status and the grid topology. The quality of data and the functional capabilities of implemented GIS solutions becomes important in this manner.

GIS, which is one of the smart grid components that DSOs tried to implement first after privatization, should be evaluated via two main objectives:

- Currently determined development areas (according to GIS rules and procedures)
- Adaptation of developments in GIS technologies into the systems

Digitalization of grid data models is one of the main issues that should be implemented in transition to smart grid. The digitalized and connected grid model serves as the basic data platform for many smart grid applications. Grid data model should be positioned as the main data source of many main processes such as advanced grid management, failure management, inventory management, grid planning, and other processes that will arise with the spread of smart grids.

It is aimed to integrate GIS with other smart grid technical components for sharing a common and up-to-date grid connection model and to complete the work of all related business processes through a common and updated grid data model. On the other hand, real-time and periodic integrations of GIS data need to be carried out effectively and efficiently.

One of the main keys to the most efficient use of GIS applications is the design of a data model that can meet the needs and the standards. It is recommended that distribution companies complete and periodically update their systems to develop a company-specific GIS data model to meet all relevant business process requirements.

Action steps and tasks recommended with respect to asset management and GIS solutions are given as below.

- Establishment of/Improving GIS Solutions
- Mobile Field Data Collection and Establishment of GIS Access Solutions
- GIS Data Model Design Update Studies Based on Smart Grid Requirements
- Collecting Smart Grid GIS Data Needs from the Field
- GIS Landscape Update Project and Landscape Integration with Other Related Smart Grid Systems



This project is funded by the European Union



Recommendation 10

Data Management and GIS Improvement

As-is Status in Turkey: Majority of DSOs have early implementations of GIS solutions, with data quality problems due to lack of proper execution of data update, management and QA&QC processes.

Prioritization: Short-term

Technical Domain: Asset Management and GIS

Recommendation 11

Advanced Asset Management

Advanced asset management is a concept that requires an asset management philosophy focusing on data analytics and in-depth analysis of asset performances. For successful realization of Advanced Asset Management system, it is necessary to carry out development, improvement, implementation and dissemination activities for asset performance management in order to correctly evaluate the performance of distribution network assets, to provide maintenance requirements with systematic, data-based and predictive approaches, and thus to increase the performance of the distribution system.

Tasks related to development of an 'Advanced Asset Management' system are recommended as below.

- Grid Asset Management Design and Planning Studies
- Development of Grid Components Operational Status/Performance and Useful Life Models
- Pilot Application Project of Asset Operational Status and Performance Tracking Field Solutions
- Establishment of Asset Management and Performance Tracking System
- DSO Technological System Elements (IT & OT) Asset Management Application
- Asset Performance Analytics Design and Concept Proof Studies
- Asset Analytics Application and Dissemination

As-is Status in Turkey: Asset management practices implemented in DSOs so far are at basic level. New tariff period will require more advanced functionalities.

Prioritization: Short and Medium- term

Technical Domain: Asset Management and GIS

Recommendation 12

Situational Awareness of Asset Performance

It is essential for DSOs to have situational awareness of their existing assets in order to efficiently manage their complex grid structure. To handle this requirement, a DSO must have reliable and capable field monitoring solutions that will provide data and intelligence in order to observe field status of assets on a continuous basis. Predicting the status of critical assets in short, medium and long term becomes a critical issue for DSOs to be able to take failure preventive actions to increase grid resilience and performance.



This project is funded by the European Union



Recommendation 12 Situational Awareness of Asset Performance

Studies and actions below are recommended for DSOs to increase their level of situational awareness with respect to their asset performances and status throughout their grid.

- Dissemination of Field Monitoring Solutions (IoT, Sensor Network) to Grid Components for Asset Operational Status and Performance Monitoring
- Development of Risk Based and Reliability Based Maintenance Planning Methodologies
- Dissemination Studies for Reliability Based Maintenance Planning Application
- Development of Asset Management Systems for Operational Life Estimation
- Aerial Photographing of OHL Assets and Thermographic Analysis Applications

As-is Status in Turkey: Asset management practices implemented in DSOs so far are at basic level. New tariff period will require more advanced functionalities.

Prioritization: Short-to-Medium Term

Technical Domain: Asset Management and GIS

2.10.3.4 Enterprise IT and Data Analytics

Today, smart grid technologies used in the electricity distribution sector are technologies that have been used in the IT sector for a long time and are adapted to the energy sector. The rapid development of technology and the recent use of operational technologies in distribution sector have revealed the need for information technologies to become more rapidly available for operational use.

IT systems enable machines to interact with users or other machines in seconds and exchange data. It is an undeniable fact that in the distribution sector, IT systems are improving in terms of both quantity and quality. Systems such as enterprise resource planning (ERP), enterprise asset management (EAM), customer relationship management (CRM), call centre, and office-based productivity tools and mobile information systems are becoming common in the distribution industry. However, the development of IT systems in the distribution industry is progressing independently of DSO operational technologies (OT).

The concept of smart grid converts distribution company operations (OT) into its conventional boundaries by including IT. It should be emphasized that IT and OT integration, in other words, convergence will provide distribution companies with more efficient, smarter, more reliable operation.

To implement smart grid deployment scenarios, distribution companies must quickly meet the requirements for IT and OT to converge both on a system scale and on an organization and human resource basis. Smart grids and IT/OT convergence will allow for better service to customers by changing almost all operations of distribution companies in many ways.

Improvement of enterprise IT systems and development of data analytics solutions possess an important aspect of Smart Grid architecture's digitalization requirements for DSOs. In this context, a total of three projects are recommended within the 'Enterprise IT and Data Analytics' domain:

- Strategic Planning and Roadmap



This project is funded by the European Union



- Digitalization of Business Processes and Enterprise IT
- Big Data Management and Analytics Platform

Further details about the recommended projects are provided in the following tables.

Recommendation 13	Digitalization Planning and Roadmap
Digitalization requires substantial planning efforts in complex operational frameworks and corporate IT architectures such as in the case of DSOs. Establishing the vision for digitalization of enterprise IT systems and infrastructures therefore must start with elaborate studies of existing situation and future requirements in alignment with the Smart Grid vision that the DSOs will follow in short, medium and long term. Since this new vision needs DSOs to be data-oriented organizations in all aspects, efforts in data analytics must also be planned within the context of digitalization efforts. A series of roadmap studies and analytical works are highly recommended in the beginning phase of Smart Grid digitalization efforts for enterprise IT infrastructure and data analytics; as presented below. • Corporate IT Infrastructures Digitalization Roadmap Study • Corporate IT Systems Requirement Determination Studies and Implementation Planning • Data Analytics Corporate Roadmap Study • Analytical Uses Development Project • Construction of Data Management Processes for Big Data Analytics	
As-is Status in Turkey: Most of the DSOs in Turkey do not have a comprehensive digitalization planning.	
Prioritization: Short-term	Technical Domain: Enterprise IT and Data Analytics

Recommendation 14	Digitalization of Business Processes and Enterprise IT
Based on digitalization roadmap studies and implementation plans, a DSO needs to review, adapt or completely revise its existing business processes according to the requirements of digitalized Smart Grid IT infrastructures. This project is recommended to focus on development and establishment of advanced IT applications on enterprise level, using the insight gained from the assessments and analyses from the roadmap studies and use case development efforts. The initial action listed below should be interpreted as an umbrella structure or a project portfolio that will eventually incorporate several development efforts in enterprise IT architecture. The latter task recommendation focuses on a specific part of enterprise IT applications that is related to the externality of DSO operations, namely the customer interaction through call-centre operations and other customer interaction channels. Digitalization in this segment is evaluated to be highly important to effectively manage the customer relations for a DSO and requires a distinct emphasis. • Implementation of Advanced Corporate Applications	



This project is funded by the European Union



Recommendation 14	Digitalization of Business Processes and Enterprise IT
Call Centre and Customer Relations Management System Improvement/Development Studies	
As-is Status in Turkey: Heterogeneous steps through several projects in call-centre automation, field management processes (metering, work force management etc.); lacking industry-wide homogeneity and alignment in all business processes.	
Prioritization: Medium-to-Long Term	Technical Domain: Enterprise IT and Data Analytics

Recommendation 15	Big Data Management and Analytics Platform
The IT software components of smart grid systems both need serious hardware infrastructures, allocation for huge investment budgets for their installation, and collect data in a geometrically increasing volume, making the distribution companies data-intensive companies. Due to the developing technology, changing business manners and customer needs, companies have started to use the data kept in their corporate systems and systems not only for basic reporting purposes, but also for creating high value services, products, and processes by using different analytical techniques and business intelligence infrastructures. It is among the first objectives of the “Big Data” concept to reuse each data together by evaluating the large volumes of data collected for different purposes, and to reach the necessary data with data mining for the processes in order to maximize efficiency from field studies to top management. Tasks below are required and recommended for a DSO to establish a firm management of big data generated from its Smart Grid systems. - Process Analytics Concept Proof and Pilot Application - Process Analytics Application and Dissemination Project - Big Data Analytics Software Platform Establishment Project - Application of Advanced Load Estimation Algorithms and Integration of MDM Data - Establishment of Advanced and Integrated Load Estimation Systems in Distribution - Development of Common Model, Exchange Methods and Protocol/Standards for EDVARs	
As-is Status in Turkey: There are initial efforts by several DSOs to implement Big Data Analytics functionalities.	
Prioritization: Medium to Long-Term	Technical Domain: Enterprise IT and Data Analytics



This project is funded by the European Union



2.10.3.5 *Integration of Distributed Generation and Energy Storage*

Distributed energy units such as small-scaled renewable energy generation units (i.e. solar PV, micro-wind) and energy storage systems are one of the prime drivers of Smart Grid transition for DSOs all over the world. Grid integration of distributed generation requires significant changes to grid management (operations, automation, protection, etc.) philosophies due to bi-directional nature of energy flow, data and control architecture in comparison to uni-directional, comparably simplistic nature of conventional power systems.

Integration of DG systems is a growing concern for many DSOs due to increasing interest and installations of private investors, that are either integrated as 'unlicensed power plants' (generally within the range of 500kW-1MW) or building-integrated solutions such as rooftop solar PV plants. To handle the increasing complexity of the situation, a number of technological advancements are necessary for grid operations that will rearrange the integration processes and energy management for DG units throughout the grid.

A total of three projects are listed as recommendations for this technical domain, that can be summarized as below:

- Distributed Energy Resources Management Systems (DERMS)
- Integration of Distributed Generation (DG)
- Flexibility Services

Further details can be found in the following tables.

Recommendation 16	DERMS
Distributed Energy Resources Management Systems (DERMS) are grid management tools that provide coordinated management of distributed energy resources, energy storage units and controllable that are connected to grid and aims to enhance and deliver value from the integrated architecture. A number of expected benefits from a typical DERMS can be listed as active load shifting / shedding, load factor improvement through load curve shaping, minimization of grid losses through phase balancing, voltage profile management, congestion management and provision of ancillary services. Improved and active energy management through DERMS is completely aligned with Smart Grid philosophies and operational requirements, making DERMS an essential component of Smart Grid architecture with significant DG penetration rates. Successful realization of DERMS for DSOs require certain steps and tasks, that are recommended below: • Distributed Energy Resources Management System (DERMS) Establishment Project • Integration of Aggregator (Aggregator) and DSO DERMS Systems • Distributed Energy Resources Coordinated Management Applications in Distribution Grids • Establishment and Integration of Distributed Generation Real Time Monitoring Systems • Medium- and Long-Term Forecasting and Action Planning Study for DGFs to Integrate MV and LV Grid • Distributed Generation Real Time Control/Command Systems Establishment and Integration Project • Application of Distributed Generation Estimation Solutions	



This project is funded by the European Union



Recommendation 16

DERMS

As-is Status in Turkey: There is not any DSO that established their DERMS, despite the fact that several DSOs experience significant DG penetration in their distribution grids.

Prioritization: Short- to Medium- Term

Technical Domain: Integration of Distributed Generation and Energy Storage

Recommendation 17

Integration of Distributed Generation

Grid integration of distributed generation requires significant changes for DSOs in terms of planning and implementation. Long-term expansion plans should be made for all electricity distribution companies regions including rooftop solar, sub-1MW solar power plants, river-type hydro, geothermal, wind and specific road maps should be prepared for electricity distribution companies.

Deploying distributed productions without the communication infrastructure and an integrated IT infrastructure is a serious risk. In addition to the possibility of impairing the quality of energy, these structures which are operated without precaution can seriously affect the topology and security of the network. Commissioning of distributed production facilities before the communication-control systems can not be operated properly will lead to uncontrolled network growth, constraint increase and waste of investment. The non-monitored network will cause new system constraints and additional investments, not the purpose of balancing the production where it is consumed.

Energy storage systems have an important share in the establishment of distributed energy systems. Investment activities are expected to significantly decrease if the network integration is done properly. For now, high cost storage facilities and units can be expected to take place in all networks in the near future.

In this recommendation, it is advised that grid connection criteria, connection and permit procedures and grid management approaches must be analysed in detail through extensive studies, evaluating future scenarios in addition to existing framework and market trends. Projects related to this recommendation can be listed as follows:

- Creating Minimum/Common Grid Connection Criteria for Different Distributed Generation Resources
- DG Facilities Energy Permits Over Grid Connection Tracking and Evaluation System
- Distributed Generation Integration Pilot Application in LV Grids and Impact Analysis
- Solution Development Project for Increasing Connectable Distributed Generation Capacity
- Analysis of Grid Effect of Hybrid LV Plants with Roof Type Solar and Storage Components on Real Systems

As-is Status in Turkey: There are a few DSOs that have executed R&D projects covering some of topics mentioned in this recommendation.



This project is funded by the European Union



Recommendation 17 Integration of Distributed Generation

Prioritization: Short-Term

Technical Domain: Integration of Distributed Generation and Energy Storage

Recommendation 18 Flexibility Services

Increasingly higher penetration rates of renewable energy based distributed generation units possess a challenge for DSOs in terms of flexibility requirements, especially in the grid sections where generation significantly exceeds energy consumption rates frequently. This requirement of flexibility can be arranged at local or aggregated levels within the grid, in order to provide services based on modifications of generated or consumed power patterns for a specific time interval and/or power rates for certain locations or grid portions. Mitigation of such problems allows DSOs to prevent undesired situations of high imbalance and enables them to maintain their grid efficiently and effectively.

Energy storage systems are highly useful system components in providing flexibility services for Smart Grid operational framework. They can balance central and distributed electricity generation, but also contribute to supply security throughout the grid. Energy storage will have a complementary effect on demand side management, flexible generation and grid development. They can also contribute to de-carbonization of other economic sectors and support increased share of the integration of variable renewable energy in transportation, buildings or industries.

In this context, extensive work is required for DSOs to understand, analyse and effectively use distributed generation and energy storage systems within their operational framework to unlock their benefits in provision of flexibility services in Smart Grid architectures. Tasks and actions below are suggested in scope of this project recommendation, which can be viewed as below:

- Analysing the Effects of Distributed Energy Resources and Flexibility Management Models on Electricity Distribution Grids
- Comparative Analysis of Different Energy Storage Technologies in Line with the Requirements of Electricity Distribution Grids and Development of Design Criteria
- Pilot Applications of Large-Scale Energy Storage System in Distribution Grids
- Pilot Application of Hydro Power Plant with Reservoir Pump in Distribution Companies with Shore to the Sea (Pumped-Storage)
- PoC Project for intense energy storage system usage in LV distribution grid
- Usage of Behind-the-Meter Storage systems and PoC project
- Storage system and DSO system interoperability PoC Project
- Creating Advanced Connection Criteria and Rules for Energy Storage Systems
- Medium- and Long-Term Forecasting and Action Planning Study for Energy Storage Systems to be Connected to the Grid



This project is funded by the European Union



Recommendation Flexibility Services 18

As-is Status in Turkey: Flexibility from distributed energy resources are evaluated under R&D projects scope on theoretical base. There is no pilot energy storage system installed and commissioned by Turkish DSOs.

Prioritization: Medium- and Long- Term

Technical Domain: Integration of Distributed Generation and Energy Storage

2.10.3.6 *Integration of Electric Vehicles and Charging Infrastructure*

Electric vehicles (EV) have the potential to revolutionize the passenger car industry with their wide-ranging effects. Global numbers of private (automobiles) and public EV's (electric buses) are on the rise and it is a major risk for distribution grids due to increased power and energy requirements on the existing infrastructure, as the grid had never been planned according to EV presence. The way EV charging infrastructure is installed and the technologies used can have a significant impact on distribution networks and DSOs need to prepare themselves for the wave of change.

New investments need to be made for a strong charging infrastructure to spread EV's. EVs represent a mobile demand for electricity, and therefore can theoretically draw electricity from the grid at any point during the day, at home or in the office, at low charging speeds or by fast charging using the public charging infrastructure. When, where and how much electrical energy the EVs draw from the grid is significantly variable and depends not only on drive behaviour but also on charge-related business models. Incentive-based applications, which are based on the principles of flexibility and load profiles to be shaped properly, are important for reducing the negative effects of EVs on the network.

In this context, it will be necessary to coordinate charge models with digital technologies (smart charge). With smart charging, charging of vehicles can be encouraged over price and control signals when low cost, renewable electricity generation or when there is no congestion in the network. Smart charging requires a digital infrastructure to enable communication between charging points and end systems so that network operators can send requests to increase or decrease demand at certain times.

Where and when the EVs are charged is also critical for distribution companies. EV's can be charged thanks to the systems that are "behind the meter". Thus, the overhead can be met by rooftop PV systems and/or batteries, and charging can be optimized to take place during the day at home or at work. The leading manufacturers of EV's, battery and PV systems are currently targeting the use of this approach.

The value of smart charging applications will increase if it supports the network to provide power quality and flexibility. Beyond smart charging, more flexibility can also be implemented through vehicle-to-grid (V2G) technologies that enable two-way charging.

The main impact of electric vehicles will be on the load management on the LV side of the distribution grid. Distribution companies are expected to correctly implement smart grid elements, manage demand at micro level, and eliminate the effect of electric vehicles to increase transformer points with the help of rooftop solar panels and storage modules. In addition, distribution companies will have to make their LV network control, smart meter, big data management, communication and information infrastructure and cyber security infrastructures suitable for



This project is funded by the European Union



this case in the “prosumer” category to be formed, in other words, they will have to plan and implement the smart grid elements.

Under the technical domain of ‘Electric Vehicles’, a total of three projects are recommended for DSOs in order to prepare themselves for the massive transformation of individual and public transportation requirements that will directly place a heavy burden on electricity grid infrastructure. Recommended projects are listed as below.

- EV Charging Characterization and Grid Integration
- Operational Management for EV Charging Infrastructure
- Vehicle to Grid (V2G) Applications

Further explanations regarding the EV projects are given in the following tables.

Recommendation 19	EV Charging Characterization and Grid Integration
	Main point of interaction between the electric vehicles and the distribution grid are the EV charging stations. As the primary energy outlet that will enable the EV’s to charge their in-car batteries, charging stations are directly fed from the distribution grid. Therefore, it is crucial for DSOs to be able to characterize the charging habits of end users, standardize EV charging station connections and continuously monitor the charging infrastructure for a seamless grid integration of electric mobility. A series of tasks and actions are recommended below for DSOs, that will assist and enable them to have deeper insight on grid integration of electric mobility and management of EV charging infrastructure. • Creating Minimum Requirements for EV Charging Stations and Grid Integration • EVs Load Characterization Studies • Analysis of EV Usage Habits and Impacts of EV Charging - Grid Integration • Medium- and Long-Term Forecasting and Action Planning Study for Electric Vehicles and Charging Stations to be Integrated to MV and LV Grid • Creation of EV Charging Station Grid Connection Criteria Document
As-is Status in Turkey: Technical and pilot studies on user profiling and widespread EV charging infrastructure management have been completed by DSOs. EV market is slowly growing its customer base. No active legislation is in place to regulate EV charging infrastructure management	
Prioritization: Short- to Medium- Term	Technical Domain: Electric Vehicles



This project is funded by the European Union



Recommendation 20

Operational Management for EV Charging Infrastructure

In connection and alignment with the previous project recommendation, it is also highly recommended for DSOs to use their insights and operational know-hows on developing operational management frameworks and strategies for effective management of EV charging infrastructure.

Inclusion of a widespread EV charging infrastructure, consisting of various types and scales of EV charging stations scattered around urban zones or transport corridors, is an important complexity that requires utmost attention for DSOs to maintain grid stability and reliability without any outages and losses. Thus, it is recommended that advanced methodologies and tools should be developed and put into operational use in order to continuously manage EV charging infrastructure and enhance true value of electric mobility without compromising operational standards and targets. Projects below are two concrete suggestions for DSOs to proceed in this subject.

- Establishment of EV Charging Stations Monitoring, Measurement and Control Platform and Integration into Grid Management Systems
- Autonomous EV Charge/Discharge Control

As-is Status in Turkey: No DSO has established an EV charging infrastructure management system.

Prioritization: Medium Term

Technical Domain: Electric Vehicles

Recommendation 21

Vehicle to Grid Applications

Vehicle-to-Grid (V2G) applications indicate the technical concept that incorporate electric vehicles and their respective batteries into the energy management schemes in Smart Grid management scenarios. Private or public EV's are generally under-utilized within 24 hours of a day, a situation which allows batteries to be used as temporary energy storage units that can be controlled by DSOs in favour of their local grid management strategies and energy requirements.

Due to the observed and expected increase of EV's in number, especially in congested areas such as urban zones, V2G concept is seen as a highly promising Smart Grid application that increases grid efficiency and vehicle utilization in multiple aspects and creates value on both sides of the equation.

DSOs are recommended to familiarize themselves with this concept with practical implementations and prepare their strategic and operational perspectives according to the random availability of electric vehicle batteries as parked vehicles in public urban spaces or built environment.

- Pilot applications of Electric Vehicle to Grid (V2G) and Electric Vehicle to Building (V2B) technologies

As-is Status in Turkey: There is no pilot application or active infrastructure for V2G pilot implementations. There is no legislation for V2G implementation by DSOs.

Prioritization: Long-Term

Technical Domain: Electric Vehicles



This project is funded by the European Union



2.10.3.7 **Telecommunication Infrastructure**

Transition to Smart Grids has triggered major topological changes in the grid architecture, not only in terms of appearing bi-directional power flows but also bi-directional communication infrastructure requirements. The need became highly apparent to establish a reliable, secure and fast communication among the Smart Grid stakeholders, and especially between the DSO and end-point systems. Therefore, advanced monitoring and control technologies are required to enable integration of all Smart Grid components and to keep the grid parameters (such as voltage, current and frequency) at certain intervals by balancing the current grid consumption/generation profile at the optimum levels that DSO must maintain.

Communication networks provide the necessary infrastructure for applications (Smart Grid Management, Smart Embedded Systems, Smart Market and Customers) used for control and management from a central location. In smart grid investments, heterogeneous/hybrid communication technologies and architectures, which generally serve different applications, participate in design processes. Communication networks are expected to meet specific requirements, in other words, reliability, delay, bandwidth and security, depending on Smart Grid applications. The complexity of the smart grid causes difficulties in choosing suitable communication networks, because there are different requirements and many parameters depending on the applications and utility expectations. In this context, DSOs all over the world face the challenge of choosing and applying the most suitable technologies that can meet their current and future communication needs.

In this context, two separate projects are recommended within the 'Telecommunication Infrastructure' technical domain. These are two major steps of ensuring that the established communication infrastructure is able to meet Smart Grid operational and technological requirements for a long period of time with high reliability, security and performance and is adapt to technological upgrades and changes in the future, allowing flexibility to DSOs in their future investments on telecommunication infrastructure.

- Interoperability Compliance
- Infrastructure Modernization

Further explanations can be found in the following information tables.

Recommendation 22	Interoperability Compliance
Smart devices, which have communication, control and data processing capabilities, form a significant part of the Smart Grid communications and control architecture. Therefore, it is highly important that these devices are up to the international standards and compliant with the rest of Smart Grid components in order to establish a healthy communication flow. These smart devices, such as smart meters or smart automation equipment, are key for enabling Smart Grid services and their capabilities are determining factors in defining the extent of Smart Grid capabilities in general. Two projects are recommended in this manner, one focusing on the smart meter interoperability and the other focusing on technological status of field automation equipment. • Establishment of Smart Meter Interoperability and Field Conditions Test Laboratory • Conversion of Field Automation Equipment Not Supporting Existing International Standards	



This project is funded by the European Union



Recommendation 22

Interoperability Compliance

As-is Status in Turkey: Smart meter interoperability is handled partially in different conceptual R&D studies and no test laboratory is available for smart meter interoperability. Field automation equipment, on the other hand, are generally deployed within SCADA or other infrastructure projects and they are partially up to international standards but require an overall review for standardized alignment.

Prioritization: Short- to Medium- Term

Technical Domain: Telecommunication Infrastructure

Recommendation 23

Infrastructure Modernization

One of the first and basic criteria for smart grid investments and projects to be successful is a well-designed telecommunication network and a suitable system architecture. Choosing the right communication technologies is the main component of this success. Technological status of the telecommunication infrastructure is playing a key role for determining how the Smart Grid components can be integrated and operated under a single communications framework.

Testing and adaptation of suitable new generation technologies is important and must always remain in focus of infrastructure management while operating the Smart Grids. Similarly, management of field activities must be tasked with capable teams and sustained continuously in order to eliminate the risks associated with infrastructure failures and operational bottlenecks due to poor maintenance. Overall assessment of existing IT and OT systems is one of the key issues and the whole communication system must be operated in an integrated fashion.

Tasks and actions related to 'Infrastructure Modernization' can be listed as below, in this context.

- Pilot Application of New Generation LPWAN Communication Technologies in Smart Meter Infrastructures
- Establishment of Field Teams Communication Infrastructures
- Assessment and Optimization of the Current Communication Structure for IT/OT
- Establishment and Integration of Communication Network Monitoring and Management Systems

As-is Status in Turkey: Modernization efforts for telecommunication infrastructure are under progress in several DSOs, without an industry-wide standardization or alignment.

Prioritization: Medium-Term

Technical Domain: Telecommunication Infrastructure



This project is funded by the European Union



2.10.3.8 *Advanced Metering Infrastructure*

Used as an inclusive term, ‘Advanced Metering Infrastructure (AMI)’ is used as a reference term that represents the overall smart metering ecosystem that covers smart meters, supporting equipment such as data concentrators or repeaters, metering communication infrastructure and meter data management systems.

AMI is one of the key components of the Smart Grid architecture because a widespread roll-out of smart meters means that the DSO gains direct monitoring and control capabilities over grid’s end-nodes. A typical range of customer numbers for DSOs range from several tens of thousands to a few millions, which means that smart metering deployment enables them to get a hold of the end-user layer of the grid; a layer that DSO has very limited visibility and no real-time data flow without AMI.

A successful deployment of AMI and a healthy operation has the potential to create significant value for the DSO and its customers in various areas. AMI enables key Smart Grid features and functionalities such as demand response, active load management, DG integration handling, EV charging station management as well as an active and efficient grid management due to high-resolution, continuous data flow from all of its end nodes that makes it much easier for the DSO to detect and attend to grid-related issues.

With all the importance and potential impact on Smart Grid operations, it is essential for DSOs to follow certain steps to establish and maintain a healthy AMI structure. They also need to manage the metering data in proper means and perform continuous data analytics on meter data. They must also be proactive in exploiting the additional benefits that AMI brings to Smart Grid operations in terms of demonstrating a higher engagement with their customer base and initiate Smart Grid concepts like demand response for further economical and operational benefits.

In this context, following three projects are recommended for DSOs.

- Smart Meter Roll-out Planning and Implementation
- Meter Data Management and Analytics
- Customer Interaction and Demand Response

Following tables contain further details on the recommended projects’ content and related tasks.

Recommendation 24	Smart Meter Roll-out Planning and Implementation
	Initial step towards establishment of a grid-wide AMI is the deployment of smart meters in the field. However, this step is not very straightforward due to the size and complexity of widespread implementation. Planning efforts are required to be extensive and highly detailed to avoid any shortcomings in terms of product requirements, roll-out progress or system integration efforts. Analysis of grid requirements, customer expectations, communication technology options, interoperability issues, data requirements are all important factors in planning phase of the smart meter roll-out projects. Implementation plans are generally scaled into a few steps of roll-out expansion and field operations are scheduled according to a certain field implementation plan that evaluates factors such as field crew efficiency, customer accumulations, grid topology and communication infrastructure availability.



This project is funded by the European Union



Recommendation 24

Smart Meter Roll-out Planning and Implementation

Certain tasks and action items that require attention in smart meter roll-out planning and implementation are given below as recommendations.

- Definition of Minimum Smart Meter Requirements and Interoperability Standards
- Creation of Common OBIS Code Structure and Object Model for Smart Meters
- Smart Meter Dissemination Planning and DSO-Specific CBA Studies
- Advanced Metering Infrastructures (AMI) Design and Planning Studies
- Smart Meter Large Scale Pilot Application Project
- Roll-out of Smart Meter Infrastructures

As-is Status in Turkey: Smart-meter roll-out plans have been identified as a primary action item in regulatory projects but there are no regulatory targets so far for large scale deployment of smart meters.

Prioritization: Short-term

Technical Domain: Advanced Metering Infrastructure

Recommendation 25

Meter Data Management and Analytics

In addition to reading and communication devices in the field, the central data management system that manages all the data shared and used in the system is also considered within the definition of smart meter system. Essentially, the meter data management (MDM) system is the central system that enables the integration of the AMI with metering operations run by DSOs and performs the process management.

The meter data management system generates the necessary reports by processing the meter readings according to the interruption time verification as well as the essential functions such as the management of the readout values subject to settlement. Smart meters can report alarm, configuration and connection problems. Such communications include diagnostic alarms, mix alarms and other abnormal conditions. All this data is processed by MDM and necessary reports are created. Meters can perform periodic software/firmware updates in meter data management system management.

Smart meters can collect information about grid events such as instant interruption, continuous interruption, low/ high voltage and high distortion, and send reports to the meter data management system. This information can be used for downtime analysis, maintenance schedule or capacity planning. It can also support other advanced applications such as getting pricing information, prepaid services and supporting customer exchanges between suppliers, that different types of meters will work integrated with the meter data management system.

Tasks related to MDM and meter data analytics are briefly presented as below.

- Establishment of Meter Data Management System (MDM)
- Meter Analytics Concept Proof and Pilot Project
- Meter Analytics Application and Dissemination



This project is funded by the European Union



Recommendation 25

Meter Data Management and Analytics

As-is Status in Turkey: Although a widespread AMI is not present in Turkish distribution sector, there are basic MDM systems installed and used by DSOs, mainly to fulfil the needs for old-generation AMR ('OSOS' in Turkish) systems that provide one-way communication from field to DSO.

Prioritization: Short-term

Technical Domain: Advanced Metering Infrastructure

Recommendation 26

Customer Interaction and Demand Response

One of the main benefits of transition to Smart Grids for DSOs is the capability of increased monitoring and control at the end-nodes of the distribution grid. This means that DSOs can have a much higher level of engagement with their customers and begin to use this capability to create and enhance added value for the grid operations that benefits both the DSO and the customers at the same time.

On top of direct benefits, such as continuous monitoring of smart meters and improve intervention methodologies for handling end-node grid failures or problematic situations; DSOs also have the capability to design and run advanced mechanisms such as 'Demand Response'. This means that DSOs have an active operational tool to manage the demand side continuously and bring higher efficiency and reliability to the distribution grid.

Certain tasks are suggested below to enable and improve customer interaction and demand response mechanisms.

- SMI - Customer Interaction Applications
- Providing a Comparable and Detailed Invoice Information to the Consumer, Establishing an Energy Data Platform for Smart Management of Metering Information
- Comparative Implementation of Different Market and Tariff Models for Demand Side Participation
- Establishment of the necessary DSO Infrastructure for Managing Heating and Cooling Peak Load
- Comparative Technological Solution Application for Advanced Demand Side Management Applications over Customers' Smart Meters

As-is Status in Turkey: Customer interaction processes are not integrated to a smart metering framework. Demand response concept is tried in few pilot projects in various scales, but no legislation or active practice is currently held by the DSOs.

Prioritization: Medium- to Long-Term

Technical Domain: Advanced Metering Infrastructure



This project is funded by the European Union



2.10.3.9 Enterprise Application Integration

For smart grid IT and OT systems to be fully functional, the systems must be integrated through an accurate and manageable integration design.

In this context, the enterprise IT integration to be established should be designed correctly and the integration of all IT and OT systems to be put into operation within the road map should be positioned appropriately within the enterprise IT architecture. In the integration studies, the applicability of the 'Common Information Model' (CIM) data model developed especially for electricity distribution grids should be evaluated in detail for all possible IT systems.

CIM is a set of standards used to create a common information model in system integration and information exchange. It aims to create a consistent data structure using object-oriented techniques. In this way, it ensures that existing instrumentation and management standards are combined using object-oriented structures and designs. CIM is a data model that enables direct data exchange between different systems operating under the same roof. The fact that it supports not only vertical but also horizontal data exchange enables communication between systems in different hierarchies. CIM allows additional applications to be integrated with minimal effort. The most obvious misconception about CIM is that CIM defines a physical data model or physical data store.

Within the technical domain of 'Enterprise Application Integration' in this context, a total of three projects are recommended for DSOs.

- Integration Architecture
- IT/OT Convergence and Interactions
- Common Information Model

Detailed explanations with respect to each project is given in the following tables.

Recommendation	Integration Architecture
27	For an effective integration of enterprise applications in Smart Grids, determination of the integration architecture is the key issue to address. Each DSO may have different system topology despite being regulated entities and a specific integration architecture is required with selection of a suitable topology and set of technologies for the integration processes. In addition to the integration of systems that are already existing or that are planned to be deployed in near term, the enterprise application integration framework must also take future systems into account as well. This requires that the DSOs are consistent with their IT and integration architecture for the future and the enterprise integration plans are future proof. Tasks below are recommended for establishing the correct 'Integration Architecture' for DSOs. • Designing DSO Enterprise IT Integration Architecture by Evaluating Different Integration Topology and Technologies • Implementation Project for Enterprise Service Bus Based Integration • Identification of Technical Criteria for Compliance of New Systems with the Company's IT Architecture



This project is funded by the European Union



Recommendation 27

Integration Architecture

As-is Status in Turkey: Although several DSOs have already comprehensive Enterprise Application Integration plans and implementation, numerous DSOs still lack these activities.

Prioritization: Medium-Term

Technical Domain: Enterprise Application Integration

Recommendation 28

IT/OT Convergence and Integrations

In line with the digitalization and integration of DSOs' enterprise applications, two technology domains that are present in the Smart Grid architecture require healthy integration. Information technologies (IT) and operational technologies (OT) are essential in their own functionalities but the DSO needs a fully-integrated system structure to be able to operate and govern the whole distribution grid without any shortcomings or problems.

It is recommended that DSOs pay significant attention to IT/OT convergence and integration efforts and divide the work into a structured breakdown in order to address all the relevant Smart Grid systems and components within the system architecture. Related tasks are suggested below.

- Grid Monitoring/Management Systems Real Time (Situational Awareness) Measurement/Data Integration
- Pilot Application of Smart Meter Data for Real-Time Data Flow to Grid Management Systems
- Dissemination of Smart Meter Data for Real-Time Data Flow to Grid Management Systems
- Real-Time Data Integration Design for Outage Management
- Real-Time Data Integration Application for Outage Management
- GIS Integration
- Asset Management System Integration
- Meter Data Management System IntegrationDesign
- Meter Data Management System Integration
- MV and LV Grid ModelSynchronization
- Integration of Other Corporate IT Systems
- WFM Integration Project

As-is Status in Turkey: Although several DSOs have already comprehensive Enterprise Application Integration plans and implementation, numerous DSO still lack these activities.

Prioritization: Medium-Term

Technical Domain: Enterprise Application Integration

Recommendation 29 Common Information Model

IEC 61970 (Common Information Model / Energy Management) and IEC 61968 (Application Integration at Electric Utilities) standards define a common information model (CIM) for data exchange, application integration, application programming interface (API) for XML messaging, and standards for electrical power systems.

CIM is a data model that enables direct data exchange between different systems operating under the same roof. The fact that it supports not only vertical but also horizontal data exchange enables communication between systems in different hierarchies. CIM allows additional applications to be integrated with minimal effort. The most obvious misconception about CIM is that CIM defines a physical data model or physical data store. CIM is the logical information model used in the definition of messages between different systems. Also, different systems and applications do not have to store their data in CIM format to connect to other systems and applications externally via CIM. In other words, it is not mandatory for an application connected to CIM to use a database draft using CIM.

There is no definitive definition that indicates that a system or application is CIM compliant. The most important bases of CIM practitioners regarding CIM compliance are interoperability tests and these tests should be taken into consideration in CIM compliance.

It is advised for DSOs to design, pilot and disseminate a CIM based grid model and data flow models in the light of the integration architecture and IT/OT integration frameworks, as presented in the tasks below.

- CIM Based (IEC 61970-453) Grid Model Integration Design
- CIMBased (IEC61970-453)GridModelIntegrationPilotApplication
- Dissemination of CIM Based (IEC 61970-453) Grid Model Integration
- Design of IT and OT Systems Integration Data Flow Model as CIM Based (IEC 61968)
- CIM based (IEC61968) Data Flow Model Pilot Application
- Dissemination of CIM based (IEC61968) Data Flow Model

As-is Status in Turkey: Although international OT products used in several DSOs have compliance with CIM standards, there are no integration implementation using CIM data exchange services in the sector yet.

Prioritization: Long-Term

Technical Domain: Enterprise Application Integration

2.10.3.10 Cyber Security

Evolution of grid management systems from conventional structure to digitalized Smart Grid systems automatically brings along the cyber threats and cyber security issues related to digitalization into the scenery. Increased integration and digitalization provide many benefits that transforms the grid management philosophies of DSOs, but this does not mean that all the efforts put into transformation will make the grid operations invulnerable to external dangers.

In contrary, all the generated data from previously non-existing Smart Grid systems and components as well as the remote control capabilities that are governed by the DSO create an enormous value that has strategic and economic value not only to DSO and its customers but also external parties that may use the opportunity for malign purposes.



This project is funded by the European Union



In order to increase the grid security and resilience for cyber threats, serious planning and implementation is required. Cyber warfare is a strategic issue that requires significant investments and must be handled not only at the DSO or industrial level but at a national level, due to potential impacts of cyber security threats towards the energy infrastructure.

The improvement of the smart grid infrastructures of the electricity distribution companies in line with the current solutions and process definitions will draw an important framework regarding the structure that should be taken as a priority in this field.

Under 'Cyber Security' domain, two projects are recommended for DSOs in order to establish a sound cyber security structure to protect their operations as well as their customers and integrated systems.

- Cyber Security Maturity Assessment, Planning and Standardization
- Operational Solutions and Business Adaptation

Further details are provided in the following tables.

Recommendation 30	Cyber Security Maturity Assessment, Planning and Standardization
In order to develop a sound strategy and establish mechanisms against cyber security threats, existing situation of each DSO must be addressed properly in terms of existing systems, practices and enterprise know-how. Determination and development of adequate cyber security measures needs thorough assessments of existing situation in alignment with existing maturity models and standards, and a cyber security roadmap must be developed to enlighten the continuous process to protect the DSO operations. In addition to planning and standardization efforts, it is also important that the technological infrastructure for the testing and simulation purposes is also established. Smart Grid systems and subcomponents are various in scale, complexity, technology, and functionality. This requires a cyber security laboratory in order to test and address potential weaknesses in Smart Grid components and develop strategies for prevention of cyber-attacks through these components before any threat exists in real. Projects below are suggested under this recommendation. • Cyber Security Maturity Model, Determination of Current & Target Maturity Levels, and Roadmap Studies • Compliance and Adaptation to IT and OT Cyber Security Standards Project • Creating Cyber Security Requirements and Implementing the Required Solutions • Establishing Cyber Security Simulation Laboratory in Smart Grids	
As-is Status in Turkey: DSOs in Turkey have received ISO 27001 accreditation as the first step. However, there are not satisfactory studies for maturity models and standardizations.	
Prioritization: Short-Term	Technical Domain: Cyber Security

Recommendation 31 Operational Cyber Security Solutions and Business Adaptation

Operational aspect of cyber security is at the centre of dealing with external threats. This can only be managed through the establishment of a central operational unit with adequate resources and necessary technological tools in order to run day-to-day cyber security operations to protect Smart Grid operations and enhance cyber security measures over time with accumulated know-how and operational capabilities.

In addition, integrated IT and OT systems within the Smart Grid architecture and their relevant business practices must be adapted to the necessary cyber security measures according to international standards and maturity assessments. Projects below present suggested items to implement in this perspective.

- Establishing the Cyber Security Operation Centre
- IT and OT Communication Infrastructures Cyber Security Solutions Application Project
- Cyber security solutions applications in data exchange services between IT/OT systems
- OT Systems Server and Local Network Infrastructures Cyber Security Solutions Application Project
- IT Systems Server and Local Network Infrastructures Cyber Security Solutions Application Project

As-is Status in Turkey: There are cyber security solutions implemented for IT/OT systems. For the next tariff period, more sophisticated solutions are planned to be implemented.

Prioritization: Short- to Medium- Term

Technical Domain: Cyber Security

2.10.4 Recommendations on Implementation Roles and Responsibilities

In recent years, advanced economies of the world have been trying to adapt to the paradigm change of energy sector. Smart Grid Roadmap's main purposes are listed below so that the sector can keep pace with those changes.

- The possible effects of electric vehicle, storage and roof-top solar panels on the distribution network, which are expected to become widespread in geometric proportions in the coming years, should be managed.
- Continuity of supply and quality of service should be raised to the EU average.
- The high technical and non-technical loss rates should be reduced to reasonable values, so that the carbon footprint of the electricity distribution sector should be minimized.
- Encourage market participation of eligible consumers to maximum level by increasing penetration level of smart meters,
- "Prosumer" phenomenon should be adapted to grid management, and integrated to the grid
- The infrastructure for the demand side market participation should be established.
- The benefits, that are gained by the application of data-driven management principles on the fully captured asset and customer data of DSO, should be reflected to tariffs in reasonable rates.
- Smart grid hardware and software elements should be produced by local resources as much as possible. This will have positive effects on the country economy and employment opportunities.



This project is funded by the European Union



- A contribution to national energy efficiency mobilization should be made.

Beyond these goals, which are specially created for the electricity distribution sector, it is recommended that the following statements, that can guide other sectors. With the help of road map studies and smart grid transformation objectives established in electric distribution sector, similar studies should be conducted in other sectors. Planning and road map preparation to gather all infrastructures of our country under “Smart Infrastructures” concept should be promoted. The regulations created for different sectors should be harmonized with "Smart Infrastructures" goal, target and road map.

To increase the benefits that can be gained from the usage of Smart Infrastructure by raising awareness of all stakeholders, it is proposed to launch a training campaign. Also, expansion of this training campaign to all parts of the country by public awareness activities and civil society organizations will make it possible to benefit more from the investments done or planned for smart infrastructures.

It is recommended that the regulator, which guides the electricity distribution sector with the country's vision, targets and needs, should consider the following statements specific to this sector.

Especially in the beginning of 4th Tariff Period, all DSOs should make medium- and long-term smart grid planning, prepare investment and operational budget in parallel with the objectives of the Regulatory Authority. EMRA should request these smart grid plans and budgets to approve in order to facilitate the adaptation to the paradigm change of energy sector. Making legislative changes that supports smart grid concept before the new tariff period, will help stakeholders to carry out a healthy process to take the necessary actions during smart grid transition in the following implementation periods.

While the regulatory institution continues to support traditional grid investments during the next implementation periods, DSOs should be requested to perform asset management activities in order to evaluate the performance and lifespan of the old and new assets of the grid; which will help to improve grid asset performance.

In addition, during the upcoming implementation periods, the regulatory body should further increase its support for R&D, pilot projects and technological investments, in order to meet the needs for smart grid transformation. Another important issue in this direction is the implementation of the technological project monitoring for the evaluation and supervision of the projects. This will allow the technological investments to be properly assessed and audited.

Another point is that the R&D studies need to be accelerated and turned into pilot projects. With the accumulation of the necessary knowledge and experience, DSO will be ready to the expected changes and developments.

Another prospect is the establishment of a Smart Grid Information Sharing Platform among distribution companies. Thanks to knowledge and experiences they can share, necessary applications will be implemented faster and with quality. Also, this will help in standardizing common applications among distribution companies.

As an abstract, main roles recommended for different stakeholders are summarized below:

Distribution System Operator

Distribution System Operators (DSOs) play a fundamental role in the operation of networks since they are responsible for the operation, maintenance, and development of the portion of the network that links the



This project is funded by the European Union



transmission system and the end customer. Moreover, DSOs play an important role as market facilitators for suppliers by making sure that the electricity is distributed in a safe and efficient manner. CEER¹⁹⁵ acknowledges also the importance of DSOs to decide on the suitable innovation solutions to be applied in their networks, according to the individual needs of the DSOs. DSOs should explore efficiencies of collaboration between electricity and gas DSOs in data collection, exchange and handling, in case smart metering data is collected and provided to the market.

Furthermore, Distribution System Operators which will play a key role in the deployment of smart grids should endeavour for;

- Integrating new generation and consumption management models into the grid operations,
- To support the expansion of small-scale, variable and intermittent generation resources (solar, wind) to be connected to the grid at different voltage levels,
- To provide necessary management infrastructures to support demand side participation,
- Starting the transformation of grid infrastructures by clarifying the requirements of new electric users such as electric vehicle charging stations, heat pumps,
- Providing the necessary infrastructure to implement new business opportunities and innovative solutions for market players,
- To facilitate Ancillary Services mechanisms through its flexibility sources,
- To realize continuous efficiency (all losses, operational activities, grid usage rates, etc.) in grid operations,
- To ensure its resilience against attacks that may occur on electrical infrastructures or natural disasters, in electricity systems of near future, which should possess user-oriented, interactive, flexible, reliable and sustainable grid, IT and communications infrastructure.

National Regulatory Authority

National Regulatory Authorities (NRAs) are responsible, among other things, about regulating network tariffs and their methodologies, as well as supervising the performance of DSOs. With regards to smart grid projects for distribution, NRAs are also responsible for setting the framework for incentivizing the smart grid-related activities. According to CEER¹⁹⁵, NRAs should not decide on the technologies and/or solutions to be used in order to carry out the DSO's distribution task, but their role is rather to set the framework so that the DSO to decide on suitable solutions according to the incentives set by each NRA. Specifically, in the case of smart meters, NRAs should be responsible of overseeing the conducting of the CBA and evaluate the outcome, both related to associated costs, as well as to expected benefits. Moreover, issues related to data handling and exchange, and ownership and management of metering equipment, should be treated by the NRAs regarding allocation of roles

¹⁹⁵ "C17-DS-37-05 – Incentives Schemes for Regulating Distribution System Operators, including for innovation", CEER, 2018



This project is funded by the European Union



National Regulatory Authority

and responsibilities in the private and the regulated domain. Finally, the NRA should request from DSOs to perform a Societal Cost-Benefit Analysis (SCBA), to evaluate the necessity of the deployment of flexibility services via analysing whether the benefits of a procurement model outweigh the resulting administrative burdens.

Other key recommendations about roles of the NRA can be listed as follows:

- Shift the allocated revenues from traditional investments to technological investments through incentives
- Develop smart grid promoting regulations
- Develop asset aging and conditional assessment approach
- Implement a concrete methodology to assess, monitor and audit the Smart Grid projects

Academia and Research Institutions

Academia, such as universities and R&D centres play an important role in smart grid activities in the European setting. Moreover, DSOs often collaborate with the academia and research institutions for their smart grid-related activities. CEER¹⁹⁵ proposes that incentives for innovation may also be anchored outside the regulatory system and therewith beyond the scope of the NRA. This may include public innovation funds for smart grid projects, national funding programs or European Framework Programs for Research and Innovation.

International Entities

Several international entities provide financing for smart grid projects. Apart from funding available from the European Commission for innovation and smart grid activities, via several funding mechanisms, such as the Horizon 2020 and the Horizon Europe framework program, the LIFE program, the Connecting Europe Facility, as well as other funding schemes, funding is also available from financial institutions and entities, such as the European Bank for Reconstruction and Development (EBRD), the EuropeAid, and others.



This project is funded by the European Union



3 Electricity Transmission Sector Report

3.1 Introduction of Electricity Transmission Part

Smart electricity grid provides possibility to new applications with far-reaching impacts: providing capacity to properly integrate more RES, distributed generation and flexibility into the network; delivering power more efficiently and reliably and comprehensive control and monitoring capabilities; using automatic grid restoration to restore outages; enabling consumers to have greater control over their electricity consumption and to actively participate in the electricity market.

The readiness level of technological developments has intensified in recent years. These developments shall be considered at both transmission and distribution network level. Therefore, at both network levels of the electricity sector, certain incentives regarding the implementation and operation of smart grids are applied. At the electricity DSO level, there are also some incentives established for the integration of renewable de-centralised distributed generation. In general, more incentives are implemented at the DSO level than at the TSO level and more in the electricity sector than in the gas sector¹⁹⁶.

The European Technology Platform for Smart Grids - Vision and Strategy for Europe's Electricity Networks of the Future defines a bold program for research, development and implementation of a strategy for modernization of the European grid that will meet Europe's needs in the future. According to this vision Europe's electric power grid must be:

- Flexible: fulfilling customers' needs whilst responding to the changes and challenges ahead
- Accessible: granting connection access to all network users, particularly for renewable power sources and high efficiency local generation with zero or low carbon emissions
- Reliable: assuring and improving security and quality of supply, consistent with the demands of the digital age with resilience to hazards and uncertainties
- Economic: providing best value through innovation, efficient energy management and 'level playing field' competition and regulation

With this vision, regulators and system operators deal with new phenomenon such as integration of renewable energy e.g. wind, solar and biogas, installation of smart grids solution, the necessary investments in new lines, substations, compensation elements and new technologies such as HVDC, STATCOM, SVC, Power Storage, Dynamic Line Rating, PMUs, WAMS, enhancement of SCADA/EMS, etc. in electricity transmission sectors. Therefore, right and timely regulations, and the implementation of incentives are needed to prepare the networks for their new and/or changed tasks. The integration of flexibility plays an important role for regulators to be fulfilled. The upgrading of networks to what is often termed a 'smart grid' usually comes with a need to be able to transfer huge amounts of data. Thus, the implementation of data hubs to manage these data is also currently growing in importance. The followings are the main objectives and challenges to be accomplished for the smooth transition in the energy sector:

- The digitalisation of power systems, decentralisation, and sector coupling.

¹⁹⁶ CEER report on Regulatory Frameworks for European Energy Networks 2019



This project is funded by the European Union



- The difficulties in replacing the existing grid infrastructure are forcing TSOs to search for the best balance between investing in new power technologies on one hand, while optimising performances and increasing the lifetime of existing ones on the other.
- The TSO/DSO interface is significant to increase system observability and enhance the deployment of new services that ensure overall system security. Considerable effort is needed to design and implement the internal electricity market.
- There have been major R&D achievements to facilitate the massive integration of renewable energy sources into the system.
- Management and control concepts will facilitate the safe integration of demand-response and EVs into the electricity systems.
- New technologies and tools will support the long-term planning of the electricity networks.

This report has been prepared for the purpose of examining the international examples related to the legislation and legal regulations that support the transformation in smart grid systems and in other words, in electrical infrastructures in different EU countries and Turkey.

Smart Grid deployment in electricity transmission activities is fundamental to upgrade transmission network operations, increase the quality of services, create value for customers, and move forward into the carbon emissions reduction. There exists a common approach in most of European countries, and at EU level, to promote smart grid technologies through regulatory incentives, enabling new business models or encourage partnerships across the energy sector. ENTSO-e, CEER, ACER and the European Commission are working on guidelines and recommendations to foster the implementation of smart grid solutions by TSOs in pursuit to the energy transition.

In the first part, the policies for the energy sector in the EU are examined. In this part, the contributions of different international institutions and organizations in the EU to smart grid arrangements were examined and the approaches and activities of EC, CEER, ACER and ENTSO-E regarding smart grid regulations in the Pan European level are summarized.

In the second part that follows, the smart grid regulations in some EU countries which are UK, Italy, Germany, France, Norway and Finland are examined, and the approaches and activities smart grid regulations in these countries are summarized, and also special operations in selected EU countries are presented. Again, in this part, different legislative practices in selected states are presented in a comparative way.

In the third part of the report, as-is policy regulatory framework in Turkey for the electricity transmission regarding smart grid arrangements are explained.

In the fourth part of the report, Gap Analysis is concluded with the different legislative practices in selected countries and presented in a comparative. An assessment and draws the main conclusions and recommendations for changes in the Turkish legislative structures to support the transformation in smart grid systems are explained with a general approach. The study covers financial regulation mechanisms and regulatory challenges and exemplary solutions for smart grids, respectively. This part of the report also deals with key issues for the concept of “smart legislation” and provides information on practices.

The final section, the Smart Grid Road Map developed for TEİAŞ is presented.



This project is funded by the European Union



3.2 European Legislative Framework Related to Smart Grids

The energy union strategy (COM/2015/080), published on 25 February 2015, as a key priority of the Juncker Commission (2014-2019), aims at building an energy union that gives EU consumers - households and businesses - secure, sustainable, competitive and affordable energy.

Due to the concern about the climate and environment, EU determines the need to establish following demanding objectives for 2030 in compliance with EU 2030 climate and energy policy targets (COM (2014) 0015)¹⁹⁷ :

- At least 40 % reduction target in greenhouse gas emissions (GHG) emissions (from 1990 levels),
- At least 27 % share for renewable energy,
- At least 27 % improvement in energy efficiency,
- Reform of the EU emissions trading scheme to include a market stability reserve,
- Key indicators - on energy prices, supply diversification, interconnections between member states and technological developments - to measure progress towards a more competitive, secure and sustainable energy system,
- A new governance framework for reporting by member states, based on national plans coordinated and assessed at EU level,
- Support the completion of the internal energy market by achieving the existing electricity interconnection arriving at a 15% target by 2030.

In order to achieve these objectives, current policy and focus points as a summary in the electricity sector are followings¹⁹⁸:

- Market integration
- Increase interconnections and electricity corridors
- Renewable integration
- Energy efficiency
- Consumer at the centre (active participation, self-consumption, electric vehicles, aggregation, etc.).

Since its launch in 2015, the European Commission has published several packages of measures and regular progress reports, which monitor the implementation of this key priority, to ensure that the energy union strategy is achieved.

3.2.1 Energy Union Strategy

The Energy Union Strategy aims at increasing the use of variable RES in the energy mix, empowering customers and putting households and businesses consumers at the heart of the European energy market. New technologies are developed, and the aim of R&I activities proposed in the Roadmap are an answer to these challenges by making use of new technologies and solutions.

¹⁹⁷ http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf

¹⁹⁸ ENTSO-E_ri_roadmap_2017-2026



This project is funded by the European Union

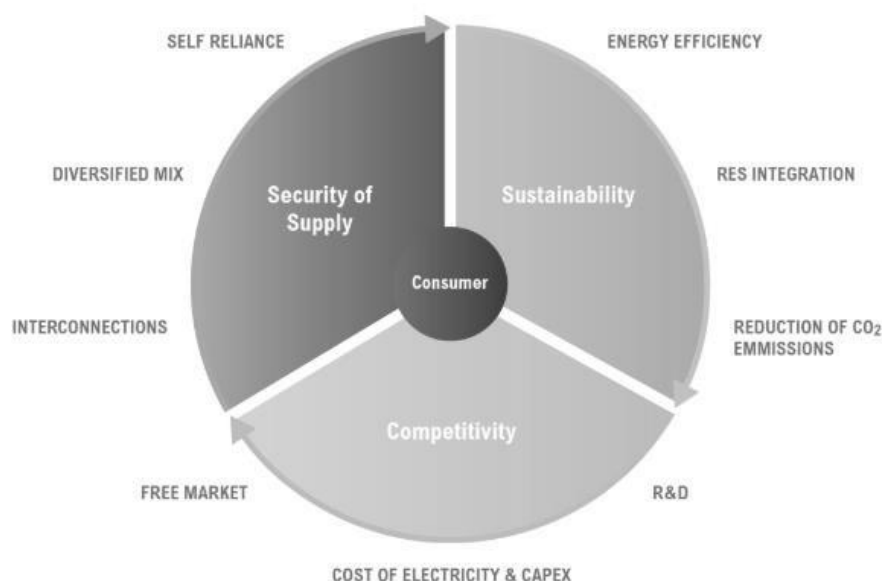


Figure 49: Energy Union Focus¹⁹⁹

The active consumer (and prosumer) will need smart grids integrating smart meters, highly developed home automation systems and appliances that enable demand response, portfolio management and load optimisation. Big Data management, the Internet of Things, post-processing and security of data are required not only for inter-TSO cooperation but also for the empowerment of consumers.

At the same time, the power system must be secure and safe through better controllability, which requires more observability. Therefore, system operation must take into account the volatility of demand, and the risks to system security due to this. On the other hand, the customer will be involved in demand response. This will require innovative solutions such as automation of the system operation, sub-station digitalisation, and the use of optical or nanotechnologies etc.

Furthermore, a stronger interface between the distribution and transmission, between wholesale and retail markets needs to be enhanced.

Electricity grids must also be prepared to create synergies with other energy networks (gas, heat) and to adopt the transition towards sustainable transport through the deployment of electric vehicles, which requires the evolution of the battery sector and creation of efficient charging station networks.

3.2.1.1 The Dimensions of Energy Union

The energy union builds five closely related and mutually reinforcing dimensions:

- **Security, solidarity and trust** - diversifying Europe's sources of energy and ensuring energy security through solidarity and cooperation between EU countries

¹⁹⁹ www.entsoe.eu



This project is funded by the European Union



- **A fully integrated internal energy market** - enabling the free flow of energy through the EU through adequate infrastructure and without technical or regulatory barriers
- **Energy efficiency** - improved energy efficiency will reduce dependence on energy imports, lower emissions, and drive jobs and growth
- **Climate action, decarbonising the economy** - the EU is committed to a quick ratification of the Paris Agreement and to retaining its leadership in the area of renewable energy
- **Research, innovation and competitiveness** - supporting breakthroughs in low-carbon and clean energy technologies by prioritising research and innovation to drive the energy transition and improve competitiveness.

3.2.1.2 *Regulation on the Governance of the Energy Union and Climate Action*

The Regulation on the governance of the energy union and climate action (EU)2018/1999 entered into force on 24 December 2018 as part of the Clean energy for all Europeans package.

The Third Energy Package²⁰⁰, the TEN-E Regulation²⁰¹ and the Clean Energy for All Europeans Package²⁰² aim at facilitating the development of the European energy networks.

The regulation emphasises the importance of meeting the EU's 2030 energy and climate targets and sets out how EU countries and the Commission should work together, and how individual countries should cooperate, to achieve the energy union's goals. It takes into account the fact that different countries can contribute to the energy union in different ways.

The goals of the regulation are:

- To implement strategies and measures which ensure that the objectives of the energy union, in particular the EU's 2030 energy and climate targets, and the long-term EU greenhouse gas emissions commitments are consistent with the Paris Agreement
- To stimulate cooperation between Member States in order to achieve the objectives and targets of the energy union
- To promote long-term certainty and predictability for investors across the EU and foster jobs, growth, and social cohesion
- To reduce administrative burdens, in line with the principle of better regulation. This was done by integrating and streamlining most of the current energy and climate planning and reporting requirements of EU countries, as well as the Commission's monitoring obligations
- To ensure consistent reporting by the EU and its Member States under the UN Framework Convention on Climate Change and the Paris agreement, replacing the existing monitoring and reporting system from 2021 onwards

²⁰⁰ "Third Energy Package" refers to Directives 2009/72/EC and 2009/73/EC, Regulations (EC) No 714/2009, (EC) No 715/2009 and (EC) No 713/2009.

²⁰¹ Regulation (EU) No 347/2013.

²⁰² "Clean Energy for all Europeans Package" mainly refers to Directive (EU) 2019/944 and Regulations (EU) 2019/942 and (EU) 2019/943.



This project is funded by the European Union



The governance mechanism is based on integrated National Energy and Climate Plans (NECPs) covering ten-year periods starting from 2021 to 2030, EU and National Long-term Strategies, as well as integrated reporting, monitoring and data publication.

The transparency of the governance mechanism is ensured by consulting wide public on the NECPs.

3.2.2 European Green Deal

Furthermore, the European Green Deal ²⁰³ published and its aims to make Europe the first climate-neutral continent by 2050. As energy production and use account for more than 75% of the EU's greenhouse gas emissions. To date, Europe has made significant progress in decarbonising its electricity production. But progress has been slower in other sectors and for other forms of energy (gas, liquid fuels, heat), and fossil fuels remain predominantly used in transport, industry, buildings, and agriculture.

In order to meet EU climate objectives, while also guaranteeing secure and affordable energy for consumers, it is needed to have better link up energy system and exploit the synergies enabled by an integrated energy system. These are:

- Increase the use of (renewable and low carbon) electricity via electrification of sectors that currently still rely on fossil fuels. Examples are the use of electric vehicles in transport, or of heat pumps for heating buildings.
- Replace fossil-based gases and fuels by renewable and decarbonised gases and fuels, especially in hard-to-decarbonise sectors such as air transport or certain industrial processes. Hydrogen produced from renewable electricity will play a key role in this context, together with the replacement of natural gas by biomethane produced from agricultural wastes, achieving thus a progressive decarbonisation of the gas sector. Such a process will require supportive market rules.
- Become more “circular” and make full use of the energy efficiency first principle. This is not only about reducing consumption, but also about the overall efficiency of energy system. An example is the use of industrial waste heat or waste heat from data centres to heat buildings, for instance through a district heating network.

Several barriers still prevent this potential from fully materialising and allowing citizens and industry to embrace cleaner energy alternatives. There is an EU initiative to strengthen the necessary links across different sectors in energy system, and to use every opportunity to reduce emissions. This integration of EU energy system is necessary to achieve a deep but also cost-effective decarbonisation of economies. It will build a more decentralised and digital energy system, in which consumers are empowered to make their energy choices.

3.2.2.1 New EU-Wide Rules for Electricity Sectors

The new rules contribute to the EU's goal of being the world leader in energy production from renewable energy sources by allowing more flexibility to accommodate an increasing share of renewable energy in the grid. The shift to renewables and increased electrification is crucial to achieve carbon neutrality by 2050. The new electricity market design will therefore help to achieve the goals set out in the European Green Deal, and contribute to the creation of jobs and growth.

²⁰³ https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf



This project is funded by the European Union



European Green Deal Action Plan for Clean, affordable and secure energy is as follows²⁰⁴;

- Assessment of the final National Energy and Climate Plans June 2020
- Strategy for smart sector integration 2020
- 'Renovation wave' initiative for the building sector 2020
- Evaluation and review of the Trans-European Network – Energy Regulation 2020
- Strategy on offshore wind 2020

The share of electricity produced by renewable energy sources is expected to grow from 25% to more than 50% by 2030. At the same time, electricity must also be produced and delivered in sufficient quantities when there is no wind or sun. Markets need to be improved to meet the needs of renewable energies and attract investment in the resources, like energy storage, that can compensate for variable energy production. The market must also provide the right incentives for consumers to become more active and to contribute to keeping the electricity system stable.

To address these issues, the EU adopted in 2019, as part of the 'Clean energy for all Europeans package', four pieces of legislation that will help adapting EU market rules to new market realities.

The Electricity Directive and Electricity Regulation:

In order to establish common rules for the generation, transmission, distribution, energy storage and supply of electricity, together with consumer protection provisions, with a view to creating truly integrated competitive, consumer centred, flexible, fair and transparent electricity markets in the EU, the new electricity directive was issued. Using the advantages of an integrated market, this Directive aims to ensure affordable, transparent energy prices and costs for consumers, a high degree of security of supply and a smooth transition towards a sustainable low-carbon energy system. It lays down key rules relating to the organisation and functioning of the EU electricity sector, in particular rules on consumer empowerment and protection, on open access to the integrated market, on third-party access to transmission and distribution infrastructure, unbundling requirements, and rules on the independence of regulatory authorities in the EU Member States. This Directive also sets out modes for EU Member States, regulatory authorities, and transmission system operators to cooperate towards the creation of a fully interconnected internal market for electricity that increases the integration of electricity from renewable sources, free competition and security of supply.

The Directive on common rules for the internal market for electricity (EU) 2019/944, which replaced Electricity Directive (2009/72/EC), and the new Regulation on the internal market for electricity (EU) 2019/943, which replaced the Electricity Regulation (EC/714/2009) on January 1 2020, introduce a new limit for power plants eligible to receive subsidies as capacity mechanisms (confirming the phasing out of subsidies to generation capacity emitting 550gr CO₂/kWh or more). Furthermore, the consumer is put at the centre of the clean energy transition and the new rules enable the active participation of consumers, whilst putting in place a strong framework for consumer protection.

By allowing electricity to move freely to where it is most needed, society will increasingly benefit from cross-border trade and competition. They will drive the investments necessary to provide security of supply, while decarbonising the European energy system.

²⁰⁴ https://ec.europa.eu/info/sites/info/files/european-green-deal-communication-annex-roadmap_en.pdf





This project is funded by the European Union



Currently, consultation on a planned procedural clarification in four electricity guidelines by way of a Commission Implementing Regulation of EC is continuing to achieve above mentioned objectives with the following target groups:

- Electricity transmission system operators (TSOs),
- Nominated electricity operators (NEMOs),
- Distribution system operators (DSOs),
- Associations of TSOs, NEMO and DSOs,
- Electricity system users and consumers and their associations,
- Regulatory authorities and other public authorities,
- The agency for the cooperation of energy regulators (ACER),
- Other relevant stakeholders (inside and outside of the European union).

Pursuant to the Electricity Regulation (EU) 2019/943 the EC is empowered to adopt and amend binding guidelines in the areas. In this context the EC seeks the views of ACER, the ENTSO for Electricity, the EU DSO entity and, where relevant, other stakeholders.

The planned EC Implementing Regulation intends to clarify ambiguous wording in the provisions on the process for developing and approving more detailed joint rules under guidelines (Commission Regulations) governing key cross-border aspects of the electricity wholesale market in the EU and to align those provisions with the new Electricity Regulation (EU) 2019/943 and the ACER Regulation (EU) 2019/942 adopted in 2019.

The proposal consulted upon for a limited and well-targeted amendment of the four Electricity Guidelines²⁰⁵ ;

- Capacity Allocation and Congestion Management “CACM” (EU) 2015/1222 of 24 July 2015,
- Forward Capacity Allocation “FCA” (EU) 2016/1719 of 26 September 2016,
- Electricity Balancing “EB GL” (EU) 2017/2195 of 23 November 2017,

Regulation on Risk-Preparedness in the Electricity Sector:

The Regulation on risk preparedness in the electricity sector (EU) 2019/941 requires EU Member States to prepare plans for how to deal with potential future electricity crises and put the appropriate tools in place to prevent, prepare for and manage these situations. Lessons-learned from 2006 European Blackout is driving factor to issue this regulation.

This new initiative followed an independent report from May 2015, which highlighted previous experience showing that Member State responses to potential crises tended to focus on the national context only, disregarding cross-border effects and thereby sometimes even exacerbating the problems, undermining the functioning of the market and driving up energy bills.

The new regulation requires that Member States, using common methods, identify all possible electricity crisis scenarios at national and regional levels and then prepare risk preparedness plans based on these scenarios. Above

²⁰⁵https://ec.europa.eu/energy/sites/ener/files/20200507_com_e-gls_amendments_consultation_document.pdf



This project is funded by the European Union



all, this preparation requires EU countries to cooperate and coordinate with neighbouring member states in a spirit of solidarity. It also establishes a new framework for a more systematic monitoring of security of supply issues via the Electricity Coordination Group.

The new rules will ensure maximum preparedness against electricity crises and effective management and ensure that markets can work as long as possible.

Regulation for Establishing the Agency for the Cooperation of Energy Regulators (ACER):

Established under the Third energy package, ACER's main role was originally confined to coordination, advising and monitoring. As the new market design rules foresee much more cross-border cooperation, the lack of regional, cross-border oversight was seen as a potential problem, with the risk of diverging decisions and unnecessary delays. Regulation (EU) 2019/942 establishing an EU Agency for the cooperation of energy regulators recasts the regulation 713/2009.

In addition to coordinating the action of national energy regulators, ACER has therefore been granted additional competences in those areas where fragmented national decisions of cross-border relevance are likely to lead to problems for the internal energy market. For example, ACER will have oversight on the future regional entities ("Regional Coordination Centres") where TSOs (Transmission System Operators) will be able to decide on those issues where fragmented and uncoordinated national actions could negatively affect the market and consumers. The proposed approach will also streamline regulatory procedures. National regulators, deciding within ACER on those issues through majority voting, will remain fully involved in the process.

3.3 Smart Grid Efforts in EU

The European energy sector is currently experiencing a major transition towards a carbon neutrality in order to reach "European Green Deal's" objectives. All solutions have been considering to address the identified needs, such as increased transmission capacity, storage, hybrid offshore infrastructure, smart grids.

The quickness of technological developments has intensified in recent years. These developments shall be considered at the transmission and distribution network level. Therefore, at both network levels of the electricity sector, some incentives regarding the installation and operation of smart grids and smart meters are applied. At the electricity DSO level, there are also some incentives established for the integration of renewable de-centralised distributed generation. In general, more incentives are implemented at the DSO level than at the TSO level and more in the electricity sector than in the gas sector²⁰⁶. European investment in Smart Grid technologies is forecasted to reach €56.5 billion during the period from 2010 to 2020, with transmission share about 37% of the total amount²⁰⁷.

Furthermore, some countries have individual incentives established in their regulatory regime. These are as follows:

- The Spanish regulatory regime includes at the electricity TSO level incentives for maximising the transmission grid availability, for the accomplishment of the investment plan approved for the company and implicit incentives to be more efficient in the cost of new assets and their operating and maintenance costs, trying to get lower costs than the approved reference values.

²⁰⁶ CEER report on Regulatory Frameworks for European Energy Networks 2019

²⁰⁷ JRC reference report on Smart Grid in Europe



This project is funded by the European Union



- Finland TSO, Fingrid incentives regulation, has established incentives for innovation. Innovation Maximum 1.0 % of turnover is reimbursed in allowed return as regulatory profit in regulatory model 2016-2023. Innovation incentive encourages the TSO to develop and use innovative technical and operational solutions in its network operations. The key objectives of research and development activities are the development and introduction of smart grids and other new technologies and methods of operation. Acceptable costs for research and development (R&D) must be directly related to creation of new knowledge, technology, products, or methods of operations.
- Luxembourg NRA wants to foster the development of smart grids and is planning to establish a specified incentive for the electricity sector until 2021.
- Norway NRA is considering changing the tariff structure for the demand for MW to influence the tariff for all customers. This could give incentives for more demand response.
- Sweden NRA also plans to implement the contents of the European Clean Energy Package and therefore, TSOs will, in most cases, not be allowed to own storage in future.

Finally, the developments of the energy networks in Europe should regularly be analysed closely in the future due to changes caused by the energy transition. The switch from conventional to renewable energy sources, a growing cooperation between (and inside) European energy networks and the integration of smart elements into the networks can be seen as the next huge challenges for network operators, but also for the regulating national authorities.

As for smart grid investments in EU, following figure shows the share of budget for different countries and project categories.

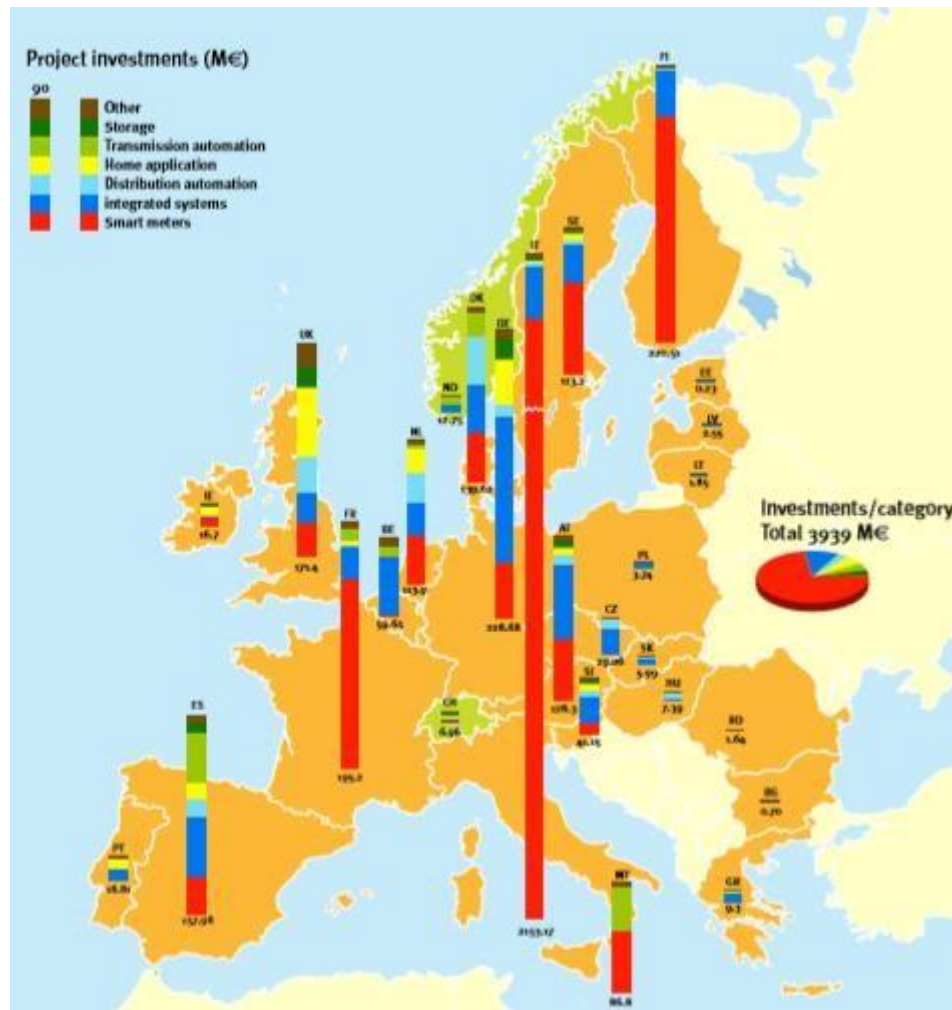


Figure 50: Geographical Distribution of Investments and Project

Categories²⁰⁸ Source: JRC Reference Report on Smart Grid Projects

in Europe

Main reasons that's why more smart grid investment incentives and consequently share is realized at the DSO level than at the TSO level in the European electricity sector can be assessed as follows:

- The TSOs, indeed, has already had a partly smart system to capable of managing and balancing the resources connected to their system, at the time being. Therefore, they prefer mainly investing in strengthening projects rather than smartening the transmission grid,
- On the other hand, due to the integration of renewable de-centralised distributed generation, DSOs roles and responsibilities are changing dramatically. The future for DSOs must be more than simply building and maintaining the distribution of energy. DSOs will have a central role in an energy ecosystem, as well as TSOs. Therefore, DSOs need Smarter Grid and Meters investment to have a more resilient and reliable grid and innovative, consumer-focused services.



This project is funded by the European Union

²⁰⁸This figure does not include the total budget of the Swedish smart meter programme (estimated budget €1.5 billion)





This project is funded by the European Union



3.4 Pan-European Activities on Design of Future Electricity Transmission Systems

3.4.1 CEER

In order to support energy regulators' and stakeholders' discussions on energy system integration, CEER considers "Whole System Approaches". This CEER further develops the Whole System Approach (WSA) concept, first introduced in 2016 on future of TSO and DSO relationship, by describing three possible WSA layers, which should be considered to reach a better outcome²⁰⁹:

- **Layer 1 "whole-network-approach"** - An integrated view of the regulation of distribution and transmission networks with a main focus on network operation and planning,
- **Layer 2 "whole-chain-approach"** - An integration across a sectoral chain (e.g. in electricity or in gas), i.e. expanding beyond networks to for instance, include demand, generation, system operation and retail, both in terms of interaction with network operators and in terms of the impacts on them; and
- **Layer 3 "cross-systems-approach"** - An integration across different energy areas, e.g. the integration of regulation of the electricity, gas and heat sectors, including with transport.

The WSA essentially means to consider the societal net benefit for the entire system, in line with the applicable energy policy objectives. The WSA also encourages network operators to consider the consequences of their decisions on other actors of the value chain. This is crucial, because when certain incentives or interests only cover specific areas (e.g. the network operator's own network activities), results could well be suboptimal.

3.4.1.1 CEER & ACER Role on EU Legislative Changes

As summarized recently through a joint paper by the European Union Agency for the Cooperation of Energy Regulators (ACER) and the Council of European Energy Regulators (CEER) have recommended legislative changes to improve the planning and implementation of electricity and gas infrastructure for the upcoming revision of the Guidelines for trans-European energy infrastructure Regulation (TEN-E Regulation) before the end of 2020 as one of the initiative of the European Green Deal to:

Based on the extensive experience on the benefits and shortfalls of the current TEN-E Regulation, national regulatory authorities (NRAs) and ACER propose legislative changes to improve the planning and implementation of electricity and gas infrastructure, aiming to make it streamlined, focused on sustainability and neutral both in terms of technology and potential conflict of interest.

In the paper, ACER and CEER propose specific recommendations in the following three areas: governance of infrastructure development; scope of principles for Projects of Common Interest; and TEN-E processes.

3.4.2 Smart Grid Task Force²¹⁰

The Smart grids task force was set up in 2009 to advise on policy and regulatory directions for the deployment of smart grids in Europe. It consists of five expert groups which focus on specific areas. Their work shape EU smart grid policies and the policy framework. The European Commission has set up a smart grids task force, which has issued

²⁰⁹ www.cceer.eu

²¹⁰ <https://ec.europa.eu/energy/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force>



This project is funded by the European Union



key reports on **standards, cybersecurity and flexibility markets**. These are largely agreed by industry, European standards organisations, public authorities and consumer organisations.

The task force consists of five expert groups which focus on specific areas. These are followings:

1. Expert group 1, EG1 – Smart grid standards,
2. Expert group 2, EG2 – Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment,
3. Expert group 3 – Regulatory recommendations for smart grid deployment,
4. Expert group 4 – Smart grid infrastructure deployment and
5. Expert group 5 – Implementation of smart grid industrial policy.

Smart Grid Task Force has worked and issued following reports on standards, cybersecurity and flexibility markets recently.

➤ **Standard Data Access & Exchanges**

In order to facilitate interoperability of electricity and gas services in retail markets and help promote competition, Expert Group EG1 focused common data format that evolved into data access (and exchange). In this framework, followings are succeeded:

- Map national practices for data access and exchange
- Identify commonalities, differences, scope for bringing them closer
- Frame recommendations: advice on what to address in implementing act(s)

Targeted processes were:

- Traditional processes examined: “Change of Supplier”, “Billing”
- New & Emerging services: “Download my data”; “Share my data” with third parties: both historical data, and near-real time data

Final report “Towards Interoperability within the EU Electricity and Gas Data Access & Exchanges”²¹¹ was published.

Outcomes of the report are followings:

- Recommendations on what to consider in secondary legislation
- Concept of a reference model / framework:
 - Core + national specificities; both evolve over time
 - Reference model = process + information + role model
- Idea tested on business use cases from emerging services: “download my data”; “share my data”; “consent management”

²¹¹ https://ec.europa.eu/energy/sites/ener/files/documents/eg1_main_report_interop_data_access.pdf



This project is funded by the European Union



➤ Cybersecurity

Expert group 2, EG2 – Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment

Cyber-security activities in EU is shown as follows. EG2 has focused on the Network Code on Cyber-security.



Figure 51: Cybersecurity in the Energy Sector

Source: MoM of SGTF-SC, Dated: 21st of June

2019

EG2 has proposed the following Structure for the Network Code on Cybersecurity.



This project is funded by the European Union

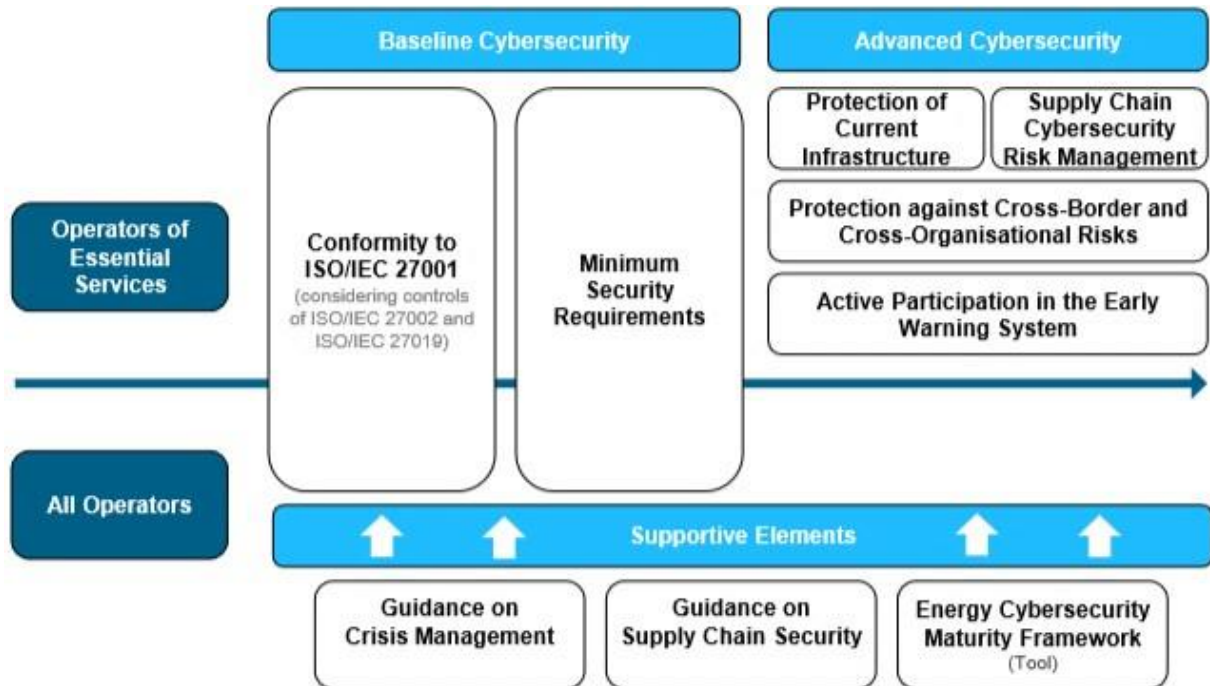


Figure 52: Proposed Structure for the Network Code on Cybersecurity by

EG2 Source: MoM of SGTF-SC, Dated: 21st of June 2019

➤ Demand Side Flexibility

Expert group 3 – Regulatory recommendations for smart grid deployment EG3

focused on following works for the Demand Side Flexibility:

- Access of flexibility to organised markets in order to ensure a level playing field between demand side flexibility and generation
- Use of demand side flexibility by system operators (DSOs and TSOs), including demand response and other flexibility services
- Contractual arrangements between final customers, aggregators, suppliers/BRPs and possibly other actors

Main objectives of the works are:

- Identify success stories and best regulatory practices across Europe
- Identify remaining gaps that have to be addressed at EU level and propose what should be the scope of further and more specific EU action (i.e. Network code) and relevant areas

Final report "Demand Side Flexibility"²¹² was published. The main outcomes of the report are followings:

²¹²<https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force>



This project is funded by the European Union



- Technical solutions: EU level principles for equal level playing field of flexibility providers and integrated system approach.
- Market access: framework for data access, flexibility providers, baseline methodology and validation based on EU principles and national best practices
- Flexibility products: product definition, data requirements and pre-qualification at least at national level, but possible template and key elements at EU level
- Consumer and incentives: financial incentives, market monitoring, awareness, and protection of consumers at national level based on EU principles and framework.

3.4.3 ENTSO-E

ENTSO-E approach is to use new technologies and solutions to deal with the challenges of variable RES increasing, empowering customers and active participation of households and businesses consumers/prosumers to the European energy market in compliance with the Energy Union Strategy.

The Research, Development and Innovation Road-map (R&I Roadmap) activities to support EU Countries Transmission System Operators (TSOs) for the period 2017-2026 was developed by ENTSO-E, together with DSOs (EDSO for Smart Grids) and the European Association for Storage of Energy (EASE) through the participation in the EC project “Grid + Storage”. This roadmap addresses both TSO and DSO functional objectives.

The R&I Roadmap was a mandated deliverable providing the medium/long-term vision for R&I activities coordinated by ENTSO-E and performed by TSOs, as similar as other deliverables. The revision is also supposed to enable alignment with the process of the European Commission’s Integrated Roadmap²¹³, which requires a more holistic vision and expanded cooperation with other actors. The Roadmap also covers Implementation Plans, issued yearly on a rolling three-year horizon, and translated into focused topics to be addressed by concrete projects.

Following processes are performed by ENTSO-E in close cooperation with relevant stakeholders to govern the R&I Roadmap:

- Designing and approval of the R&I Roadmap,
- Support to the EC for defining priorities and R&I programs,
- Encouraging TSOs to pool efforts and resources to perform R&I projects,
- Monitoring the achievements of the performed R&I projects,
- Disseminating, facilitating, replication and implementation of results by the entire ENTSO-E community.

ENTSO-E R&D Roadmap aims at creating a supportive stakeholder environment for TSOs in conducting R&D. It covers a large amount of TSO R&D activities and shows how necessary they are in realising Europe’s climate and energy policy targets, but also how they support other TSO tasks related to EU network codes and ten-year network development plans.

ENTSO-E R&D roadmaps outline a methodology to achieve EU objectives and lay groundwork for the upcoming electricity highways, smart grids, and the change to a low-carbon electricity system.

²¹³ EC Integrated Roadmap (2015), C (2015)61317 final



This project is funded by the European Union



Defining a comprehensive R&D Roadmap is challenging. Implementing it is even more challenging. TSO cooperation is key as well as TSO collaboration with universities, research institutes, DSOs, generation companies, consumers, and industrial manufacturers. This way not only are the R&D Roadmap targets met, but results are optimised as knowledge is quickly disseminated and shared among stakeholders and interested parties.

The ENTSO-E R&I strategy scope is to accomplish the following:

- Ensure system view: develop and move towards a system view in which services such as flexibility or data handling structures will emerge, requiring very close cooperation across TSOs and across TSOs and DSOs. R&I is a key component for the operation and development of the pan-European energy system aiming at integrating new technologies, innovative solutions and new actors in the short term (e. g., facilitate the implementation of the network codes) and long term (e. g., planning, new grid architectures that maximise social well-fare at the European level).
- Ensure that the three dimensions of innovation (technology, process and business model innovation) are all addressed. Ensure that R&I activities lead to implementation of the Smart Systems concept. Consider technology readiness levels (TRL) when defining project and system requirements. The setup of commonly agreed-upon interfaces between the new actors and network operators as well as the development of new business models would facilitate tapping into the unused potential to ensure the present and future energy system needs cost-effectively.
- Cooperate with regulators and DSOs, and advocate for a fit-for-purpose regulatory scheme supportive of innovation in networks, which sends the right signals to underpin innovation activities at the TSO level and to free the necessary level of expertise and resources of the system operators.

ENTSO-E has proposed as an important step in this direction and proposes a complementary, longer-term vision in consistent with the Clean Energy Package which entails the following key messages²¹⁴:

- Implementation of the Clean Energy Package for Europe's green energy transition on time has the priority for ENTSO-E and TSOs,
- ENTSO-E supports the transition of energy sector from a fossil fuel dominated and supply-centric model to a clean, digitalised and electrified consumer centric system with many distributed resources in Europe.
- Future system operations will rely upon a system of systems that should work as one. They will ensure seamless integration of growing shares of decentralised resources and power electronics. They will allow for alignment with needs of all grid connected assets and be further coupled with other sectors. Innovation and cooperation will be key enablers.
- Different but interoperable market design features could be incorporated in the current target model to allow Europe as a whole to meet the 2030 challenges, which vary across countries and market time frames.
- To work as one, a system of systems should build on a multilevel architecture that articulates different geographical scales and functional layers through multilateral interfaces that are interoperable with each other

²¹⁴ https://vision2030.entsoe.eu/wp-content/uploads/2019/11/entsoe_fp_vision_2030_web.pdf



This project is funded by the European Union



- The governance of this pan-European system of systems will involve multiple stakeholders. In this context, TSOs will play a key facilitation role, together with DSOs, supported by RCCs, and in dialogue with stakeholders.

3.4.3.1 **Joint Activities of ENTSO-E and EDSO**

Evolutions in the grid operation sector will require an ever-closer cooperation between Transmission System Operators and Distribution System Operators. The current interaction between TSOs and DSOs has been investigated for six specified grid operation challenges, and possible future ways of cooperation have been identified:

- Congestion of Transmission-Distribution interface
- Congestion of transmission lines
- Balancing challenge
- Voltage support (TSO-DSO)
- (Anti-)Islanding, re-synchronization & blackstart
- Coordinated protection

For each case, country experts provided first-hand information about the status and expected development of TSO-DSO interaction in their respective countries. This resulted in an overview, by country, of the interaction between grid operators and provided input for the discussion about how this interaction could evolve in years to come. Technical aspects, as well as policy aspects, have been taken into account.

The European Network of Transmission System Operators for Electricity (ENTSO-E) and the European Distribution System Operators' Association (E.DSO) have been co-organised "InnoGrid" as an EU event on innovation in electricity networks. The 2020 edition will focus on the paramount role of Networks to make the Green Deal reality, while putting customers and citizens at a centre stage. Power electronics, dynamic line rating, smart substations, digitalisation at large, an effective cybersecurity framework are main objectives at InnoGrid 2020. R&D projects, pilots and breakthrough technologies will be at the heart of the discussions at this edition, presented by project promoters, TSOs and DSOs from Europe.

3.4.3.2 **ENTSO-E's Brief Overview on Status of Activities in Different Smart Grid Domains**

ENTSO-E and its Members (TSOs) have created a public platform for communication and exchange of best practices applied at national level²¹⁵. These innovative solutions focus on power system modernization, security and system stability, power system flexibility, power system economics and efficiency, ICT and digitalization of power system and other innovative applications to support the achievement of the current EU goals and national strategies.

Electricity Transmission innovation projects are classified under each of the following topics:



This project is funded by the European Union



Table 14: Electricity Transmission Innovation Projects: ENTSO-E Clusters²¹⁶

Innovation Area	Brief Description	Functional Objectives
C1 Power System Modernisation	This cluster aims at developing an optimal grid design, based on the use of the most cost-effective technologies/solution, which should enable more flexibility (through the use of demand response, storage, or interface with other energy networks). It also looks at smart asset management models and methodologies, and the improvement of public awareness and acceptance.	- T1 Optimal grid design: Planning, adequacy, tools - T2 Smart Asset Management: Predictive and on-condition maintenance; CAPEX optimisation - T3 New materials & technologies: Use of new materials and power technologies; new construction and maintenance methods - T4 Environmental challenges & Stakeholders: Environmental impact, public acceptance, stakeholder's participation
C2 Security and System Stability	This cluster addresses the improvement of the observability and controllability of the transmission system. This will be carried out through the development of methods, technologies and tools able to handle, process and interchange measured and forecasted data in real time across TSOs but also with DSOs. Network modelling and dynamic security tools are part of this cluster. It aims at improving defence and restoration plans for the pan-European grid. The operation of the power system will be based on the development of new procedures, strategies and models for ancillary services coming from different sources: RES, DSOs, energy storage, etc.	- T5 Grid observability: Observability of the grid: PMUs, WAM, Sensors, DSO information exchange - T6 Grid controllability: Controllability of the grid; frequency and voltage stability, power quality, synthetic inertia - T7 Expert systems and tools: Decision support tools, automatic control and expert systems - T8 Reliability and resilience: Défense and restoration plans, probabilistic approach, risk assessment, self-healing - T9 Enhanced ancillary services: For network operation; cross-border supply of services

²¹⁶ ENTSO-E Research, Development & Innovation Roadmap 2017–2026





This project is funded by the European Union



Innovation Area	Brief Description	Functional Objectives
C3 Power System Flexibility	This cluster supports the deployment of existing and new system flexibility options such as: - Storage solutions for fast-responding power (time dimension) and energy (less capacity needed) as well as for novel solutions for system services. Technical requirements, economic, market and environmental aspects must be evaluated. - Demand response encompassing the development of tools and specifications for the control of such resources. It will also address the integration of electric vehicles and the modelling of customer behaviour and quantify the degree of flexibility provided by the distribution networks. - ICT and enhanced RES forecast techniques would support the optimal capacity operation of the power system while maintaining the quality and security of the supply. - The enhanced use of the transmission assets.	- T10 Storage integration: Definition and use of storage services; system added value from storage - T11 Demand Response: Tools to use DSR, Load profile, EV impact - T12 RES forecast: Improved RES forecast and optimal capacity operation - T13 Flexible grid use: Dynamic rating equipment, power electronic devices; use of interconnectors - T14 Interaction with non-electrical energy networks: Interaction/coordination with other energy networks (gas, heat, transport)
C4 Power System Economics & Efficiency	This cluster aims to propose ways and means to facilitate interactions between the European electricity markets and the pan-European transmission system. The objective is to achieve a more efficient market with an optimised energy mix and security of supply through integration of market and grid operations. All time horizons are treated in this cluster. On the one hand, tools and methods will be proposed to enhance the optimisation of the energy flows at short-term horizons in the pan-European system, considering the intermittency generated by RES. On the other hand, the cluster aims to make proposals to coordinate investments in a context where the quality of the market prices to generate the correct signals for investment is regularly questioned.	- T15 Market – grid integration: Integration of market and grid operation across timeframes (up to realtime) - T16 Business models: For storage, grid extension, distributed generation for optimal investments in the network - T17 Flexible market design: Market design for adequacy, flexibility use, cross border exchanges, rationale use of RES, demand management



This project is funded by the European Union



Innovation Area	Brief Description	Functional Objectives
C5 ICT & Digitalisation of Power System	This cluster aims at considering Big Data management through data-mining tools and the development of interfaces with neutral and transparent data access. The cluster will also consider recommendations for standardisation activities and protocols for communications and data exchanges, the use of new technologies such as the Internet of Things and cyber security issues. ICT is an enabling technology for managing the flexible energy system described in C3.	• T18 Big data: Big data analytics, data mining, data management • T19 Standardisation & data exchange: Standardisation, protocols for communications and data exchange with DSOs and other grid operators • T20 Internet of Things: New communication technologies, Internet of Things • T21 Cybersecurity

ENTSO-E's evaluations on the latest situation for each innovation clusters are summarized as follows²¹⁷:

➤ Power System Modernization

HVDC Links: Interesting developments are expected to take place, especially around stability issues within conditions of high penetration levels of power electronics (incl. converter-based renewable generation and high voltage direct current (HVDC) links).

Smart asset management is gaining attention with interesting projects – technologies, tools and applications – to be expected in the future. Currently there are few success stories

➤ Security and System Stability

PMUs: The use of Phasor Measurement Units (PMUs) and other sensor technologies has increased awareness and accuracy. Supporting and simulation tools and data processing equipment have contributed to these developments. Work continues on further improvements, not only on TSOs' own system observability, but also on DSOs' systems (merging TSO/DSO models). Data collection, processes, protocols and standards should be harmonised more.

New Integrated Technologies: The proper control and impact on the stability of the system of new integrated technologies, such as storage, converter-based renewables and HVDC, will require further research and demonstration.

Reliability and resilience in terms of defence and restoration plans, probabilistic approach, risk assessment and self-healing, started as RD&I activities with some ongoing projects that will deliver results in the future.

The impact of storage flexibility is partially addressed.

➤ Power System Flexibility from Generation, Storage, Demand and Network

²¹⁷ ENTSO-E Monitoring Report on Research, Development & Innovation Roadmap 2017–2026



This project is funded by the European Union



Storage Devices: Power system flexibility using storage have had the lion share in terms of number of projects. However, the lower maturity levels of the technology and the specificities of different types of storage technologies need to be further addressed. Challenges remain on the optimal use and distribution of storage devices, the needed technical requirements to facilitate service provision and the business models development.

HVDC: Hybrid AC/DC solutions, HVDC reliability, meshed DC grids, services from HVDC multiterminal networks are topics where European research will need to step into more in the coming years.

Dynamic Rating Equipment: The developments are better regarding dynamic rating equipment and power flow devices, but it is still necessary to develop comprehensive methodologies to provide a common framework for investment-decision discussion with national regulatory authorities (NRAs).

Accurate power forecasting: especially from renewable energy sources, accurate power forecasting still seems to be a challenge. A range of ongoing projects will hopefully increase coverage of this objective. However, more attention will be needed when it comes to estimating secondary/tertiary reserve against those accuracy levels

➤ **Power System Economics and Efficiency**

Flow-based market coupling is still subject to investigation and there is need for more RD&I.

Flexibility and Ancillary Services: There have been very promising results around business models that include flexibility considerations and ancillary services provisions. However, considering the future needs and structural changes of the industry, this topic remains high on the research agenda.

➤ **Digitalisation of Power System**

The Digitalisation of the Power System : Overall, the digitalisation of the power system, big data management, ICT and communication advancements, along with all their benefits and challenges, is a new and wide area to explore that will require increased focus over the coming years.

Data Management: There has been some progress on local data management system and developments on the standardisation front: IEC61850, CIM standard series and communication protocols. Work is ongoing, with important projects to deliver results in the coming period.

Data Exchange: The field of data exchange models between TSO/DSO, and other agents such as EV chargers, has seen advancements. However, wide application and assessment is pending.

Open source modelling: the impact of Internet of Things (IoT) and related interface tools are emerging.

Cybersecurity: has been acknowledged as an important field and major activities are ongoing at national and European level. The research work should continue supporting this area which becomes increasingly critical.

3.4.3.3 **ENTSO-E Suggestions to Reach “European Green Deal’s” objectives**

In order to reach “European Green Deal’s” objectives, ENTSO-E suggestions are as follows:

- The large integration of renewable energy sources, mainly offshore wind and HVDC interconnectors are expected to achieve European Green Deal’s objectives. In order to support the interoperability for a secure



This project is funded by the European Union



operation of the future European energy system and the realisation of interaction studies for multi-vendor AC and multi-vendor multi-terminal DC systems, a standardised control interface for HVDC is required.

- Electrification of end-uses, digitalisation and smart sector integration will have an important role for the integration of an increasing share of renewable energy sources.
- In order to develop bold and agile innovation strategies to fast-track the integration of clean energy solutions, TSOs cooperation with policymakers, distributions system operators and stakeholders is required.

In this context, ENTSO-E has developed a Research, Development, and Innovation (RDI) Roadmap for 2020–2030. The ENTSO-E RDI Roadmap combines the opportunities provided by technological trends, the needs of TSOs arising from system operations and market evolution, and inputs from policy objectives of the European Commission and other stakeholders.

Three major areas for research, development and innovation and six European innovation flagships are defined for in deep electrification, enhanced grid use, control centre operations and interoperability as well as offshore development considering constraints such as environmental impact, permitting procedures, public acceptance, risk of stranded assets, etc²¹⁸.

The three major areas are as follows:

1. One System of Integrated Systems (OS); focuses on market expansion, through electrification sector coupling and integration, TSO-DSO interface, and the coordination of market players,
2. Power Grid (PG), the Backbone of the Energy System; Increased grid capacity and optimization as well as large-scale deployment of solutions and services with high Technology Readiness Levels (TRLs)
3. Cyber-Physical System (CPS); focuses on ensuring the technical soundness of the system in terms of digitalisation and inter-operability, including integration of power electronics and offshore developments.

The six flagships under the three major areas are as follows:

1. Optimise cross-sector integration to focus on significantly improving efficiency and flexibility as well as the reliability and adequacy of the energy system, requires that:
 - Markets for cross-sector integration are developed and coupled,
 - System operators and market parties have access to planning and optimization tools to develop and maintain an integrated system, and
 - The creation of an integrated system of governance.
2. Develop an ecosystem for deep electrification to focus on deep electrification of energy end uses, will require:
 - A new and comprehensive TSO-DSO interface to provide grid users with the best service,
 - New scenarios and modelling techniques, and
 - The development of new market concepts and ancillary services to integrate flexible new sources.

²¹⁸ ENTSO-E RD&I Roadmap, 2020-2030



This project is funded by the European Union



3. Enhance grid use and development for a pan-EU market, tools, algorithms, and control systems need to adapt accordingly to:
 - Enable enhanced Pan-EU powersystems,
 - Develop interoperable, integrated, and standardized platforms, and
 - Find new approaches to grid design and asset management.
4. Enable large-scale offshore wind energy, offshore grids and related advanced system models are needed, along with suitable new High Voltage Direct Current (HVDC) connections and improvements in the supply chain to scale up delivery. To meet these goals will require:
 - Thoughtful regulatory guidelines,
 - The development of interoperable hardware and software solutions for Direct Current (DC) grids and systems, and
 - Consistent attention to developing new HVDC technologies and materials.
5. Secure operation of widespread hybrid AC/DC grid, to overcome the technical challenges associated with the management of hybrid Alternating Current (AC)–Direct Current networks the following solutions are important:
 - Hybrid AC/DC power flow and system modelling,
 - Control, operation, and protection of hybrid AC/DC grids, and
 - Hybrid AC/DC systems to provide ancillary services.
6. Enhance control centres operation and interoperability, improved system monitoring and control capabilities through enhanced information and communications technology (ICT) infrastructure are needed. This requires focusing on:
 - The interoperability of control centres,
 - Enhanced control centre development and wide-area monitoring, and
 - The development of guidelines and tools to manage highly complex interoperated systems.

ENTSO-E expects that the realisation of the aforementioned flagships will benefit the whole energy value chain and TSOs will step up collaboration with universities, research institutes, equipment manufacturers, distribution system operators, digital companies, market participants, start-ups and consumers.

3.5 Smart Grid Regulations in Electricity Transmission: International Benchmark

The analysis of international experiences aims to extract relevant information necessary to know how smart grid regulations are implemented in selected European countries. We have analysed the regulatory approaches in use in each country but also the application of these practices by each TSO.

Consolidated descriptions serve as a benchmark on international practices related to regulations and tariff methodologies for smart grid activities in the electricity transmission sector. The following countries are considered in the analysis:



This project is funded by the European Union



- UK,
- Italy,
- Germany,
- France
- Sweden and
- Finland.

This recap helps us to design the most suitable smart grid regulatory recommendations for Turkey case.

3.5.1 UK

3.5.1.1 *Government Policies in Energy Sector*

In June 2019, Parliament increased the UK's existing commitment to an 80% reduction on 1990 emissions levels by legislating for a net zero greenhouse gas emissions target by 2050. Reflecting the different circumstances of different parts of UK, in September 2019 the Scottish Parliament legislated to set a net zero target for 2045, and the Welsh government intends to introduce legislation to amend its existing target to achieve net zero no later than 2050.

To meet the challenge of net zero, they try to urge, especially in decarbonising transport, heating, and industrial use of energy, consequently, it will require a huge increase in renewable and low carbon electricity. It is also necessary new technologies investments for an energy system which can continue to reliably supply energy when consumers need it. New technologies are also needed for better use of data and Artificial Intelligence (AI) to boost flexible demand.

UK Government sets the overall framework and policies for meeting its targets. In doing so it is necessary to make the highest-level decisions about how the costs of the transition to be met, and how to balance different objectives. Within that framework Ofgem, the energy regulator, has a crucial role to play in helping the UK decarbonise its economy – and, to protect the consumers in this transition. Ofgem regulates the energy network companies, the system operator, the functioning of the wholesale market and the energy suppliers. These companies and consumers themselves need to do things differently to meet the challenge of net zero: to rewire the electricity system, to move away from natural gas (without carbon capture and storage), to operate and plan differently, and develop new approaches to provide energy and energy services to consumers – especially those that enable consumers to use less energy and to use it at different times. Ofgem provides the regulatory frameworks and design and support market frameworks to enable this, to support innovation and protect consumers.

Ofgem's regulation aims to facilitate the most effective path to net zero at the lowest cost to consumers, in the context of government policy.

Due to the continuing fundamental change in energy sector, it is needed to evolve the regulatory and market arrangements to ensure protects and advances consumers' interests and enables them to benefit from innovation and new services. Ofgem sets out his strategy to regulation over the coming years in the context of the energy system transformation, and how his current and proposed activities fit within this.



This project is funded by the European Union



Ofgem's overall aim is to ensure a regulatory framework that drives innovation, supports the transformation to a low carbon energy system and delivers the sustainable, resilient, and affordable services that all consumers need.

Ofgem sets out his current priority actions to address the key challenges and opportunities that future changes could create for different aspects of the energy market and regulatory arrangements under the following subjects:

- Cross-cutting platforms to support the energy transition
- Balancing supply and demand at all times
- Efficient locational management and development of the energy system
- System coordination and the institutional framework
- Supporting innovation whilst ensuring good outcomes for consumers

3.5.1.2 **Electricity Transmission Sector**

In the UK,²¹⁹ the regulator Ofgem sets price controls – a ceiling on the amount companies can earn from charges to use the transmission networks. RIIO is Ofgem's performance-based framework to set the price controls. The current network price controls for Electricity Transmission (RIIO-T1) run from 2013-2021.

Transmission system operation (the SO) and transmission ownership (the TO) roles are separated in the UK. There are 3 licensed Transmission Operators (TOs) and 12 Offshore Transmission Operators (OFTOs) in UK. These operators can develop, operate and maintain the high-voltage system within their own geographical transmission areas, and own OFTO assets. There are various conditions on TOs in the Standard Licence Conditions, which are specific to security of supply.

The three TOs are:

- National Grid Electricity Transmission plc (NGET) for England and Wales
- Scottish Power Transmission Limited (SPT) for Southern Scotland
- Scottish Hydro Electric Transmission plc (SHET) for Northern Scotland and Scottish Islands Groups.

A legally separate electricity system operator (NGESO) was established within National Grid Group, separate from NGET in April 2019.

There are limited duties on Ofgem to encourage innovation in terms of the statutory framework, however the duty to encourage innovation is likely implicit in the more general duties on Ofgem to ensure that it secures the efficient and economic execution of activities by licensees.

3.5.1.3 **Background on Smart Grid Vision**

Ofgem has published a "Smart Grid Vision and Routemap" report in 2014 to continue to invest in smart technologies in the near term and integrate them into existing networks; and to maximise the economic and commercial benefits for the country as a whole. This report was not revised later on, but "Smart Systems and Flexibility Plan", explained in below section, was published July 2017 by HM Government and Ofgem.

²¹⁹ www.ofgem.gov.uk



This project is funded by the European Union



The Smart Grid Forum's vision for UK's smart grid was²²⁰: "A smart electricity grid that develops to support an efficient, timely transition to a low carbon economy to help the UK meet its carbon reduction targets, ensure energy security and wider energy goals while minimising costs to consumers. In modernising our energy system, the smart grid will underpin flexible, efficient networks and create jobs, innovation, and growth to 2020 and beyond. It will empower and incentivise consumers to manage their demand, adopt new technologies and minimise costs to their benefit and that of the electricity system as a whole."

A significant progress has been succeeded in UK for deploying smart grids through a range of work and initiatives, including Ofgem's new RIIO Price Control model that places greater emphasis on supporting network innovation and the creation of the Low Carbon Networks Fund, which provides funding for network company innovation projects that test and trial new smart grid technologies and solutions. The Vision and Routemap reflects on the implications of the development of smart grids for the energy system as a whole but is primarily focused on the distribution network where most action is needed at this stage. Therefore, just following item is relevant for the transmission system:

- Provide the strategic direction on the future of the electricity system and value of smart grids, through for example: strengthening further the underlying evidence base and the analysis of the economic benefits of smart, particularly for wider energy systems such as heat; implementing key Government policies like Electricity Market Reform (EMR); and developing strong network operator leadership in rolling out successful smart grid pilots into business as usual solutions.

The diagram below outlines the role and relationships between different elements of the smart grid as it evolves incrementally to enable whole energy system integration.

²²⁰ Smart Grid Vision and Routemap

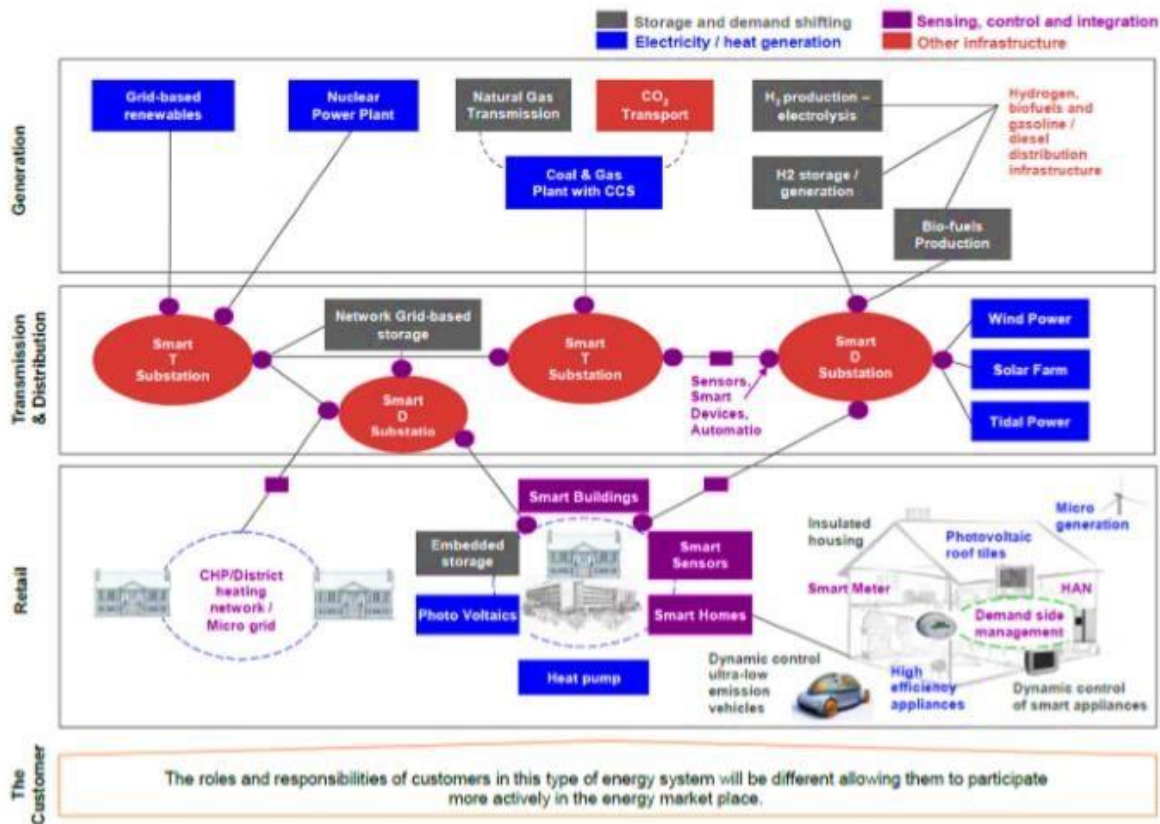


Figure 53: Role and Relationships Between Different Elements of the Smart Grid

Regulatory Framework:

Network operators, suppliers and regulators need to facilitate low carbon deployment in generation, supply and consumption, while ensuring security of supply. The system is becoming much more complex as the need to balance supply and demand at local levels intensifies and there is a need for technologies that enable the intelligent control of the network, including a much greater role for storage.

Investment will be required in the short-term to develop these systems in order to start preparing for the projected take-up of low carbon technologies. Existing regulatory and commercial frameworks need to evolve to incentivise this investment, while at the same time, ensure that all stakeholders (network operators, suppliers, generators and consumers) are able to participate fully in the deployment of smart grids and that benefits are fairly distributed along the value chain. They need to enable the introduction of new consumer incentives, for example, time of use tariffs, which encourage consumers to use energy at times of the day when it is cheaper to do so (e.g. off-peak).

Following progress has already been made:

- The Low Carbon Network Fund was introduced in 2010 to encourage network companies to sponsor projects, which trial innovative technological operating and commercial arrangements, to facilitate the transition to a low carbon future.



This project is funded by the European Union



- Ofgem has introduced the new RIIO framework to enable transmission networks to help deliver a low carbon UK
- The Smart Grid Forum is considering the commercial and regulatory barriers to the deployment of smart grids in UK and working with a wide range of stakeholders
- The Smart Grid Forum is considering how scalable commercial models for non-firm connections (i.e. where connected parties sign up to interruptible connections) can be rolled out across UK, as a means of speeding up connection times and helping to avoid the need for network reinforcement.
- The Energy Network Association (ENA) has worked to revise Engineering Recommendation to make it clear that demand side response can be taken into account as an alternative to network reinforcement, whilst maintaining security of supply.
- The ENA has formed a working group to propose models of how DSR can be 'shared' across network companies in the first instance with a view to outline how such a model could work across all interested parties e.g. suppliers, aggregators, DNOs, Transmission Owners, and National Grid.
- Department for Business, Energy & Industrial Strategy, BEIS (Former DECC) has chosen a market-wide Capacity Market open to parties who are able to provide reliable capacity, including DSR and storage. Designing a cost-effective network for net zero, the network price controls are among the key regulatory tools that Ofgem tries to facilitate at lowest cost to consumers. They enable Ofgem to directly fund the networks to efficiently deliver the infrastructure that will support a decarbonised future; support innovation projects to develop and prove new solutions; and incentivise new ways of working that will deliver sustainable outcomes for consumers and wider stakeholders. Ofgem's price controls are set under RIIO (Revenue = Incentives + Innovation + Outputs) regulatory framework and determine the revenues networks can recover as part of energy bills, so that consumer interests are protected. The cost of operating, maintaining, and strengthening these networks is significant. This currently averages around £12.5 billion each year.
- Currently these network costs amount to about a quarter of total consumer costs of gas and electricity to reach to net zero in the short term. The next price control (RIIO-2) periods run from 2021 to 2026 for gas distribution and electricity and gas transmission, and from 2023 to 2028 for electricity distribution. These years are expected to see fundamental changes to meet net zero at lowest cost. It is foreseen that embedding coordination and flexibility into the design of the RIIO-2 price controls is important to provide for a level playing field between traditional network reinforcement options and potentially lower cost flexible solutions, such as storage and demand-side response. In addition, a suite of net zero investment and innovation mechanisms, including the strategic network innovation fund and a new net zero reopener will be introduced to enable key developments in regulatory policy or technology to be reflected flexibly in the price controls.
- BEIS, Ofgem, the ENA and network operators are working together to help shape the new European Network codes being developed as part of the Third Energy Package²²¹ to ensure they reflect the needs of United Kingdom's networks.

²²¹ Third Energy Package is replaced by Clean Energy for all Europeans Package





This project is funded by the European Union



3.5.1.4 **Investment Mechanism**

The main mechanism to ensure the delivery of appropriate investment in the transmission network is through the RIIO (Revenue=Incentives+Innovation+Outputs) model. RIIO-T1 price control decisions are built on a traditional RPI-X model. The SOs and TOs submit business plans to the NRA for assessment and approval. Ofgem's criteria and methodology for outputs assesses the proposed investment projects in a TO's business plan in terms of Reliability, Wider Works, and Innovation.

Overall revenues that TOs can recover are limited through a cap, implemented via a licence condition on TOs, on the maximum revenue that may be recovered through the TO's Transmission Network Charges. A similar condition operates in respect of SO revenue restrictions for NGET. Both conditions contain the detailed formula by which revenue maximum revenue is calculated for the year. The variable inputs (such as Corporate Debt Expenditure) are updated through an ongoing Annual Iteration Process, with such iterations being executed through Directions issued by Ofgem to TOs/SOs under the Special Conditions.

TOs propose projects as part of their business plan, Ofgem examines carefully and approves the investment plan, setting the maximum recoverable revenues that TOs can charge to deliver the approved plan. TOs then fund this by preparing a statement setting out their charges (one for each TO) that is to be consistent with the revenue caps that Ofgem set, and which is ultimately approved by Ofgem. In this way, development of the transmission network is ultimately paid by end-user customers, as the retail charge for electricity includes transmission charges as a cost component of this.

Allowed revenues are capped but mechanisms are in place, which allow for potential uncertainties identified in SO/TO business plans. These are tightly defined and include incentive arrangements that set percentages of under/over recovery of revenues that SO/TOs absorb and what levels of additional cost/savings are passed on to consumers. A key element is the defined 're-opener' mechanisms, which are specific circumstances where TOs can request Ofgem to review of costs considering certain specified events. For example, for RIIO-T1 categories include the possibility of re-openers for SO/TOs spend on security enhancement to support security of supply, and also the ability to apply for a revenue adjustment mechanism for innovation projects, that enables companies to apply for additional funding within the price control period for the rollout of initiatives with demonstrable and cost effective low carbon or environmental benefits.

The TO licence contains criteria regarding security of supply. Standards are not fixed and can change over time. The TSO also has an obligation to undertake an annual Network Options Assessment report. This report contains a CBA of proposed investments, including proposed system reinforcements for security of supply. In general, SO/TOs can invest whatever they want. The NRF is considered quite clear and accommodating to new investments. Stakeholders also note that the security of supply has priority and considered as high level.

For the interconnection investments:

- Companies can prefer for a regulated application to Ofgem where a project is approved, and revenue is protected/restricted through a Cap and Floor regime to the price they can receive for the energy supplied. Through the cap and floor approach, developers identify, propose, and build interconnectors and there is a cap and floor mechanism to regulate how much money a developer can earn once in operation. Cap and floor regime duration is 25 years, and actual revenues earned are assessed against the cap and floor levels every 5 years, with the ability for interconnectors to request within-period adjustments. This approach is intended to be a risk sharing mechanism between customers and developers or,



This project is funded by the European Union



- Companies can build such assets outside of the regulated route but do so entirely at risk without regulatory backstop.

Most of the Projects of Common Interest would likely include the cap and floor regime.

Current Incentives²²²:

In coherence with changing in UK's energy mix, the gas and electricity networks operational needs are also changing. Ofgem provides essential backing to innovative projects which aim to help make the energy networks smarter, accelerate the development of a low carbon energy sector as well as deliver financial benefits to consumers. The projects help develop crucial knowledge and expertise which is being shared across the industry.

As part of the RIIO-T1 and RIIO-GD1 price controls Ofgem introduced a Network Innovation Stimulus. The Stimulus includes two annual Network Innovation Competitions (NICs) one for electricity transmission companies and one for gas network companies.

Through the NICs these companies compete for funding for the research, development, and demonstration of new technologies, operating and commercial arrangements. Funding is provided for those innovation projects which meet Ofgem's evaluation criteria. Ofgem's review and assessment of the projects are supported by three independent expert panels.

Current Funding:

Ofgem introduced the Electricity Network Innovation Competition (NIC) as part of the RIIO price controls.

The Electricity NIC is an annual opportunity for electricity network companies to compete for funding for the development and demonstration of new technologies, operating and commercial arrangements. Funding provides for the best innovation projects which help all network operators understand what they need to do to provide environmental benefits, reduce costs, and maintain security as United Kingdom (UK) moves to a low carbon economy. Up to £70M per annum is available through the Electricity NIC.

Through the 2019 process, Ofgem awarded two electricity NIC projects: WPD's DC Share and SSEN's Resilience as a Service. The projects in the 2019 Funding Decisions are below.

1. Proteus (National Grid Electricity Transmission): Project aims to develop and demonstrate a transmission-connected 50MVA virtual synchronous machine (VSM) STATCOM controller in partnership with a supplier, building on recent research and development and bridging the current technology gaps.
2. RICA (National Grid Electricity Transmission): The project aims to develop and demonstrate a lower cost reinforcement solution by retrofitting insulated cross-arms to overhead lines, allowing an increase in voltage rating on existing towers.
3. Category Examples of solutions New transmission lines based on innovative technology or change of technology of existing lines:
 - New HVDC lines (allow to control the power flow; less expensive for long distance transport; undergrounding less complex),

²²² <https://www.ofgem.gov.uk/electricity/transmission-networks/network-innovation>



This project is funded by the European Union



- Replacement of HVAC by HVDC lines (less complex and less expensive; more compact design),
 - Underground cables or GIL (more expensive than OHL but can help improving public acceptance and accelerate the authorisation process),
 - Design of overhead line poles (can help improving public acceptance and accelerate the authorisation process),
 - Replacement of conventional overhead line conductors by high-temperature conductors (more expensive than conventional ones but can allow to provide additional capacity at a lower cost level and more quickly than by building completely new lines).
4. Introduction of dynamic capacity rating with the aim of utilising existing transmission lines or transformers at higher levels:
 - Spectrum of technological options ranging from a differentiation of rating levels according to fixed time intervals (e.g. seasonal or time-of-day) down to online monitoring of equipment temperature and adaptation of capacity rating in real-time operation.
 5. Installation of power flow control components in order to better adapt power flow patterns to capacities and topology of the existing grid.
 - Phase-shifting transformers,
 - Semiconductor-based FACTS elements (including HVDC converters).
 6. Investment into components contributing to ancillary services provision (reactive power / voltage control, short-circuit power, momentary power reserves and black-start capability),
 - Purely phase-shifting generators (offer operational flexibility and can serve to improve cost efficiency),
 - FACTS elements (see above). New or extended power system control and automation technology with the aim to lower the risk of disturbances threatening security of supply,
 - Improvements in observability and controllability based on conventional sensor and actor devices,
 - Wide-area measurement systems (aiming at synchronously measuring power phasor angles at the grid nodes to improve observability),
 - Real-time dynamic security assessment tools (aiming at observing stability phenomena beyond static voltage/current measurements).
 7. Category examples of solutions partial automation of system operation processes aiming at better utilisation of existing grid capacities Automatic switching of network devices (in connection with adaptive protection schemes) or of generation-side or demand-side flexibilities in case of grid component outages in order to reduce the demand for (n-1) capacity reserves. Improvement of approaches to curative congestion management providing the possibility to operate systems closer to their technical limits and/or to improve security of supply
 - Generation-side flexibilities (especially renewables),
 - Demand-side flexibilities (DSM/DR),



This project is funded by the European Union



- Storage components; and
- Technologies coupling the electricity sector with other sectors (gas, heat, traffic).

3.5.1.5 *Smart Systems and Flexibility Plan*

The Government and Ofgem have set out a Plan in July 2017 to enable the development of a smart, flexible energy system to reduce costs for consumers and industry and support the growth of innovative new businesses.

In UK, the System Operator, transmission owners, distribution network operators, generators, suppliers, aggregators, technical companies, Local Enterprise Partnerships, local authorities, community energy groups, and consumer groups, amongst others, are already considering the challenges and opportunities smart technologies bring. This Plan maps out how stakeholders want to work together on this transition. More widely, they recognise that smart energy is central to many other changes in energy system and the wider economy. It is an important part of the Industrial Strategy, given its potential to reduce energy costs, increase productivity, and increase export smart energy technology and services to the rest of the world. It is a central part of how power sector can be decarbonised, in compliance with the Government Clean Growth Plan.

Security of supply is vital. A smart system can deliver energy security at a lower cost than would otherwise be the case. As new smart technologies and solutions emerge, the System Operator and the energy market will have a more diverse range of options for balancing supply and demand. At the same time, it is essential that a smart system remains a secure system. A smart system will need to mitigate new risks, such as cyber risks, because it will be more complex and more driven by data and communication technologies.

The actions proposed in the plan are designed to work together with different potential approaches to long-term heat decarbonisation, including greater electrification. Finally, a smart energy system is part of the Government's wider Digital Strategy, as it uses digital technology and data, improving the energy system's integration with related systems, e.g. heat, transport, utilities and buildings.

In parallel with this work, Ofgem has set out a number of complementary work streams in its Forward Work Programme²²³ which support the aims of this Plan and interact with the actions. These include the regulatory framework for the future energy system, future System Operator incentives, and a Targeted Charging Review.

Innovation has been developing in the T1 period into T2 plans, and to be continued to innovate utilising advanced asset management capability. Total plan cost for this priority is 14% lower as a result, passing on £707m cost savings to consumers. Ofgem also have a stretching additional £27m forward looking efficiency on protection & control, rolling out smart ways of working into further assets types.

Innovation applied to T2 plan Description Saving £m Reducing the cost of replacement – through smart interventions with the supply chain, to develop innovative solutions to address the life limiting components of protection and control systems. This has enabled:

- Replacement of “the brain”, retaining associated infrastructure including complex plant wiring
- Warranty and support periods provided by suppliers, similar to that of replacement sites
- Less time on site, less resource required, reducing cost

²²³ https://www.ofgem.gov.uk/system/files/docs/2017/03/ofgem_forward_work_programme_2017-18.pdf



This project is funded by the European Union



- Outage times shortened with benefits of reduced system risk and increased system security and reliability

3.5.1.6 **Designing a cost-effective network for net zero²²⁴:**

The network price controls are among the key regulatory tools that Ofgem has to facilitate net zero at lowest cost to consumers. Ofgem will enable directly fund the networks to:

- Efficiently deliver the infrastructure to support a decarbonised future,
- Support innovation projects to develop and prove new solutions; and
- Incentivise new ways of working that will deliver sustainable outcomes for consumers and wider stakeholders.

Ofgem will use these price controls to deliver the network changes that are needed to achieve net zero. Ofgem will ensure that networks continue to connect the low carbon technologies required to meet climate change targets and maintain high levels of reliability, while ensuring that network capacity is not increased unnecessarily or at high cost. Ofgem's price controls are set under our RIIO (Revenue = Incentives + Innovation + Outputs) regulatory framework and determine the revenues networks can recover as part of energy bills, so that consumer interests are protected. The cost of operating, maintaining and strengthening these networks is significant. This currently averages around £12.5 billion each year, a figure which is likely to increase in the short term to move net zero target. Currently these network costs amount to about a quarter of total consumer costs of gas and electricity. The next price control (RIIO-2) periods run from 2021 to 2026 for gas distribution and electricity and gas transmission, and from 2023 to 2028 for electricity distribution. These years are expected to see fundamental changes to meet net zero at lowest cost. The route that is taken to decarbonise will depend on government policy, technological developments and consumer behaviour as well as regulatory policy choices. The CCC has advised that government must take some key decisions, in particular on the future of heat, in the mid-2020s. Ofgem also acts together with others, including local and regional governments. Ofgem, therefore, recognise the importance of embedding coordination and flexibility into the design of the RIIO-2 price controls. These price controls will provide for a level playing field between traditional network reinforcement options and potentially lower cost flexible solutions, such as storage and demand-side response. Ofgem will retain the approach of previous price controls to allow to reopen the price control with uncertainty mechanisms in response to major system or policy changes. In addition, Ofgem will introduce a suite of net zero investment and innovation mechanisms, including the strategic network innovation fund and a new net zero reopener, that can help to enable key developments in regulatory policy or technology to be reflected flexibly in the price controls. These would allow for net zero-related actions to be put into place in the price controls at any time, rather than just during the preparatory phase prior to the start of each control period.

3.5.1.7 **Brexit**

The UK withdrew from the European Union as of 1 February 2020. The Agreement on the withdrawal of the United Kingdom of United Kingdom and Northern Ireland from the European Union and European Atomic Energy Community entered into force on the same date²²⁵.

It provides for a transition period which will end on 31 December 2020. During the transition period, Union law, with a few exceptions, is applicable to and in the UK.

²²⁴ Ofgem Decarbonisation Action Plan

²²⁵ Decision amending Regulation (EU)2018/1999 on the governance of the energy union and climate action for the withdrawal of the United Kingdom from the EU



This project is funded by the European Union



For the purposes of Union law applicable to it during the transition period, the UK is treated as an EU Member State, but will not participate in EU decision-making and decision-shaping.

3.5.2 Italy

Terna S.p.A. is the Electricity transmission and dispatching activities company in Italy. Terna is the only TSO of the national high-voltage network although less than 1% of the network are owned by other parties. Authority for Energy, Networks and Environment (ARERA) is the independent regulatory body for energy markets in Italy.

Terna has to submit a Development Plan to the Ministry for getting approval, after taking account of the assessments of the Authority for Energy, Networks and Environment (ARERA). The document is prepared each year, and which includes all the development activities undertaken, or to be undertaken, to the Transmission Network. This development plan is a modern and up to date plan which includes integration of renewable sources, improvement in service quality and resilience, the development of interconnection capacity, the end of network congestion and connection works to the national grid.

The main targets are follows:

- Reduction in CO₂ emissions
- Reduction in congestion for approximately
- Greater exchange capacity with other countries
- Greater capacity of power from renewable sources

ARERA has no specific duty to encourage smart grids, but it participates in the approval process for the 10-year Development Plan for the national transmission network shall make that plan public. In the case of smart grid solutions that are regarded as promising, the ARERA may value the possibility of an initial support, including specific incentives. In any case, the possibility to define specific incentive rules for smart grid projects is not an automatic process and the results in any case uncertain. In addition, ARERA also controls and assesses the implementation of the 10-year Development Plan of ENTSO-E. ARERA controls the ENTSO-E's plan with cooperation with the Agency for Cooperation of Energy Regulators (ACER).

Although the TSO have no certain duties regarding the application of smart grid solutions, the TSO has developed a specific "Innovation Plan" which includes also smart grid projects.

That plan is not only a collection of projects but also includes partnerships with different actors (universities, industries, other TSOs and DSOs etc.). there are 6 other groups which is shown below except smart grid in this plan:

- a. Transmission Technologies,
- b. Electric Power System Operation,
- c. Grid & Markets Development,
- d. Storage,
- e. Business improvement,
- f. Sustainability



This project is funded by the European Union



The smart grid projects usually approved and incentivized by the NRA for learning that in the end might result in a cost reduction and/or in better and faster implementation of future applications. For this reason, TSOs prefer smart grid projects that result in an OPEX increase.

The main mechanism for investments is the tariff which is set by ARERA. The tariff system aims to create a balance between the costs of maintaining and developing the network and the remuneration of that services. Terna supervises the control of the entire high and very high voltage transmission network and dispatches electricity throughout the national territory. The tariff is determined by providing of this service results in a dispatching cost to which all customers contribute through the payment of fees for the dispatching applied to the electricity drawn from the network. explicit regulatory support for specific technologies in Italy is WACC Premium.

According to the current framework OPEX and CAPEX have very different regulatory treatments:

- OPEX are recognized through a typical profit-sharing mechanism, which provides strong incentives for efficiency. OPEX level is taken every 4 years and it is used as a basis for the next 4 years period,
- CAPEX is remunerated via through a RAB based mechanism with smaller incentives for cost reduction. classic as well as smart grid projects and solutions have the same WACC, generally.

3.5.3 Germany

TenneT TSO GmbH, Amprion GmbH, 50Hertz Transmission GmbH and TransnetBW GmbH are the electricity transmission systems operators ("TSOs") in Germany. Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen, "BNetzA") certifies TSOs to provide compliance with applicable requirements. In addition, calculation of revenue allowances for TSOs is based on the Ordinance on Incentive Regulation (Anreizregulierungsverordnung, "ARegV").

BNetzA is an authority for electricity TSOs at a national level. In federal states, there are also state regulatory authorities which are responsible for regulating energy supply companies whose networks are inside the federal region's borders with fewer than 100,000 customers. All regulatory tasks and powers are included the German Energy Industry Act (Energiewirtschaftsgesetz, "EnWG") which is the main pieces of legislation in the electricity sector.

All TSOs are responsible to submit an onshore national network development plan (NDP) to BNetzA every two years. TSOs which connect Offshore Wind Farms (OWF) to the transmission network, i.e. TenneT TSO GmbH and 50Hertz Transmission GmbH, are also responsible to prepare a separate offshore network development plan which contains development of the offshore connection lines for the next ten to fifteen years.

In Germany, there is no certain duty to encourage smart grid. ARegV is technologically neutral and fosters smart grid projects indirectly only specific research and development costs. The regulation is also neutral regarding project categories, such as innovative or conventional, PCI or non-PCI. Although BNetzA has also no certain duty to encourage smart grid, the regulatory landscape includes implicit powers and duties of BNetzA to encourage smart grid projects which provided economic efficiency. These power and duties of incentive regulation creates implicit incentives for TSOs to develop smart grid projects in order to reduce their actual costs. BnetzA also approves the projects falling under the investment measure regime by primarily looking at the project reason rather than the cost.



This project is funded by the European Union



In the German Regulation, there is also no definition or mention for smart grid. Nevertheless, Smart grid projects are separated three types of projects:

- Smart grid projects resulting in lower costs for the TSO,
- Smart grid projects falling under the investment measure regime.
- Smart grid projects resulting in higher costs for the TSO, but also resulting in benefits to the society that are not taken into account sufficiently.

In onshore side, regulation is directed for applying to the high-voltage direct current technology could be considered as a smart grid. In offshore side, the smart grid has been promoted for offshore wind generation.

All of the future plans of the electricity sector in Germany are merged in a national framework as called as Energiewende. Energiewende, one of Germany's most important projects, aims to convert country's energy supply to renewable energy resources. Energiewende also aims to increase energy efficiency. In this way, Germany is playing a major role in climate protection. Germany plans to convert to 100% renewable energies by 2050, by considering targets and using a roadmap. Other purposes of the Energiewende is followings; reduce global CO2 emissions, limit global warming and create a secure, sustainable and affordable energy supply. Some of the main topics of the Energiewende is are following;

- Energy Efficiency
- Renewables
- The Power Grid
- The People and The Energiewende
- Costs
- Employment and The Economy
- Mobility
- Climate Protection
- Storage
- The Global Energy Transition

In Germany, the regulatory principle is characterised as incentive-based revenue cap mechanism. The actual costs of TSOs are separated from network tariffs in the regulatory period. This situation creates incentives for the TSOs to use efficiency gains. Although, the regulation implicitly incentivises the TSO to invest in smart grid causing in lower cost in the regulatory period, incentives might be reduced for long-term cost reductions because efficiency gains must be passed on to consumers in the next regulatory period. Hence, TSOs have less incentives for investing smart grids with times exceeding one regulatory period even if they result in major advances.

The Bnetza approve capital and operating costs (usually equals 0,8 % of the costs of the assets) of investment measures required for the expansion or restructuring of transmission systems. the costs are reflected in the revenue cap already during an on-going regulatory period. Only thereafter an ex post control takes place by means of an as-is-evaluation. Any deviations between planned and actual costs will be recognised in the regulatory account.



This project is funded by the European Union



Investment measures primarily focuses on CAPEX. In addition, also a certain share of OPEX is approved as investment measure. CAPEX will be accepted assuming they are 100% efficient for a certain period of time. After that, they will be integrated into the regular cost base level and could be cut through efficiency regulation. Each approved investment measure receives a fixed allowance of OPEX.

3.5.4 France

The CRE (Energy Regulatory Commission) regulates the French electricity market. The CRE has not only a regulator role but also an advisory role with the power to make proposals and give opinions. RTE which is an independent TSO owns and operates the electricity transmission network in France since 2000.

RTE prepares each year a 10-year Network Development Plan which is submitted to the CRE for its approval and amendments. The 10-Year Plan includes the main transmission infrastructure which needs to be built or upgraded over the next ten years and also contains investments already decided, and new investments to be implemented within three years. In addition, this plan complements, at a national level, the European 10-year Network Development Plan implemented by ENTSOE. CRE examines the 10-Year Plan submitted by RTE every year and consults the ACER for approving the plan and decides that RTE to or no modify this plan.

If RTE does not implement approved smart grid projects investment in the 10-Year Plan within the period of three years, the CRE may require RTE to execute the investment or call for a tender to implement the investment.

The regulator's main mechanism to ensure to provide of appropriate investment in the transmission network is the economic regulation process through price control (TURPE). However, there are no particular duties of the CRE to directly encourage smart grid projects, the TURPE tariff also serves as an incentive to control costs. The main incentive measure for smart grid investments as well as other investments is the way CAPEX are dealt with at the time of setting the tariff. RTE's capital cost differentials between forecast and actual costs are now 100% covered by the tariff through the CRCP, which is likely to limit the incentive for TSOs to control their investment costs. However, overruns beyond approved investment expenditure will not be compensated. for Smart grid Projects which exceed 30 Mio. € must be presented to an external expert to set the budget and incentives.

Smart grid investment expenditures are entirely covered in TURPE. Tariff also strengthens financial performance incentives and gives to RTE the opportunity to obtain additional budgets for financing smart grid projects. Smart grid development is also courage by TURPE that extra (minor costs) charges is offset. CRE seeks to establish a balance though price control. Investments of smart grid nature have to be efficient. in the event that RTE spends more than the allowed budget, the difference will not be covered by the CRCP. In addition to the tariff, wide smart grid projects are separated smaller parts for limiting the risks in early stage of smart grid project.

RTE have certain duties for innovative and smart grid solutions. These are as follows:

- Technological change: offering new technical development solutions by fostering the emergence of new components
- Digital change: development of methodologies to facilitate maintenance, optimization and contributing to the development of smart networks

The regulatory principle is described as incentive-based revenue cap with pass through elements. The treatment of CAPEX encourages effective smart projects. There is a statutory objective to offer new technological solutions and develop methodology for optimization and development of smart networks. for this reason, in tariff, there are



This project is funded by the European Union



incentives for smart grid projects in CAPEX. Also, the TSO can recover smart grid projects costs via the TURPE tariff mechanism and can gain additional budgets for these projects subject to a cost-benefit analysis.

3.5.5 Sweden

The Legal Framework for transmission system in Sweden is mainly comprised by the Electricity Act. The regulatory responsibility within the sector is divided between three government agencies;

- The Swedish Energy Markets Inspectorate is the main regulatory body. According to the act, The Swedish Energy Markets Inspectorate are network authority. It is also responsible for determining the revenue cap and electricity market.
- The Swedish Energy Agency is the administrative authority responsible for regarding supply and usage of energy. This is also responsible for ensuring security of supply and promoting research and innovation within the energy sector,
- Svenska Kraftnät is sole TSO in Sweden. Svenska Kraftnät is also co-owner of Energiforsk AB. This company is implementing and coordinating research and development within the energy sector.

Svenska Kraftnät has to implement necessary investment projects for fulfil the regulatory duties. The TSO is also responsible for deciding which projects are necessary according the duties which are determined by regulation and government. Svenska Kraftnät Regulation promotes research and development of new techniques. On the other hand, Government directions are set once a year and specify the objectives to be focused on for the upcoming period. TSO prepares Network Development Plans, System Development Plans and other development plans for the transmission network by considering ENTSO-E's Ten-Year Network Development Plan.

TSO establishes a research and development plan which is divided into four areas for every three-year period. These areas;

1. New techniques: Developing new techniques and knowledge for operational security, cost efficiency, and an environmentally sustainable network,
2. Future electricity systems: Managing future challenges and issues,
3. Maintenance and planning: Surveillance and control of the transmission system for improving the forecast models,
4. Security of competence: Ensuring future long-term security of competence.

The Inspectorate has limited duties to encourage new technology projects and does not directly encourage smart grid projects. The revenue cap may indirectly fund smart grid projects. On the other hand, The Swedish Energy Agency support development of new technologies directly by funding these projects.

The Inspectorate has no certain duty for involvement in the financing of investments, but TSO's revenue cap is determined by Inspectorate. If the combined revenues exceed the revenue cap by more than five percent, revenue cap shall be reduced by amount of exceeding part for the following period. The revenue cap can be adjusted during or after the supervisory period. TSO can also apply for reconsideration and the Inspectorate may change the revenue cap independently if there are special circumstances caused to increase or if TSO has submitted inaccurate or insufficient information. There are certain aspects of the revenue cap for investments in new technology. Revenue cap may be calculated without assets that are not necessary for the network operations for incentivizing



This project is funded by the European Union



to investments in new network infrastructure. The TSO's investments in new technologies are financed also investment grants and congestion revenues.

The Inspectorate considers the quality and efficiency of the network operations for deciding the revenue cap which is based on OPEX. The OPEX is separated into two categories, these are costs that the TSO can affect and costs the TSO does not have any effect over such as losses and some certain fees etc. The operational costs which the TSO can affect are based on historical costs and these costs are considered with efficiency requirement. For this reason, full costs may not include in the revenue cap by Inspectorate if operations could be implemented more efficiently. The CAPEX does not base on regulated efficiency requirements. In addition, if the combined revenue exceeds or falls short of the revenue cap during the period, following period's amount shall increase or decrease the cap. When calculating capital costs, the depreciation period corresponds to the economical lifespan of the asset.

3.5.6 Finland

The primary pillars of Legal Framework for electricity transmission sector in Finland, are the Electricity Market Act and Act on the Monitoring of the Electricity and Gas Markets.

The regulatory responsibility within the electricity sector has separated between three government agencies:

- The Ministry of Economic Affairs and Employment – Government's role is limited to developing the electricity market
- The Energy Authority (EA) is the regulator for the electricity market. EA administers a licensed regime for the electricity market, which is created by the Monitoring Act. The EA gives licenses and monitors compliances of the requirements of the licenses. EA also regulates in economic regulation through reasonable return which is a "Rate of return" financing mechanism.
- Fingrid Oyj (Sole TSO) is the owner and operator of the transmission network. Fingrid is responsible for operation, maintenance, renewal and development of the transmission network.

The TSO submit a ten-year development plan, which is updated every two years. The development plan must be based on ENTSO-E's TYNDP. The TSO must publish the plan after stakeholders' comments. Interconnectors investments which are part of the TYNDP must be submitted to not only EA but also Ministry of Economic Affairs and Employment. Ministry of Economic Affairs and Employment set up a working group tasked with investigating the possibilities of smart grids in the electricity market. The group prepares a report about their studies.

EA has not any certain duties for encouraging smart grid projects. The Tariff contains smart grid incentives. EA encourages smart grid projects by allowing for the deduction of up to 1% of project costs when calculating adjusted profits. Costs included in the smart grid incentives must be related to defined projects which create new knowledge, technology, products or methods of operation in network operations. Accepted incentives must be public so they can be used by the sector as a whole.

The EA conducts the TSO's regulated profits in accordance with a regulatory methodology. Prices are adjusted accordingly during the regulatory period. The EA calculates reasonable return which based on TSO's submitted information for each year of eight years period. Current tariff covers the regulatory periods 2016-2019 and 2020-2023. Tariff is calculated by applying the regulated asset value to WACC and comparing to profit. EA confirms possible surplus / deficit in related with reasonable return at the end of the period and following tariff is adjusted by considering that. Tariff has a number of incentives in place, which the TSO can benefit from. Incentives are about investments about network and new technology. There are no requirements to meet performance standards in



This project is funded by the European Union



tariff. The network investments incentive is calculated as the difference between regulatory which is calculated as the annual straight-line depreciation over its selected regulatory lifetime and accounting depreciations so that incentive is not considered as an “incentive” , but rather as recovery of accelerated depreciation. Smart grid projects are generally CAPEX based solutions.





This project is funded by the European Union



3.5.7 Recap of EU Countries

Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
Incorporation of smart grid costs to TSO revenue determination (Is there any pre-defined ratios, what are considered as CAPEX, what are considered as OPEX)	£12.5 billion each year for Gas and Electricity Networks	Smart grid investments are not considered different than other investments which have same WACC system.	Smart grid investments are not considered different than other investments.	Smart grid investments are entirely contained as well as RTE's other investment expenditures by tariff. (TURPE)	Smart grid investments are not considered different than other investments of Svenska Kraftnät.	Smart grid investments are not handled different than other investments of Fingrid.	For R&D there is pre-defined ratio (1% of TEİAŞ' system usage revenue), but, for smart grid investment there isn't. Smart grid investments are not considered different than other conventional investments which have same WACC system.



This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
Are there incentives by NRAs to encourage TSOs for roll-out/deployment (operational use) and large-scale pilot trials? If yes, what are the mechanisms/rules/principles used?	Yes, there are through RIIO price control mechanism. The SOs and TOs submit business plans to the NRA for assessment and approval. Ofgem's criteria and methodology for outputs assesses the proposed investment projects in a TO's business plan in terms of Reliability, Wider Works, and Innovation.	ARERA has no certain duty to encourage smart grid projects, but NRA has ability to set some targets regarding smart grid projects which are efficient. For smart grid solutions, the ARERA may value the possibility of an initial support, including specific incentives which are decided individually for each project. There is no definite incentive.	BNetzA has no certain duty to encourage smart grid projects. BNetzA creates implicit incentives for TSOs over the network tariffs. This incentivises are used to reduce actual costs of investments (which are deemed necessary or efficient by BNetzA) by TSOs but these efficiency gains must be passed on to consumers in the next period.	TURPE gives to RTE to obtain additional budgets for financing smart grid projects if confirmation of its feasibility which is based on cost-benefit analysis. For this reason, CRE allows a budget to RTE in order to promote smart grid projects.	The Inspectorate has limited duties and does not directly encourage to smart grid projects. The revenue cap may indirectly fund smart grid projects. On the other hand, The Swedish Energy Agency support development of new technologies directly by funding these projects.	Although EA has not any certain duties for encouraging smart grid projects, The Tariff contains smart grid incentives. Tariff encourages smart grid projects by allowing for the deduction of up to 1% of project costs when calculating adjusted profits. Costs included in the smart grid incentives must be related to defined projects which create new knowledge, technology, products or methods of operation in network operations. Accepted incentives must be public so they can be used by the sector as a whole.	EMRA has no certain duty to encourage smart grid projects. EMRA doesn't have any mechanism for assessment and approval of TEİAŞ' Yearly Investment Program. This yearly investment program is subject to approval of the presidential strategic investments' unit.



This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
Relation between energy policies and regulatory frameworks for smart grid roll-out. (Example: governments set RES targets and NRAs defines the relevant regulations and TSO plan their activities according to those regulations. What are those regulations by NRAs?)	Government set a net zero greenhouse gas emissions target by 2050. Furthermore, Ofgem published a decarbonization action plan. Ofgem will use RIIO-2 to deliver the network changes needed to achieve net zero target.	TYNDPs and Innovation plans are prepared in line with EU targets and Ministry targets (reduction in CO2 emissions, reduction in congestion, greater capacity of power from renewable sources, etc.) and need to be approved by both NRA and the ministry.	The Energiewende project of the Germany set targets for renewables, energy efficiency, storage capacity etc.	For the approving of TNYDP of RTE, CRE verifies whether the plan includes all investment needs consistent with the European Commission's Third Energy Package requirements and targets.	TYNDPs and R&D Development Plan are prepared related to EU and Ministry targets and also in line with ENTSO-E's TYNDP.	TYNDP must be submitted in line with EU TYNDP's targets	There is implicitly relation between Government energy policies and regulatory frameworks for smart grid roll-out. For example, government set high level policies and targets to increase usage of domestic and renewable energy and EMRA defined the relevant regulations which are Capacity Mechanism, and several law, regulation and communiqués on renewables and TEİAŞ prepared investment program and planned to operate capacity mechanism according to those legislations.





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
NRAs' (and CEER's, ACER's) role in pan-European TSO activities (ENTSO-E). (National TSOs relations with their NRAs in this process) (focus is still technology investments not infrastructure investments)	Due to the similar decarbonization policies with EU, Ofgem considers EU directives, internal market rules, network codes, etc. However, they don't have vote right in decision mechanism.	The 10-year Development Plan of ENTSO-E is controlled by ARERA within the context of cooperation with the ACER. ARERA also considers EU directives, internal market rules, network codes, RES targets, and ENTSO-E's roadmaps etc.	TSOs also consider EU directives, internal market rules, network codes, RES targets, and ENTSO-E's roadmaps etc.	The CRE consults ACER for doubtful cases in TYNDP. CRE also considers EU directives, internal market rules, network codes, RES targets, and ENTSO-E's roadmaps etc.	Svenska Kraftnät considers EU directives, internal market rules, network codes, RES targets, and ENTSO-E's roadmaps etc.	Fingrid considers EU directives, internal market rules, network codes, RES targets, and ENTSO-E's roadmaps etc.	Due to the process of EU accession of TURKEY and the synchronous connection of Turkish power system with ENTSO-E Grid, EMRA considers, EU directives, internal market rules, network codes, etc. However, they don't have vote right in decision mechanism.





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
How do TSOs plan their smart grid and technology deployment activities? TYNDP? Business Plan? Separate Planning?	Ofgem's criteria and methodology for outputs assesses the proposed investment projects in a TO's business plan in terms of Reliability, Wider Works, and Innovation.	Smart grid projects are included in TYNDP, which is prepared by TSO and updated every year. Apart from this plan, it is included in the Innovation Plan, which also includes innovative projects other than the smart grid.	SmartGrid projects are included in On-Shore and Off-Shore Development Plans which are include projects of next 10-15 years. All TSOs have to submit On-Shore DP in every two years and TenneT and 50Hertz have to submit also Off-Shore DP.	Smart grid projects are included in TYNDP, which is prepared by RTE and must be updated every year. In addition, RTE must also prepare an Annual Investment Plan in each year for approving by CRE.	Smart grid projects are included in TYNDP, which is prepared by Svenska Kraftnät and updated every year. Apart from this plan, TSO also prepares a three- year R&D Plan which also includes smart grid projects.	Smart grid projects are included in TYNDP, which is prepared by Fingrid and must be updated every two years.	Smart grid projects are included in yearly investment program and master plan ²²⁶ , which are prepared by TEİAŞ.

²²⁶ TEİAŞ' 2019 Annual Report





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
NRAs' approach for regulating achievement targets of Smart Grid for TSOs.	Ofgem encourages innovation in terms of the statutory framework, however the duty to encourage technology investment and smart grid activities is likely implicit in the more general duties on Ofgem to ensure that it secures the efficient and economic execution of activities by licensees.	Although NRA encourages innovation in terms of the framework, duty to encourage smart grid activities is more implicit than other duties. NRA controls that project for efficiency.	Individual efficiency targets of TSOs are defined by BNetzA in maximum revenue of each year. These targets are formulated and distributed across the tariff period in a way that enables the TSO to achieve these targets.	NRA encourages smart grid projects in terms of the technological and digital change, however duty to encourage smart grid activities is more implicit than general duties. NRA controls that project's efficiency and budget.	NRA has limited duties for encouraging smart grid projects in terms of the framework. NRA controls that project's efficiency and quality.	NRA's duty for encouraging smart grid projects in terms of the framework is more implicit than other duties. NRA controls that project's depreciation differences.	EMRA has not introduced any mechanism for regulating achievement targets of smart grid for TEİAŞ yet. Because: - Performance indicators are not introduced and implemented to measure continuity of supply. - No efficiency indicator is used in Turkey, although, it is defined in secondary legislation.





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
Monitoring and reporting requirements for TSO about their technology investment and smart grid activities	TOs prepare a statement setting out their charges (one for each TO) that is to be consistent with the revenue caps that Ofgem set, and which is ultimately approved by Ofgem. However, there is no separate reporting for their technology investment and smart grid activities.	However, there is no special reporting and monitoring requirements for smart grid projects, NRA controls the projects with efficiency.	Although there is no certain reporting and monitoring requirements for smart grid activities, NRA considers the efficiency of projects.	If TSO spends more than the provided budget, the difference will not be covered by the regulation framework. If TSO does not carry out the smart grid investments which are included in the 10-Year Plan in three years, the NRA may require TSO to execute this investment, call for a tender to execute out the investment and may request to modify the TYNDP.	Although there are no certain requirements for reporting and monitoring of the projects, The Inspectorate considers the quality and efficiency of the projects to determine incentives by over the tariff	Projects has no requirements to meet performance standards, reporting and monitoring in Finland. EA controls difference between straight-line depreciation and accounting depreciations	There are no certain requirements for reporting and monitoring about the TEİAŞ' technology investment and smart grid activities





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
NRA-TSO relations for defining the regulatory frameworks for new technologies	Through the Innovation Competitions under the RIIO framework, Ofgem encourage network companies to compete for funding for research, development and demonstration of new technologies and operating and commercial arrangements.	ARERA encourages the transmission operator with a framework promoting higher benefits and/or lower costs.	Through the simulation of competitions of incentive regulation, BNetzA motivates and encourages TSOs to implement their smart grid investments more cost efficiently.	RTE created a workgroup to develop not only a common and regulatory framework but also technical and economical hypotheses. CRE, RTE, distribution operators, electricity suppliers, universities, manufacturers are members of this work group.	The Inspectorate encourages the TSO to implement smart grid technologies on network in terms of the Cost-Benefit Analysis	The Authority aims to guide and encourage the TSO also to increase the quality and efficiency of new technology investments	There are no defined EMRA-TEİAŞ interaction requirements in the legislation for defining the regulatory frameworks for new technologies.





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
NRAs attitudes towards Sector Coupling in their regulations	Generally, the term typological investment relates to technical solutions that TSOs can adopt to provide the transmission capacities needed to cover the transmission demand of grid users. Technologies coupling the electricity sector with other sectors (gas, heat, traffic) is possible for congestion management.	Although ARERA does not follow a comprehensive sector coupling methodology, the regulatory framework includes “sector coupling” mention in Storage part.	However, The Climate Action Plan of Germany contains little reference to sector coupling, Renewable energy Act contains that plan.	CRE considers that the current regulatory framework is not an obstacle for sector coupling and supports the EU and CEER’s work on this issue.	Although there is no framework about sector coupling, The Inspectorate considers sector coupling when setting low carbon targets.	Regarding to sector coupling, although not common in regulation, the existing regulation includes only storage.	There are no defined EMRA-TEİAŞ interaction requirements in the legislation for defining the regulatory frameworks for new technologies.





This project is funded by the European Union



Innovation Regulatory Feature	United Kingdom	Italy	Germany	France	Sweden	Finland	Turkey
NRAs regulatory role for TSO-DSO relations/joint activities towards smart grid rollouts	Ofgem set regulatory framework, particularly its RIIO framework for transmission and distribution networks, already provides the necessary conditions for DNOs, the SO and TOs to evolve and deliver the joint activities towards smart grid rollouts. Ofgem works with industry over where any regulatory clarifications or changes may be needed for future.	ARERA aims to coordinate between distribution and transmission operators within the scope of the integration of renewable energy generation with MV-HV network.	Bnetza aims to coordinate and collaborate between TSOs and DSOs regarding the objectives of increasing renewable energy and their integration into the grid within the scope of Energiewende	CRE aims that coordination between TSO and DSO for flexibility of network.	The Inspectorate aims that provide network flexibility by working both system operators together with new technology investments.	NRA coordinates TSO and DSO in new smart grid investments related to grid flexibility.	EMRA doesn't have any regulatory role for TSO-DSO relations/joint activities towards smart grid rollouts.





This project is funded by the European Union



3.6 As-Is Policy and Regulatory Framework in Turkey for Electricity Transmission

In Turkey, smart grid costs are considered as CAPEX. There are no pre-defined ratios and explicit incorporation of smart grid costs to TSO revenue determination.

There are no incentives by EMRA to encourage TEİAŞ for roll-out/deployment operational use and large-scale pilot trials of smart grids. Therefore, the mechanisms/rules/principles to use incentives are not defined.

However, there is implicit relation between energy policies and regulatory frameworks for smart grid roll-out. For example, government set high level policies and targets to increase usage of domestic and renewable energy and EMRA defined the relevant regulations which are Capacity Mechanism, and several laws, regulation and communiqués on renewables and TEİAŞ prepares investment programs and plans their activities according to those legislations.

TEİAŞ has also prepared a Master Plan²²⁷. Current master plan covers 2024-2029 period. This plan includes:

- 10-year regional demand forecast for the summer peak, winter peak and spring minimum hours of the transmission network,
- Current and anticipated generation potential (including natural gas constraints, particularly uncertainty that may occur in renewable energy sources (seasonal drought, high/low solar or wind generation, etc.)) with the sub-scenarios by considering power plant efficiency parameters,
- HVAC/HVDC Converter Transformer Substation, HVDC Submarine Cable, UHVAC Voltage Level of Transmission Facilities (420 kV Above AC Power Transmission Line and AC Substations), upgrading HVAC underground cable technology to be launched in the coming years,
- Priority of the investments included in the 10-year transmission system investment plan.

TEİAŞ has published the 2019-2023 Strategy Plan²²⁸ which is in line with high level policy documents sorted hierarchically in below:

1. 11th Development Plan (2019-2023)
2. Medium Term Program (2020-2022) / New Economy Plan
3. 2020 Presidential Annual Program
4. National Energy Efficiency Action Plan (2017-2023)
5. National Energy and Mining Policy
6. Strategic Plan of the Ministry of Energy and Natural Resources (2015- 2019)

The strategy plan covers examine the current state of electric power system protection, substation automation, SCADA/EMS, and communications in TEİAŞ's system to establish a basis for the definition of the most appropriate Smart Grid applications for the Turkish transmission system.

²²⁷ TEİAŞ' 2019 Annual Report

²²⁸ <https://webapi.teias.gov.tr/file/080af670-d5cb-4e53-b188-11a187da2037>



This project is funded by the European Union



This strategy plan covers also objective, vision and strategy for TEİAŞ's electricity network of the future. This vision defines a bold program for research, development, and implementation of a strategy for modernization of the Turkish grid that will meet Turkey needs in the future.

Taking into consideration the strategy plan, TEİAŞ includes smart grid projects to the yearly Investment Program which is common for all asset investment. There is no separate investment program. This yearly investment program is subject to approval of the presidential strategic investments' unit.

The Smart Grid subjects in the strategy plan of TEİAŞ are defined as a reliable and secure electricity infrastructure that can meet future demand growth based on the following, which together characterize a Smart Grid:

- Increased use of digital information and controls technology to improve reliability, security, and efficiency of the electric grid.
- Reliable operations of grid and resources, with full cyber-security.
- Deployment and integration of renewable resources and generation.
- Development and incorporation of demand response, demand-side resources, and energy- efficiency resources.
- Deployment of 'smart' technologies (real-time, automated, adaptive, interactive technologies that optimize the physical operation of appliances, consumer devices and industrial equipment and processes) for metering, protection, monitoring, control, and communications concerning grid operations.
- Integration of 'smart' power system devices (transformers, breakers, etc.).
- Deployment and integration of advanced electricity storage and peak-shaving technologies, including pump-storage.
- Development of standards for communication and interoperability of appliances and equipment connected to the electric grid, including the infrastructure serving the grid.
- Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.
- Efficient and reliable, and that it achieves these goals through advanced digital and communications technologies that allow them to integrate domestic and renewable energy resources of different types anywhere in the electric power system is common and essential in strategy plan that covers Smart Grid vision.

3.7 Gap Analysis and Regulatory Recommendations for Electricity Transmission

3.7.1 Overarching Principles

Main principles for the development of smart grid regulations are briefly described below:

Overarching Principles for Smart Transmission Grids

OP1: Output and input regulation

EMRA should consider outputs in the regulation of TEİAŞ, by designing the regulatory framework taking into account both the economic and technical aspects, as well as the fact that developing a smart grid is not a goal in itself, but is a means to an end, i.e. a regulatory approach towards smart grids alone, is not envisaged. However, since the deployment of a smart grid is a heavy technical endeavour, input regulations cannot be neglected. Input regulations may be related to the preparation and approval of the network codes, as well as to standardization issues which fall under the input regulation.

OP2: Effects and benefits expected by smart grids

The application of smart grid technologies and services for TEİAŞ, should have clear effects and benefits towards both the system, as well as towards the system users. Such benefits may include:

- Increased sustainability,
- Adequate capacity of transmission grids for RES integration,
- Adequate grid connection and access for all kinds of grid users,
- Satisfactory levels of security and quality of supply,
- Enhanced efficiency and better service in supply and grid operation,
- Coordinated grid development through regional and local grid planning to optimize system; and
- Participation in the market by new players as a means of flexibility for power system operations.

OP3: Performance indicators and output measures for smart grids

EMRA should have in place a clear and straightforward approach for the evaluation of smart transmission projects, based on performance indicators and output measures. The evaluation framework should be based upon transparent Key Performance Indicators (KPIs), so that all targets are measured and evaluated in an observable, quantifiable, and verifiable manner.

OP4: Encouraging innovation along research, development, demonstration chain

EMRA should foster innovation and research and development (R&D) activities related to smart grids for transmission. KPIs for innovation and demonstration projects should differ from the performance indicators for large-scale and/or rollout projects. This differentiation is justified by the fact that the innovation and R&D activities include also additional elements, such as the dissemination of the results and the required training, as well as they should also take into account the replicability of the projects.



This project is funded by the European Union



Smart grid technologies for transmission networks, as well as potential demonstration and large-scale projects, should be evaluated according to a strategic roadmap for smart grids for energy networks. This evaluation needs to take into considerations the following aspects:

- Identification of what it is research, development, demonstration and deployment,
- Ex ante and ex post assessment of benefits,
- Ensure market participants as point of contact to the customers assuring that independent market operator is involved in measuring benefits,
- Replicability and openness of projects,
- Transparent validation procedures,
- Well-defined and transparent criteria for monitoring of demonstration projects,
- Evaluation of project indicators tailored to each demonstration allowing to measure projects' results; and
- Ensure proper coordination among research projects, including avoidance of overlapping and duplication.

It remains at EMRA's responsibility to assess the benefits and the costs of the possible large-scale or demonstration projects for smart grids, according to national priorities and in coherence with the applicable national regulation systems.

OP5: Standardization, harmonization and interoperability

Interoperability is a key requirement for smart grid projects. It should be mentioned that even though some technological domains are already covered by a sufficient number of standards, there are cases where interoperability standard are missing. Moreover, there technical domains where a large number of standards are available, thus making the selection of the appropriate standards by system operator is a complicated process.

It is highly recommended that TEİAŞ establishes a task force for the implementation of smart grids in its operations. The purpose of this task force is to deal with inter alia services and functionalities for smart grids, as well as a standardisation strategy for smart grids.



This project is funded by the European Union



3.7.2 Regulatory Recommendations to Support Smart Grid Roll-out in TEİAŞ

ID	Feature	Recommendation	Explanation	Supportive Arguments	As-Is Status in Turkey	Key stakeholders involved
R1	Tariff Methodologies and Incentives	Incentivizing Strategic Smart Grid Projects	Additional premium might be added to CAPEX in case TEİAŞ makes expenses for strategic smart grid projects (e.g. fostering sector coupling, new market services, renewable integration etc.). EMRA may select a few projects for each tariff period that will receive the incentive.	Smart grid investments should be incentivized based on performance criteria and decoupling should be considered successful completion and operation of specified strategic smart grid projects.	There are not specific incentives for smart grid projects.	EMRA, TEİAŞ
R2	Tariff Methodologies and Incentives	Allocated CAPEX for Smart Grid and Technology Investments	- Identification specific CAPEX category for smart grid investments in revenue cap of TEİAŞ - 5-10% of the network CAPEX is recommended to be allocated for smart grid rollout investments	Since smart grid and technology investments for TEİAŞ bear a higher investment cost and risk compared to conventional network reinforcements, EMRA should make sure that these higher investment cost and risks are properly accounted for in regulatory assessments for allowing smart grid and technology investments to be considered as a viable network planning option for electricity transmission.	There is not specific CAPEX category and/or pre-defined ratio in revenue cap of TEİAŞ for smart grid and technology investments.	EMRA, TEİAŞ



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-Is Status in Turkey	Key stakeholders involved
R3	Tariff Methodologies and Incentives	Incentives for Extension of Network Assets Lifetime	Development of indirect incentive methodologies to increase network asset performance and extend operational life through advanced asset management practices.	Smartgrid investments should be incentivized implicitly based on efficiency performance indicators and assessed by international benchmarking or referring to a reference network ²²⁹ .	In Turkey, although written in the secondary regulation, the target efficiency levels of the TSO has not yet defined by EMRA.	EMRA, TEİAŞ
R4	Smart Grid Planning	Including Smart Grid Planning in Master Plan/TYNDP Process	Smart Grid Planning to share with EMRA for monitoring and tracking the progress.	Including a smart grid planning in master plan that further innovation in the operation of transmission systems would be beneficial in terms of overall efficiency, and indeed necessary if electricity system is to proceed in the most cost-effective way.	Smart grid projects are included in yearly investment program and master plan ²³⁰ , which are prepared by TEİAŞ. However, there is not specific process for EMRA' monitoring and assessment.	TEİAŞ and EMRA

²²⁹ EC/DG Report on "Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure?"

²³⁰ TEİAŞ' 2019 Annual Report



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-Is Status in Turkey	Key stakeholders involved
R5	Smart Grid Planning	CBA as a Complementary Tool of Decision Making in Planning	CBA methodology to be incorporated in planning processes for strategical smart grid projects.	CBA methodology to be incorporated in planning processes for new strategic smart grid projects will be provided cost effective way for prioritization and efficiency of new investments accommodating including social welfare.	There is not any specific CBA methodology to be incorporated in planning processes for strategical smart grid projects.	EMRA, TEİAŞ
R6	Smart Grid Planning	Harmonization of Smart Grid Planning Activities of Different Energy Sectors	Electricity distribution, gas distribution, gas transmission smart grid rollout planning should be harmonized.	It is important to focus on market expansion, through electrification sector coupling and integration, TSO-DSO interface and the coordination of Gas DSOs-BOTAŞ and the other market players through harmonization of smart grid activities.	There is not any specific program /mechanism to fund SG	EMRA, TEİAŞ
R7	Monitoring Requirements	Identification of KPIs for Monitoring the Success of Smart Grid Projects	Implementation of concrete methodologies for evaluating, monitoring and auditing Smart Grid projects and their benefits	Smart grid investments should be monitored and assessed based on quality performance indicators and efficiency performance KPIs targets.	There is not any specific KPIs for Monitoring the Success of Smart Grid Projects SG	EMRA, TEİAŞ



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-Is Status in Turkey	Key stakeholders involved
R8	New Services and Business	New Flexibility Resources and Ancillary Services	Definition of roles, responsibilities and revenue streams for regulated entity (TSO) (Demand Response, Power Storage, Distributed Generation) (evaluate the procurement model for flexibility resources in Ancillary Services using a cost-benefit analysis approach.)	High renewable energy penetration, intermittency and low inertia generate an increased level of threats, which require a full use of new flexibility resources and enhanced ancillary services.	"Electricity Market Ancillary Services Regulation Draft" including demand side participation was published by EMRA.	TEİAŞ, EPDK, DSOs and the other system users.
R9	Other Recommendations	Identify High-Priority Technology Areas for Domestic Industry	Supporting target areas for technology development and export (storage, IoT, data analytics, network management software, cyber security, etc.)	In order to support domestic industry in the development of technology and systems to help them participate in the future energy market and become leaders in technology export, it is necessary to identify high priority technology areas and openly share expertise, data and tools with stakeholders with the aim of accelerating improvements across the Whole System for domestic industry, as well as society.	There is not any specific program /mechanism to identify high priority technology areas for domestic industry.	TEİAŞ, EMRA, Industry Organizations, Universities, TUBITAK,



This project is funded by the European Union



ID	Feature	Recommendation	Explanation	Supportive Arguments	As-Is Status in Turkey	Key stakeholders involved
R10	Other Recommendations	Communication and Dissemination Activities	TEİAŞ should make sure that results and lessons learned from smart grid demonstration projects are disseminated.	In case of smart grid demonstration projects for electricity transmission, financed or co-financed by additional grid tariffs or from public funds, TEİAŞ should ensure the dissemination of the results and lessons learned to all interested parties, including other market participants, etc.	There is not any specific program /mechanism for communication and dissemination activities in smart grid demonstration projects.	TEİAŞ, EMRA, Industry and other market players.
R11	Other Recommendations	Participation in Standardization Organizations	TEİAŞ should participate in standardization organizations regarding smart grids.	The purpose of the participation to Standardization Organizations is for TEİAŞ to adopt and/or to cooperate in the development of protocols and standards related to information management and data exchange to ensure the interoperability in current and future deployment of smart grid projects for electricity transmission.	There is not any specific program /mechanism to participate in standardization organization regarding smart grids.	TEİAŞ and Standardization Institutions.



This project is funded by the European Union



3.8 Smart Grid Roadmap for TEİAŞ

For the energy system to integrate various sources of renewable energy and ensure that production and consumption of electricity always match, the grids need to become smarter. This requires a high-level of digitalisation and automated communication and control.

3.8.1 As-is Status of Smart Grids in TEİAŞ

In order to establish a basis for the definition of the most appropriate Smart Grid applications for the Turkish transmission system, the current state of electric power system protection, substation automation, SCADA/EMS, communications and interoperability among all these applications in TEİAŞ's system have been assessed.

3.8.1.1 Overview of the Current SCADA/EMS

The first SCADA/EMS System for electricity generation and transmission system in Turkey was established in the second half of the 1980s. This system was renewed in 2004, extended in 2011 by three additional RCCs and upgraded with the addition of some new functions recently. One of the most important additions provided by the new SCADA/EMS system is the Operator Desk for Renewable Energy Resources to allow for the integration of a large numbers of wind farms into the Turkish Power System. This Operator Desk have the following functions:

- SCADA/Monitoring
- Generation Curtailment
- Wind Energy Forecast
- Static Analysis
- Dynamic Analysis

The SCADA/EMS System includes the following 11 control centres:

- National Control Centre (NCC) in Ankara.
- Emergency National Control Centre (ENCC) in Ankara.
- Nine (9) Regional Control Centres (RCCs) at Northwest Anatolia (Adapazarı), Central Black Sea (Samsun), Central Anatolia (Ankara), Trace (İstanbul), West Anatolia (İzmir), Southeast Anatolia (Elazığ), East Mediterranean Sea (Adana), East Anatolia (Erzurum) and West Mediterranean Sea (Antalya).



This project is funded by the European Union

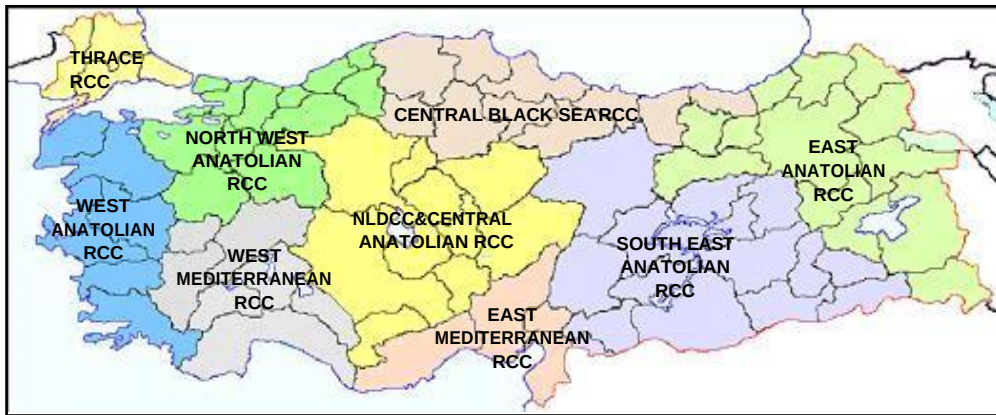


Figure 54: National and Regional Control Centres (RCCs) of TEİAŞ

The following Energy Management System (EMS) Programs that are deployed at NCC and ENCC.

- State Estimator (SE)
- Contingency Analysis (CA)
- Power Flow Analysis (DPF)
- Automatic Generation Control (AGC)
- Reserve Monitoring (RM)
- Interchange Transaction Schedule (ITS)
- Short-Term Load Forecast (STLF)
- Dispatcher Training Simulator (DTS)

However, they are not fully operational today as a part of the SCADA/EMS System. Existing situation is summarized as follows:

- State Estimator (SE): Due to insufficient amount of real-time data from the power system and the network model being not updated, SE is not converging. Therefore, SE functionality has not been utilized yet.
- Contingency Analysis (CA): Since SE is not providing converged results, CA is not used for the time being.
- Dispatchers Power Flow (DPF): Since SE is not providing converged results, DPF is not used for the time being.
- Short-Term Load Forecast (STLF): Not used for the time being. Related staff at NCC prefers to use old excel sheets for this purpose instead of using STLF available in the existing SCADA/EMS System.
- Dispatcher Training Simulator (DTS): DTS is available only at NCC. Since Network applications (SE and DPF) are not providing converged results; DTS is not used for the time being.

Current development for TEİAŞ SCADA/EMS²³¹

²³¹ TEİAŞ Strategic Plan, 2019-2023



This project is funded by the European Union



Since the tender for the connection and integration of RTUs to be established within the scope of RTU Supply and Facility Project to the existing TEİAŞ SCADA / EMS System was completed at the end of 2018, the targeted number of RTU installation could not be reached. SCADA / EMS systems to be strengthened and expanded to ensure reliable operation of the national electrical system with real-time information have not been completed yet.

On the other hand, "Development / strengthening of the SCADA / EMS System and information security infrastructure of TEİAŞ" project has been cancelled by the EU Delegation.

Within the scope of the "RTU Procurement and Installation Project", the supply of 232 Remote Terminal Units (RTU), 103 Information Collection Panels (BTP) and other related devices (energy analyser, converter for transformer tap changers, etc.) needed in 232 Substations and its facility is being built.

Additionally, the Contract for the "RTU and Peripheral Units Procurement Project" was signed on December 18, 2019, and within the scope of this Project, 156 Remote Terminal Units (RTUs) to be installed in 156 Substations. There will also be 74 backup RTUs. 91 pieces of Information Supply and installation of the Collector Panel (BTP) and other needed related devices in 156 Substations (energy analyser, converter for transformer tap changers, etc.) will be provided and installed.

In this way, it is aimed to ensure that our National Electric System is operated more effectively.

According to the 2020 Presidency Annual Program Energy / Measure 496.2: Studies will be carried out to develop a National Smart Grid Management System and National SCADA to be used in Energy State Economic Enterprises, SEEs.

3.8.1.2 Overview of the Current Ancillary Services

Since the 18th of September 2010, the Turkish power system has been operating synchronously parallel with the ENTSO-E CESA. Therefore, TEİAŞ as the Transmission System Operator (TSO) in Turkey has to obey all rules and regulations of the system which is similar to all other member TSOs. For this synchronous area, the maximum instantaneous power deviation is defined to be 3.000 MW. This is based on operational characteristics concerning system reliability and the size of loads and sudden outage of two biggest (1500 MW of each) generation units of Nuclear Power Plant located in Europe. Each system has to fulfil the reserve requirements to contribute to primary frequency control in case of a loss of loads or an outage proportionally with the system size. In addition, each system has to provide tie-line control and frequency restoration reserve by means of secondary frequency control. These services are called as Ancillary Services.

Ancillary Services are procured by the system operator by means of Ancillary Service Agreements. These services include system restoration (black start capability²³²), instantaneous demand control, regional capacity allocation, primary and secondary frequency control and reactive power control. Currently, primary and secondary frequency control, reactive power support Ancillary Services are in force.

Ancillary Services provision is regulated by the Electricity Market Ancillary Services Regulation²³³ and Electricity Grid Regulation²³⁴.

²³² Black start is to restore the power system after a complete or partial system collapse

²³³ This is published in the Official Gazette no:30252, dated 26/11/2017

²³⁴ This is published in the Official Gazette no:29013, dated 28/05/2014



This project is funded by the European Union



All generation units of power plants with an installed capacity above 30 MW are obliged to perform certification tests in compliance with Electricity Grid Regulation and provide unpaid reactive power control services to the system.

All certified/qualified generation units of power plants, except renewables, with an installed capacity above 50 MW can provide paid primary and secondary frequency control services to the system.

In November 2017, a new Ancillary Services Regulation was put into action, changing the entire methodology of payment for ancillary services. However, due to further improvements required in the infrastructure, it was put into application only recently in February 2018. This change will potentially have considerable effects on the market in the near future.

According to the a.m. changing, the provision of primary and secondary frequency control services is based on daily Ancillary Services market operated by TEİAŞ.

Currently, TEİAŞ is procuring about 300 MW primary frequency control reserve and about 1000 MW secondary frequency control reserve through the ancillary services market. Each certified/power plant shall offer at least ± 1 MW and ± 5 MW primary and secondary frequency control reserve capacity respectively to enter the ancillary services market.

TEİAŞ is also planning to establish a market infrastructure to be ensured demand-side participation. Demand Side Participation Application is a mechanism that enables the management of peak demand by taking advantage of this flexibility of electricity consumers with flexible / shift-able loads. In order to implement the mechanism, it is aimed to bring consumers with flexible loads together (aggregation) and to give them the opportunity to move in the balancing power market. In order to reduce the ratio of peak demand to average demand in electrical energy, a free market-based demand-side participation mechanism will be implemented²³⁵.

Ancillary Services Central Monitoring and Control System (ASMS)

Real-time data needed by the Ancillary Services Central Monitoring and Control System (ASMS) was expected to be provided by the SCADA/EMS System via an ICCP connection implemented between the NCC and this system. The ASMS was intended to monitor the behaviour of those generators that have agreed to supply ancillary services, in order to validate the ancillary services data (frequency and voltage control) for the financial settlements. The power plant data was planned to import from the SCADA system via ICCP link.

In addition to the interface with SCADA, this tool was expected to evaluate the CVS files that are prepared by the power plants daily. This functionality was expected also enable the evaluation of the ancillary services performance of power plants which are not connected to the SCADA system and provided backup data in case of communication problems between power plants and SCADA system.

However, this system is not in operation. The evaluation of the ancillary services performance of power plants have been performing manually based on the CVS files prepared by the power plants daily.

²³⁵ TEİAŞ Strategic Plan, 2019-2023



This project is funded by the European Union



3.8.1.3 Overview of the Current Communication System

The backbone TEİAŞ telecommunications network, comprised of different telecommunications media, provides the communications between the TEİAŞ National Control Centre (NCC), the Emergency National Control Centre (ENCC), nine (9) Regional Control Centres (RCC), and Remote Terminal Units (RTUs) at most of the substations and power plants connected to the transmission network. There is about 27,000 km fibre optic communication infrastructure.

TEİAŞ' primary communications between the NCC and the RCCs is based on Metro Ethernet Virtual Private Network (VPN) leased lines. This Metro Ethernet links can support 5 Mbps or more. The previous primary communication system, SDH 2 Mbps fibre optic links and leased TDM network are used as the standby links between the NCC and the RCCs, along with some secondary standby satellite channels. Links between the ENCC and the RCCs is either 2 Mbps Metro Ethernet links or 2 Mbps TEİAŞ fibre optic links. The link between the NCC and the ENCC consist of a 20 Mbps TEİAŞ fibre opticlink.

The communication protocol used between RCCs and the NCC/ENCC is IEC 60870-5-104. most commonly, the Inter-Control Centre Communication Protocol (ICCP) is also used for real-time data exchange with control centres of distribution and generation companies in Turkey, the National Control South Centres of the neighbouring countries such as Greece and Bulgaria as well as with ENTSO-E Coordination Centre in Switzerland.

Each RCC is connected with 2 neighbouring RCCs via 2 Mbps TEİAŞ fibre optic links. 2 Mbps Metro Ethernet links are used between the control centres of the distribution and generation companies and the NCC systems.

TEİAŞ exchanges SCADA data between the TEİAŞ NCC and the NCCs of Greece and Bulgaria. For communication with Bulgaria, the existing fibre optic cables (OPGW) are used. For Greece, a leased line between TEİAŞ and Greece NCC is used for this purpose. TEİAŞ exchanges real time data with NCCs of the neighbouring countries as well as with the ENTSO-E South Coordination Centre in Switzerland via the Greek and Bulgarian connections.

In addition to the SCADA system which communicates with the substation RTUs, TEİAŞ can implement additional systems to collect specific types of information. These additional systems include:

- National Power Quality MonitoringSystem
- Load Dispatch Information Monitoring System (YTBS)
- Special Protection System (SPS)
 - ENTSO/E border substations: designed and implemented in order to support the AC interconnection between Turkey and the ENTSO-E network according to equity and solidarity principal.
- Automated Meter Reading System (OSOS)

Moreover, TEİAŞ will exchange data from the Wind Monitoring and Forecasting System (RITM) implemented by TÜBİTAK for the MENR, General Directorate of Energy Affairs.

National Power Quality Monitoring System:

TEİAŞ has a National Power Quality Monitoring System (NPQMS) for measuring all electrical quantities and power quality parameters in the Turkish Power System. Additional data is collected from 6 PMUs that are retrieved from



This project is funded by the European Union



the ENTSO-E South Coordination Centre in Switzerland. This PMU data is used for monitoring low-frequency inter-area oscillations.

Power quality monitors have already been installed some of substations and power plants. All of these monitors have PMU capability, but currently only few of them have the PMU capability activated. In order to have wide area monitoring, wide area protection applications, and the need of phasor data for improvement of convergence and quality of the result of State Estimator in SCADA/EMS System, the relevant PMU capabilities shall be activated.

Communications with Distribution System Operators (DSO)

There is no data exchange between the NCC SCADA system and Distribution System Operators (DSOs). It is expected that connections between TEİAŞ NCC and DSOs will be necessary in the future in order to exchange information on the distributed energy resources (DER) systems that are connected to the distribution grid. In particular, the NCC collects MW and MVAR data on all DER systems larger than 10 MW and on all DER power plants that are larger than 30 MW. This DER data will be aggregated for each interphase between the transmission and distribution systems.

As DER systems become more prevalent in distribution systems, the TEİAŞ will need more aggregated information from the RCCs, DSOs, and larger customers. This information will include not just “after-the-fact” metering, but more real-time information as well as weather and load/generation forecasts. Both the TEİAŞ and the DSOs will need to execute contingency analyses for better understanding what responses to make to adjust to renewable variations, customer decisions, and market incentives.

TEİAŞ will need to have increasing insight into the DSO operations, including forecasts of generation, an understanding of market responses by DER owners/operators, as well as the changing load profiles. TEİAŞ may also be able to utilize the market and DSO capabilities to modify energy usage patterns (relieve overloaded HV lines), to expect DER systems to “ride-through” voltage and frequency anomalies, and even to use frequency support from MV/LV DER systems to help maintain power system stability.

Communication with Renewable Energy Sources (RES)

Future operations will be challenged by renewable energy plants, both wind and solar, where variable availability and rapid fluctuations must be taken into account. Communications will be increasingly important to monitor and coordinate these power plants, not only to collect data directly from the plants but to have up-to-date data from all parts of the power system in order to better manage these fluctuations specially during emergency conditions.

Cyber Security

Cyber security has become a major requirement for all critical infrastructures, particularly the crucial electric power infrastructure. Cyber-attacks can seriously affect operational systems. Security by obscurity is no longer a valid strategy.

The TEİAŞ operational systems are kept separate from the corporate system, and the operational communications channels are isolated from the corporate communication channels. However, none of the communication protocols used to exchange operational data include cyber security.

Cyber security personnel will need to oversee all of the cyber security requirements for the operational systems, including the periodic training of other personnel in cyber security procedures, the continuous evaluation of existing and new cyber security requirements, and the specification and testing of systems, equipment, and communication protocols for cyber security compliance. In all communications and systems designs, cyber security must be



This project is funded by the European Union



incorporated from the outset and managed in the lifecycle, including from manufacturers, through factory development, installation within TEİAŞ, during operations, as part of maintenance, and even when equipment is retired.

Best practice guidelines shall be used to determine the most appropriate security policies, security procedures, and the security technologies for TEİAŞ.

Tele-protection System:

The telecommunication channels between substations are used primarily for tele-protection. The communications interfaces between protective relays at the ends of the protected transmission lines depend on the available technology at the specific location.

For 400 kV transmission lines:

- If fibre optic channels are not available, two power line carrier (PLC) channels (main and back up) coupled to two different phases are used for tele-protection.
- If fibre optic channels are available, the main tele-protection is via PLC, and the backup tele-protection is via a fibre optic channel.

For 154kV transmission lines:

- If fibre optic channels are not available, one PLC channel is used for tele-protection.
- If fibre optic channels are available, one separate fibre optic pair is used for tele-protection or a fibre optic channel via SDH is used.

In addition, the communication channels to some substations are chained through other substations for data monitoring, as well as for RTU and PAX voice communications. The inter-substation communication for voice communication and tele-signalling consist of fibre optic channels where available and PLC channels.

There is no data exchange between the NCC / RCCs SCADA/EMS systems and protection system. In order to have wide area protection applications, integration of the protection system and the NCC / RCCs SCADA/EMS systems is required.

3.8.1.4 Overview of the Current Substation Automation System

Substation automation is one of the important components of a smart grid. The substation automation systems are at the end of the electric power system's functional hierarchy and they provide two essential functions:

- Data source for local automation functions and for the system operator or system level automation functions
- Execution level for the system operator or system level automation functions.

The availability of synchro-phasor measurements is changing the way substation and power system management and automation are being done in advanced smart grid applications, so they need to be also considered as part of the evaluation of substation and power system automation.

The existing level of substation automation systems in the Turkish electric power system is very limited.



This project is funded by the European Union



Substation automation systems have already been partially or fully installed at some 400 kV or 154 kV Gas Insulated Substations (GISs).

The vast majority of substations in the system are manned and even at some substations the measurements on the transmission lines are manually recorded on an hourly basis and reported by phone to the system operator in addition to transmission of real-time data via RTU to SCADA System.

On the other hand, some of the Power Quality Monitoring devices, installed at some substations in the framework of the National Power Quality Monitoring System, already been equipped with synchro-phasors measurements capability. PMU feature based wide area monitoring and control systems shall be added to the remaining Power Quality Monitoring equipment which are very important for substation automation.

Based on the analysis of the current protection and substation automation systems, improvement on the situational awareness of the dynamic state of the electric power system based on synchro-phasor measurements and other substation information, the efficiency of commissioning and maintenance process of protection and control systems and the efficiency and reliability of substation automation systems are also very important.

3.8.1.5 Overview of the Current Protection System

TEİAŞ's practice and strategy in development and application of standard protection, automation and control schemes is currently based on the development and implementation of standard protection and control schemes using advanced microprocessor based multifunctional protection Intelligent Electronic Devices (IEDs) from leading global suppliers.

The existing protection philosophies for each of the existing voltage levels in TEİAŞ's electric power system are based on commonly accepted protection principles.

Within the scope of Protection Tools Development Project; Efforts are being made by TÜBİTAK MAM Energy Institute and TEİAŞ to develop and increase the scope of the Protection Information System, which provides tools for modelling, providing operational support and analysing the protection system required for the reliable protection of the electricity transmission system of TEİAŞ, through the Load Dispatch Information System. The mentioned project consists of 6 (six) work packages. These are followings.

- Protection Modelling Tools Work Package: Necessary software development activities are carried out for modelling current transformers, voltage transformers and relays in the Protection Information System.
- Protection Operation Tools Business Package: Facilitating calculation and control tools development activities are carried out in protection system operation.
- Protection Analysis Tools Business Package: To perform protection analysis, analysis file creation and development of analysis tools that perform protection analysis in power systems are carried out.
- Protection Reporting Tools Work Package: Necessary software development activities are carried out for reporting the protection system.
- Relay Modelling Services Work Package: It is aimed to model the overcurrent, distance and differential protection functions in the electricity transmission line, transformer and MV feeders where are interface with distribution companies.
- Capacity Building Services Work Package: to be provided using the system and its outputs more effectively



This project is funded by the European Union



and efficiently.

3.8.1.6 Overview of Geographic Information System (GIS)

TEİAŞ 'Geographical Information System (GIS); Turkey GIS environment to be transferred to the general electricity transmission lines, process-based GIS software covers mobile GIS software and for field teams 3D WEB-GIS software.

With TEİAŞ-GIS, within the area of responsibility of TEİAŞ; substations, transmission lines, etc. Authorizations for the management of geographic transmission network and inventory data in the Geographical Information System environment in accordance with the network data model, monitoring the business processes of ongoing and future energy transmission line and substation projects, accessing data via a central server, and accessing data to internal and external users It allows sharing within. It is a GIS-supported, web-based and mobile-enabled information system that is integrated with the TUCBS Project, in compliance with ISO-TC 211 and OGC standards, supporting INSPIRE Directives.

TEİAŞ GIS, graphical and verbal data related to the transmission network inventory, with spatial analysis and reporting in accordance with the geographical electricity network data model; It includes transferring to the Geographical Information Systems environment, managing data in a central database, monitoring the stages of planning, survey and project, expropriation, EIA, maintenance activities, presenting and sharing via web application.

It manages the following daily business processes of TEİAŞ:

- Planning,
- Survey and Projecting,
- Environmental Impact Assessment (EIA),
- Expropriation,
- Connection Agreement and
- With Business Tracking applications.

3D WebGIS applications, MobilCBS applications and Desktop GIS applications have also been developed.

3.8.1.7 Overview of Interoperability

Interoperability readiness is becoming extremely important including automating information exchanges and business processes for system operators and utilities. Almost every new system or application will be required to securely interact with other applications or systems considering applicable industry standards as well as ENTSO-E cyber security rules.

The current status of the interoperability of TEİAŞ' systems are summarized as follows:

- TEİAŞ Intelligent Electronic Devices such as Phasor Measurement Units (PMUs), Digital Protective Relays (DPRs) and Digital Fault Recorders (DFRs) are not integrated with SCADA/EMS
- Currently, there are no data exchanges or interaction between the SCADA/EMS System and other enterprise applications.



This project is funded by the European Union



- The network model used by EMS is managed within SCADA/EMS System. There are no data feeds from systems like GIS and/or network model management solution.
- There is no Real-Time Data Exchanges with the other SCADA/EMS Systems using ICCP such as: National Control Centres of the neighbouring countries, SCADA Control Centres of the Distribution Companies, the Organized Industrial Zone, the Generation Companies and Ancillary Services Central Monitoring and Control System.
- There is no Non-Real-Time Data Exchanges. Moreover, Network Applications (State Estimator, Power Flow Analysis) are required to create network snapshots using IEC CIM RDF, PSS/E, DigSILENT Power Factory and UCTE formats; and these snapshots shall be used by other applications such as PSS/E program to be used for generation of the Day-Ahead Congestion Files (DACF) required by ENTSO-E.
- Due to the lack of data, short-term wind generation forecasting system (a specific tool of the “wind energy desk”) is not capable of forecasting wind generation per wind farm, per region and for the entire country as a whole. There is no data exchange from RITM236 (Wind Power Monitoring and Forecasting Centre) yet.
- There is an on-line Dynamic Stability Assessment (DSA) system in the SCADA/EMS to ensure that Turkey’s power grid is not adversely impacted by integration of many high capacity wind farms. This system takes the current state as well as the forecasted states of the system to evaluate the stability of the system and proposes remedial measures such as re-dispatch, load shedding and change transformer tap position if the system cannot meet its performance criteria.
- The current and expected steady state as well as the dynamic models of the Turkish power grid are inputs to this system and collect real time information from the Turkish SCADA/EMS. However, SE functionality has not been utilized. Therefore, real time data input is not possible.
- SCADA/EMS and Dispatcher information System-YTBS, are two separate systems. Effective and efficient interface between these will be important considering security challenges.
- No interface between National Power Quality Monitoring System and power system operational tools (SCADA/EMS, YTBS, etc.).
- No interface between Wind Monitoring and Forecasting System (RITM) and power system operational tools (e.g., YTBS).
- Meteorological data to the SCADA/EMS environment to improve system effectiveness.

3.8.1.8 **Overview of the Current Business Processes**

Interoperability readiness is becoming extremely important including automating information exchanges and business processes for utilities internally and externally with their stakeholders.

Deployment of ‘smart’ technologies as automated, adaptive, interactive technologies that optimize the physical operation of appliances, consumer devices and industrial equipment and processes for metering, protection,

²³⁶ External wind power forecast could be the forecast produced by Energy and Natural Resources Ministry wind monitoring & forecasting centre (RITM).



This project is funded by the European Union



monitoring, control and communications concerning grid operations and process and Performance Improvement of TEİAŞ, following developments are in progress²³⁷:

1. "Load Dispatch Centre Information System (YTBS) Development Project", "Planning Technical Support and R&D Project" "Grounding Technical Assistance Project "and" National Power Quality Monitoring System Project " are upgraded by TÜBİTAK MAM Energy Institute in order to improve the technological infrastructure used in the planning and operation of the transmission system and to operate the transmission system more effectively.
2. Examining theoretically HVAC / HVDC Converter Substation, HVDC Submarine Cable, UHVAC Voltage Level of Transmission Facilities (above 420 kV AC Power Transmission Line and Substations), HVAC underground cable technology above 2000 mm² cross section for Turkish transmission network to be launched in the coming year.
3. Standard Infrastructure / Cabling and Modular Data Centre Installation: Communication infrastructure cabling works have been completed in 22 Regional Directorates of our Corporation, 20 Operation and Maintenance Directorates and 19 Group Chief Engineering. Fibber optic lines have been installed instead of existing copper cables to interconnect network switches for more reliable and high capacity communication. Standard Modular Data Centre cabinets were purchased for system rooms. The 8th Regional Directorate's Data Centre installation has been completed, and currently the installation of other Data Centres is continuing.
4. Antivirus and Mail Gateway Software Renewal: Under the coordination of the Ministry of Energy and Natural Resources, within the scope of the SGOM (Cyber Security Operations Centre) Project, the Antivirus program was established on central servers to be used on the user computers of TEİAŞ' Central and Provincial Organization. Antivirus program is used to prevent, detect and remove malware. The Mail Gateway software examines the content and attachments in the e-mails sent to the Electronic Mail System and quarantines the harmful ones.
5. Central Firewall, DDOS Attack Prevention Device Renewal: Within the scope of the "Security Solution Procurement Project for Information and Critical Infrastructure Systems", the existing firewall has been replaced with a firewall operating in a redundant structure with a higher technology. During the change, the rules on the old firewall were transferred to the new firewall without any interruption, as a result of careful studies. DDOS Attack Prevention Device was installed with Firewall Event Management and Reporting Product.
6. Web Gateway Device Installation: A Web Gateway Device was installed and commissioned to prevent the personnel of the Central and Provincial Organization from accessing harmful websites within the scope of the SGOM Project under the coordination of the Ministry of Energy and Natural Resources.
7. Network Improvement Studies of the Provincial Organization: Standard network switches configured by TEİAŞ IT staff were sent to Regional Directorates, Operation and Maintenance Directorates and Group Chief Engineering and commissioned. Thus, user computers in the entire provincial organization can be controlled and managed from the centre.
8. Operational Management System (OMS): Equipment Test processes with the approval flow of the Load Dispatch Permission in the Operational Management System (OMS), where:

²³⁷ TEİAŞ' 2019 Annual Report



This project is funded by the European Union



- a. Records of primary, secondary, electronic equipment, substation, lines and poles are kept,
 - b. Failure records, maintenance and tests are made,
 - c. Work orders are created and
 - d. Root cause failure analysis is performedwere taken into service.
9. System Usage Management System (SUMS): Having the interactive operation and information system for transmission system users, which are distribution companies, Organized Industrial Areas, independent generation companies and eligible consumption companies and signed Connection Agreements and System Usage Agreements with TEİAŞ, SUMS was established to managed the scope of the agreements. This system is capable in which the letter of guarantee and the amount of missing or excess collateral are kept, System Usage and Operation Invoices are prepared and invoiced, Reactive, SCADA, and Feeder force outages annual penalties are calculated and invoiced to Transmission System Users.
10. Inventory Management System: The Inventory Management System, the software in which the materials entering and leaving the warehouses are defined, entry and exit transactions are made, the accounting transactions for these entries and exits are made and the reports of these transactions are taken into use.
11. Information Systems Inventory Tracking and Fault Reporting Program: The software in which the records of the informatics inventory within TEİAŞ' central and regional organization are kept and where breakdown, embezzlement and scrap transactions are applied to the inventories has been put into use. In addition, risk analysis of inventories is performed in the software.
12. Manageable Floor Printer System: Within the scope of the joint project initiated by the Ministry of Energy and Natural Resources for the Central Organization, its affiliated, related and related Institutions / Organizations with the aim of central integration of secure printing systems and optimizing printing costs; 35 Central Floor Printers and Secure Printing Software has been provided and transition to the Managed Floor Printer System has been achieved in the Central Units of TEİAŞ in order to reduce printer consumable costs in TEİAŞ' Central and Regional Units, to save energy, to increase printing safety, to minimize the damage to the environment and human health, to meet the photocopy and scanning needs through the same system.



This project is funded by the European Union



3.8.2 Smart Grid Roadmap for TEİAŞ

In order to meet Turkey's energy policy objectives for 2023 and beyond, major transformation of our electricity infrastructure is necessary. Strengthening and upgrading existing networks is of greatest importance to integrating an increasing amount of renewable energy generation, using domestic energy resources, enhancing grid security, developing the energy market, and realizing energy saving and efficiency. To achieve these goals, it is not only necessary to build new lines and substations, but it is essential to make the overall electricity system smarter through the integration of Information and Communication Technologies (ICT).

For Smart Grids to deliver their envisaged benefits however, the realization of physical infrastructures alone will not be sufficient and must be complemented by the emergence of new business models and practices, strengthen the institutional capacity of TEİAŞ, new regulations, as well as more intangible elements such as changes to consumer behaviour and social acceptance. Many different stakeholders are involved in this process and different forms of cooperation are already arising.

In order to have the smooth integration of renewable energy sources and full usage of domestic energy resources, a more efficient and secure electricity supply, and an energy market with full inclusion of consumers, following Road Map is suggested for the Turkish transmission system considering time horizon as short term, midterm and long term assignments.

3.8.2.1 Short Term Project Recommendations

Short term recommendations cover the time horizon of 1-3 years for implementation. These are as follows:

Recommendation 1 Development of Smart Grid Planning for TEİAŞ

Transmission systems are generally considered to be relatively "smart" and amenable to innovation. The contribution of connected generation to transmission system security, the need to accommodate varying and multidirectional power flows and the need to balance energy on a continuous basis require sophisticated protection, monitoring, supervision and management systems. However, there is evidence to have a smart technology plan that further innovation in the operation of transmission systems would be beneficial in terms of overall efficiency, and indeed necessary if electricity system is to proceed in the most cost-effective way.

A Smart Technologies Planning for TEİAŞ can describe the elements needed in implementing a "Smart Grid" by outlining how the electricity delivery system can be modernized so it monitors, protects, and automatically optimizes the operation of its interconnected elements—from the central conventional generator and decentralized intermittent generation through the high-voltage network and distribution system, to HVDC, B2B, energy storage installations, to enhance SCADA/EMS, and to end-use consumers and their flexible load for demand response. This comprehensive plan highlights emerging concepts of cyber and physical security, resiliency, and the newest architecture—"The Integrated Grid".

Following Technical Domains shall be considered for TEİAŞ Smart Technologies Plan, it is shown as a summary.



This project is funded by the European Union

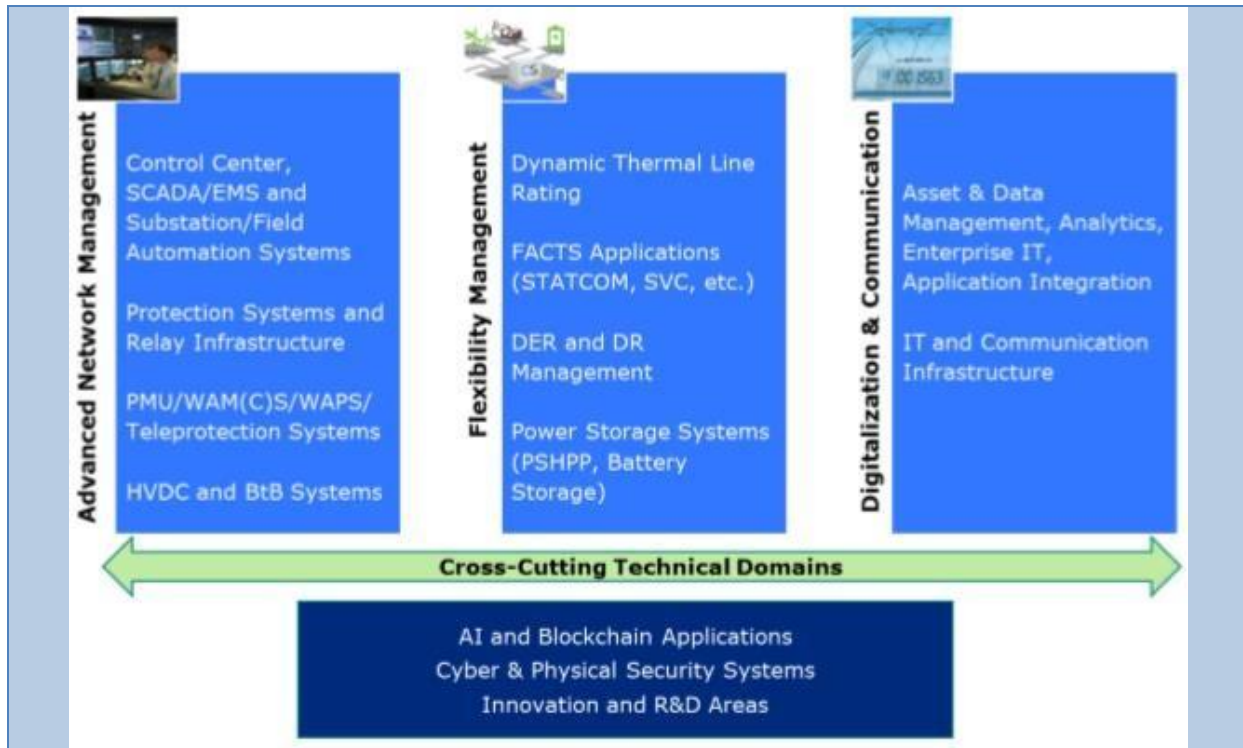


Figure 55: Technical Domains for TEİAŞ Smart Technologies Plan

As-is Status in Turkey: There is not a smart technology plan. However, it is decided to determine a roadmap for smart grids / systems in the electricity and natural gas transmission and distribution sector²³⁸.

Prioritization: Short-term

Technical Domain: Smart Grid Planning

Recommendation 2 Modernization and Upgrade of Existing SCADA/EMS System with Advanced Functionalities

SCADA/EMS system is a critical component of a utility's operation. It directly supports the generation and delivery of power and other utility services. The digital transformation of utilities requires full mobilization of network assets in a reliable way to ensure maximum transmission of energy from multiple sources. High renewable energy penetration, intermittency and low inertia generate an increased level of threats, which require a full understanding of real-time and future network status, to allow a fast response as rapid changes occur.

Advanced SCADA/EMS has the full power to enable operators towards best operation performance, minimizing risk and increasing flexibility.

As-is Status in Turkey: TEİAŞ is continuing to modernization and upgrade of existing SCADA/EMS System with advanced functionalities. Therefore, this system has not been utilized fully time being.

²³⁸ TEİAŞ Strategic Plan, 2019-2023



This project is funded by the European Union



Recommendation 2 Modernization and Upgrade of Existing SCADA/EMS System with Advanced Functionalities

Prioritization: Short-term

Technical Domain: Advanced Network Management

Recommendation 3 Enable EMS and State Estimation Functionalities

SE is a key enabler for an active network control because, the state of the network must be known in order to efficiently control a network. SE uses network data, real-time measurements, load and production forecasts, and fixed load and production profiles as inputs and, based on this information, estimates what is the most likely state of the network at a given moment. The estimated quantities are node voltage magnitudes and node power injections and current flows in all network nodes and lines.

EMS is the brain of the transmission network management. It facilitates system operators' duties, such as congestion management, operational planning and field management, asset, and maintenance management. EMS covers steady state and dynamic analysis, such as load flows, contingency, short circuit, voltage and frequency analysis in general.

In order to enable EMS functionalities, SE functionalities shall be enabled. Consequently, in order to enable SE functionalities, sufficient amount of real-time data from the power system and the network model shall be updated. Thus, SE can converge, and SE and EMS functionality can be utilized.

Advanced SCADA/EMS has the full power to enable operators towards best operation performance, minimizing risk and increasing flexibility.

As-is Status in Turkey: Due to the lack of updated real time measurements and the network model, SE and consequently EMS functionalities have not been utilized.

According to the 2020 Presidency Annual Program Energy / Measure 496.2: Studies will be carried out to develop a National Smart Grid Management System and National SCADA to be used in Energy State Economic Enterprises, SEEs²³⁹.

Prioritization: Short-term

Technical Domain: Advanced Network Management

Recommendation 4 Initiation of Remote Control (Telecontrol) in TEİAŞ Substations

Automation of Substation is one of the important components of a smart grid. The substation automation systems are at the end of the electric power system's functional hierarchy and they provide two essential functions:

²³⁹ TEİAŞ Strategic Plan, 2019-2023



This project is funded by the European Union



Recommendation 4	Initiation of Remote Control (Telecontrol) in TEİAŞ Substations
- Data source for local automation functions and for the system operator or system level automation functions - Execution level for the system operator or system level automation functions. The availability of synchro-phaser measurements is changing the way substation and power system management and automation are being done in advanced smart grid applications, so they need to be also considered as part of the evaluation of substation and power system automation.	
As-is Status in Turkey: The existing level of substation automation systems in the Turkish electric power system is very limited. Substation automation systems infrastructure have already been partially or fully installed at some 400kV or 154kV Gas Insulated Substations (GISs). However, they are not utilized. The substations in the system are manned	
Prioritization: Short-term	Technical Domain: Advanced Network Management

Recommendation 5	Telecommunication Modernization Project
It is highly recommended that the modernizing TSO's telecommunication system for solving the limited performance and flexibility problems of legacy technology and developing more advanced and flexible plans for network operations. The purposes of that are also developed technical analyses, real-time forecasts, remote monitoring - controls. This modernization also includes followings; - Substation Monitoring Systems - Renewable Generation Monitoring Systems - Load-Generation Shedding systems	
As-is Status in Turkey: There is no comprehensive telecommunication modernization project.	
Prioritization: Short-term	Technical Domain: Telecommunication

Recommendation 6	Implementation of Fault Management System
The fault management system is recommended to TSO for operational and planning purposes. - Reduces impacts of outages. - Reduces unplanned outages - Restoration of outages efficiently	
As-is Status in Turkey: There is no implementation of fault management system.	
Prioritization: Short-term	Technical Domain: Advanced Network Management



This project is funded by the European Union



Recommendation 7 Implementation of GIS and Asset Data Management

GIS provides solutions across the entire enterprise for applications in business, engineering, environmental management, and other disciplines necessary for comprehensive and effective transmission management. GIS shall cover following functions in general:

- Asset Data Management
- Engineering Environmental Studies
- Grid Analysis
- Land Management
- Logistics
- Market Assessment
- Regulatory Compliance
- Right-of-Way Management
- Site Selection
- Vegetation Management

As-is Status in Turkey: TEİAŞ has already implemented GIS and Asset Data Management recently. However, this system does not cover all of the aforementioned functions.

Prioritization: Short-term

Technical Domain: Asset Management

Recommendation 8 Implementation of GIS and OMS and Integration with Enterprise Systems

A geographic information system is essential for electric utility companies. It provides the foundational layer of technology for effective asset management as well as regulatory compliance. Companies use GIS for multiple purposes, from managing field operations to performing spatial analysis.

It's crucial to have an accurate asset inventory with electric poles, transformers, cable lines, substations and other electric utility assets properly mapped. GIS allows to manage the asset data a lot easier and enables to take insight from the infrastructure.

With a properly set up GIS suite, followings can be gotten insights from infrastructure data by:

- Analysing usage patterns
- Recognizing problems and risks like power outages
- Having oversight about energy consumption



This project is funded by the European Union



Recommendation 8	Implementation of GIS and OMS and Integration with Enterprise Systems
- Finding potential threats to the power grid - Managing utility asset repairs In order to use GIS and OMS functionalities more efficiently, it is necessary to integrate this system with enterprise system, such as SCADA/EMS, National Power Quality Monitoring System (NPQMS), etc.	
As-is Status in Turkey: EAI is an on-going task in TEİAŞ.	
Prioritization: Short-term	Technical Domain: Enterprise Application Integration

Recommendation 9	Long-Term Forecasting and Planning/Simulation Software
Electrical power system simulation involves power system modelling and network simulation in order to analyse electrical power systems using design/offline or real-time data. Long term forecasting power system simulation software's are a class of computer simulation programs that focus to prepare a long-term electric energy generation and transmission expansion plan that took the following into consideration: - Demand/spatial load forecasting - Existing generation potential - Potential generation means - Fuel sources - Existing of transmission infrastructure - Tie lines, import and export capabilities - Source diversity in accordance with the relevant laws and regulations, etc.	
As-is Status in Turkey: TEİAŞ has already had PSS/E and DigSILENT Power Factory software's for transmission expansion plan and PROMOD for generation expansion plan. However, they are not integrated and interoperable with each other and the other software for efficient usage.	
Prioritization: Short-term	Technical Domain: Power System Planning

Recommendation 10	Installation of an Enterprise Asset Management System
Enterprise asset management system provides a holistic view of an organization's physical assets and infrastructure throughout their entire lifecycle, from design, commission, or procurement, through to operation, maintenance, disposal, and replacement. This system covers following functionalities: - Asset lifecycle management - Work order management	



This project is funded by the European Union



Recommendation 10	Installation of an Enterprise Asset Management System
• Material management • Labour management • Service contract management • Financial management • Reporting and analytics	
As-is Status in Turkey: TEİAŞ has not installed an Enterprise Asset Management System. In order to use public resources efficiently, it was decided to reduce the financial burden by digitizing business and transactions, and to strengthen the decision support mechanism by integrating information systems with each other²⁴⁰.	
Prioritization: Short-term	Technical Domain: Asset Management

Recommendation 11	Assessment of Cyber Security Maturity Level
Cyber security has become a major requirement for all critical infrastructures, particularly the crucial electric power infrastructure. Cyber-attacks can seriously affect operational systems. Security by obscurity is no longer a valid strategy. Cyber security personnel will need to oversee all of the cyber security requirements for the operational systems, including the periodic training of other personnel in cyber security procedures, the continuous evaluation of existing and new cyber security requirements, and the specification and testing of systems, equipment, and communication protocols for cyber security compliance. In all communications and systems designs, cyber security must be incorporated from the outset and managed in the lifecycle, including from manufacturers, through factory development, installation within TEİAŞ, during operations, as part of maintenance, and even when equipment is retired.	
As-is Status in Turkey: The TEİAŞ operational systems are kept separate from the corporate system, and the operational communications channels are isolated from the corporate communication channels. However, none of the communication protocols used to exchange operational data include cyber security. It has been decided to carry out cyber security studies in a way to meet international norms within the scope of security of supply and protection of critical energy infrastructures²⁴¹.	
Prioritization: Short-term	Technical Domain: Cyber Security

²⁴⁰TEİAŞ Strategic Plan, 2019-2023

²⁴¹TEİAŞ Strategic Plan, 2019-2023



This project is funded by the European Union



3.8.2.2 Mid-Term Project Recommendations:

Mid-term assignment means to implement suggestions within 3 years. These are as follows:

Recommendation 12	Fault Locationing System
The fault location system is a solution for safe, fast, and easy locating a faulty place on transmission system, particularly for underground and submarine cable system. This system is required for reduction of time taken to attend fault site by maintenance staff and related outage duration.	
As-is Status in Turkey: There is no separate fault location system, but new <i>microprocessor-based relays</i>, already installed recently, have this function.	
Prioritization: Mid-term	Technical Domain: Advanced Network Management

Recommendation 13	Advanced Protection Functionalities
Advanced Protection Functionalities can be provided with microprocessor-based relays which are known as Intelligent Electronic Devices (IED). These devices can provide several protection functions and control functions; controlling separate devices, an auto-reclose function, self-monitoring function and communication functions, being main their features: • Many functions in a singlerelay • Group settings readily changeable for changes in feeder configuration • Programmable output relays • Communication ports for connection to SCADA – <i>Supervisory Control and Data Acquisition</i> (Systems, Modems, and Personal Computers) • Sequence-of-events stored for many recentfaults • Oscillography or waveform capture — storage of pre- and post-fault current and voltage waveform data for analysis of faults • Measurements • Interlocking • Aid to circuit breaker maintenance. Fault interrupting duty, per phase, can be recorded • Fault Locator — Displays distance to fault	
As-is Status in Turkey: TEİAŞ has already renewed most of the old relay with <i>microprocessor-based relays</i>. However, all functions of them have not been utilized yet.	
Prioritization: Mid-term	Technical Domain: Advanced Network Management



This project is funded by the European Union



Recommendation 14	Dynamic Thermal Line Rating
There are unused margins between the limits defined by static ratings and the "true limits" measured by a real-time thermal rating system. The dynamic thermal line rating of a transmission line is calculated in real time based on online measurements of the loading of the asset and local weather conditions to maximize use of line capacity, when environmental conditions allow it, without compromising safety. This is important to reduce congestion management cost.	
As-is Status in Turkey: There is no dynamic thermal line rating application.	
Prioritization: Mid-term	Technical Domain: Advanced Network Management

Recommendation 15	Short-Term Load Forecasting Software
Short-Term load forecasting (STLF) is an integral part of the SCADA/EMS which helps power system operators with various decision-making in the power system, including supply planning, generation reserve, system security, dispatching scheduling, demand-side management, financial planning, day ahead market and so forth.	
As-is Status in Turkey: TEİAŞ has STLF software, but not use for the time being.	
Prioritization: Mid-term	Technical Domain: Advanced Network Management

Recommendation 16	Distributed Energy and VPP Management Systems
TSOs shall be able to utilize the market and DSO capabilities to modify energy usage patterns (relieve overloaded HV lines), to expect DER systems to "ride-through" voltage and frequency anomalies, and even to use frequency support from MV/LV DER systems to help maintain power system stability. One of the ways of managing energy resources distributed in a centralised manner on a small and medium scale is through virtual power plants. Thanks to Cloud technology, Virtual Power Plants allow to add the capacities of different distributed renewable energy resources to improve energy generation, network management and the selling of electricity to the market. Distributed Energy and VPP management system can provide new solutions for the energy transition and help to move towards the decentralised electrical system of the future through the addition of distributed energy resources on a BtB level.	
As-is Status in Turkey: TEİAŞ just collects MW and MVAR data on all DER systems larger than 10 MW and on all DER power plants that are larger than 30 MW. This DER data is aggregated for each interphase between the transmission and distribution systems. A prediction algorithm for electricity generation from solar energy will be developed and prepared a report on renewable focused VPP²⁴². There is no distributed energy and VPP management system.	

²⁴² TEİAŞ Strategic Report, 2019-2023



This project is funded by the European Union



Recommendation 16	Distributed Energy and VPP Management Systems
Prioritization: Mid-term	Technical Domain: Advanced Network Management

Recommendation 17	Implementation of a WFM/M-WFM System
Workforce Management System and/or Mobile Workforce Management System is recommended to TSO for improving workforce productivity and more effective asset management. WFM solves the problems related to outages, inspection, maintenance and construction. Main purpose of this system is achieving business effectiveness and peak operational performance. Workforce Management System contains following parts; - Forecasting: Imports needed historical data automatically and delivers workload forecasts accurately - Scheduling: Aims to finish work with right resources in the first time. Optimizes the assignments and schedules with the most efficient possible. Reoptimizes the schedule when there is any change - Dispatch: Offers to personnel a detailed look at the program which contains timelines and tabular windows. Monitors personnel and status of the work. Gives alarms to specific conditions that needs personnel attention and action. Monitors the position of the fleets - Mobile: obtains and manages all of work orders wirelessly on a mobile device. Provides real-time status updates. Reviews and work orders on the mobile map Reporting: Optimizes operations with performance reports. Provides specific visibility and insight for status with long-range trending views.	
As-is Status in Turkey: There is no implementation of a WFM/M-WFM System.	
Prioritization: Mid-term	Technical Domain: Enterprise IT Systems

Recommendation 18	Pilot and Roll-out Projects for Advanced IoT/Sensor Technologies
The Internet of things (IoT) refers to every object, which is connected over a network with the ability to transfer data. Users perceive this interaction and connection as useful in their daily life. However, any improperly designed and configured technology might be exposed to security threats. Therefore, an ecosystem for IoT should be designed with security embedded in each layer of its ecosystem. Then IoT Security Framework can be used to develop a Secure IoT Sensor to Cloud Ecosystem. IoT applications use large arrays of sensors collecting data for transmission over the Internet to a central, cloud-based computing resource. Analytics software running on the cloud computers reduces the huge volumes of generated data into actionable information for users, and commands to actuators back out in the field. Sensors are one key factor in IoT success, that simply convert physical variables into electrical signals. They have needed to evolve into something more sophisticated to perform a technically and economically viable role within the IoT environment.	
As-is Status in Turkey: There is no pilot or roll-out projects for advanced IoT/sensor technology.	



This project is funded by the European Union



Recommendation 18	Pilot and Roll-out Projects for Advanced IoT/Sensor Technologies
Prioritization: Mid-term	Technical Domain: Asset Management

Recommendation 19	Big Data Management Platform
A big data management platform is a kind of software that manages the gathering, storage, and organization of data to have useful information. This platform use big data and artificial intelligence algorithms to process and analyse large data sets about users from various sources.	
As-is Status in Turkey: There is not any big data management platform.	
Prioritization: Mid-term	Technical Domain: Enterprise IT Systems

Recommendation 20	Advanced Technologies for Physical Security
The use of advanced technologies for physical security like access control, network and asset protection, which is as important as cyber security, is recommended to the TSO. It aims the surveillance critical assets and offices of TSO. It provides to anticipate and respond against system disturbances.	
- Motion, sound, video, radar and seismic sensors - Infrared, ultrasonic, micro and radio wave detectors - Surveillance cameras with IP - Advanced video analytics - Auto alarm triggering systems	
As-is Status in Turkey: There is no comprehensive advanced technologies for physical security.	
Prioritization: Mid-term	Technical Domain: Security

Recommendation 21	Usage of Drones for Conditional Assessment of Network Assets
The transmission network is continuously changed by maintenances, upgrades or replaces of equipment. In order to ease these implementations, a new lifetime prediction system which has condition, predictive and risk-based approaches is recommended to TSO. This method defines new and more reliable monitoring system. The other purposes of this system are followings:	
- maintains robust and cost-effective transmission network - optimizes the asset management	



This project is funded by the European Union



- schedules maintenance for transmission network flexibility
- reduces costs
- increases human safety

increases asset availability

As-is Status in Turkey: there is no usage of drones for the conditional assessments of network assets.

Prioritization: Mid-term

Technical Domain: Asset Management

Recommendation 22 Modernization and Reinforcement of OT Cyber Security Systems

Electricity TSO are strongly recommended to modernize and reinforce their OT Cyber Security Systems, since;

- Controlled and Secure Incidents
- Secure Controls to Operating Systems
- Improve Cyber Resilience
- Effective Cyber Response

This implementation also contains followings,

- Network Access Control
- Risk Analysis and Treatment.

As-is Status in Turkey: There is no modernization and reinforcement of OT cyber security systems.

Prioritization: Mid-term

Technical Domain: Cyber Security

Recommendation 23 Modernization and Reinforcement of IT Cyber Security Systems

Electricity TSO are strongly recommended to modernize and reinforce their IT Cyber Security Systems, since;

- Secure Controls to Information Systems
- Reducing Vulnerabilities
- Improve Cyber Resilience
- Effective Cyber Response

This implementation also contains followings;

- Secure Coding
- Secure Encryption



This project is funded by the European Union



Recommendation 23	Modernization and Reinforcement of IT Cyber Security Systems
- IT Security for Power System Design Security - Security Architecture - Risk analysis and treatment. - Network access control - Information access control	
As-is Status in Turkey: There is no modernize and reinforce their IT Cyber Security Systems. However, it has been decided to carry out cyber security studies in a way to meet international norms within the scope of security of supply and protection of critical energy infrastructures²⁴³.	
Prioritization: Mid-term	Technical Domain: Cyber Security

Recommendation 24	Risk Management and OHS System
Risk management and OHS system shall be used to gain Accurate Insights on Organizational Risks through Streamlined Assessments, Record Risk Findings, Assess Controls, Recommend Action Plans, & Monitor Key Metrics. This system, through a software, should cover followings in general: • Field crew management • Risk management • Incident Management • Contractor management • Policies and procedures • Asset safety • Hazard registers • Chemical management, etc.	
As-is Status in Turkey: TEİAŞ has already got ISO 18001 certificate recently. However, there exists no comprehensive Risk management and OHS system together with relevant software.	
Prioritization: Mid-term	Technical Domain: Security

²⁴³ TEİAŞ Strategic Plan, 2019-2023



This project is funded by the European Union



3.8.2.3 Long-Term Project Recommendations

Long term assignment means to implement suggestions within 5 years. These are as follows:

Recommendation 25	Implementation of PMUs and WAMS
The Wide Area Measurement System (WAMS) based on technology which offers emerging and highly functional solutions for power systems analysis, monitoring and control and aimed to provide control room operators with new, advanced monitoring tools and automatic corrective controls, both phenomenon- and event-based, linked with a SPS facilities. the integration between WAMS and SCADA/EMS. In particular improving state estimation, event detection, frequency stability assessment, islanding detection and restoration tests support. The basic processing functions can be included automatic alarms, online frequency domain analysis, modal analysis and coherency areas monitoring. The first step of the Terna WAMS is to develop and involve the installation of Phasor Measurement Units (PMUs) and a dedicated data network with monitoring applications for data processing as well as an intelligent display at the National Control Centre. One of the critical aspects of the WAMS is the location and number of the PMUs necessary to assure complete system observability (e.g. for linear state estimation).	
As-is Status in Turkey: There are some PMUs implementation, but it is limited. There is no implementation of WAMS.	
Prioritization: Long-term	Technical Domain: Advanced Network Management

Recommendation 26	Flexibility Resource Forecasting (RES Forecasting, DR Forecasting)
It is recommended that TSO implement forecasting systems that include renewable energy sources and demand response scopes for operating the network. This system contains; - Analyses from historical timeseries. - Forecasts and verifications on weather conditions Develops Strategies for markets - Decision support - Analyses the node level accurately. - Increases system flexibility. Provides ancillary services with renewables	
As-is Status in Turkey: TEİAŞ has renewable desk within SCADA system, but there is no comprehensive Flexibility Resource Forecasting (RES Forecasting, DR Forecasting)	
Prioritization: Long-term	Technical Domain: Advanced Network Management



This project is funded by the European Union



Recommendation 27	Lightning Location System
Lightning strikes are one of the most dangerous problems for disruptions in the transmission network. Lightning location System collects the real-time data and statistics about lightning frequency and it's hazardous nature. It is highly recommended to TSO for improving OHL engineering, network operations and the works of field crews with the effective and smart design Lightning Location System implementation. Lightning location system's other purposes and contents are followings; - Scoring the effects of surge arresters on lightning spectrum and transmission lines - Collects Lightning trends and forecasts the amount of lightning's potential damage - Calculates mean flash density at ground level for each region. - Estimations for lightning strikes' location and amplitude of return stroke current. - Reduces the repairing time and improves power quality - gives an indicator for installing new transmission lines. reduces of effects of the transient faults on transmission lines.	
As-is Status in Turkey: There is no lightning location system.	
Prioritization: Long-term	Technical Domain: Advanced Network Management

Recommendation 28	Demand Response Management System
It is highly recommended that electricity TSO should always develop a Demand Response Management System by considering communication and load management technologies, to do the active management of loads on a Day-to-day which bases on balance of generation and demand. Approaches to demand response management system include; - Provides the abilities to reach load locations and turn off devices. - Limits demand - Improves cost control - reduce technical losses - improves utilization of assets - Optimizes Transmission network power flow, Provides Remote network monitoring	
As-is Status in Turkey: There is no demand response management system.	
Prioritization: Long-term	Technical Domain: Advanced Network Management



This project is funded by the European Union



Recommendation 29	Intelligent Predictive Maintenance Practices
It is recommended that to implement modern network management by considering on the developing technology level, Electricity TSO should integrate the predictive maintenance approach to network asset management and outage/ maintenance management processes. This approach aims the followings; - Improve security of supply - Extend the operational life of the network inventory - Make stock management processes more efficient - Reduce maintenance costs - Reduce the OHS risks of operators Pre-detection of faults that may occur in the network inventory	
As-is Status in Turkey: There is no intelligent predictive maintenance practices.	
Prioritization: Long-term	Technical Domain: Asset Management

Recommendation 30	Implementation of Big Data Analytics
Data landscape are changing with recent developments in telecommunications and data analytics technologies. with the implementation of smart grid solutions for the electricity transmission grid, TSO will have a large volume of data. Value, variety, velocity, veracity and volume are characteristics of the Big Data concept. Big Data Analytics concept is becoming more important by following purposes; - Digitalization - Better tailor communication - Increasing Transparency for setting price and operation - more confident decision making - Advanced Asset Management Facilitate of identifying operation and market cases	
As-is Status in Turkey: there is no implementation of big data analytics	
Prioritization: Long-term	Technical Domain: Enterprise IT and Application Integration



This project is funded by the European Union



Recommendation 31	Implementation of HVDC
High-Voltage Direct Current (HVDC) cables/lines/ Substation are an efficient way of transporting electricity over longer distances. Potential HVDC Cable/Line/Substation Implementations: - YEKA (Karapınar, etc.), Nuclear Potential Sites (Sinop, İğneada, etc.) and for Replacement of Old Lines for Connection of Major HPPs in South-East Part of Turkey - Not all renewable energy production will be decentralised in the future, at the same time, offshore wind will become increasingly important in the energy mix. That requires electricity to be transported from offshore wind parks to the large, congested loading areas with high levels of short circuit currents and loop-flow, mainly industrial sites and cities, onshore, over long distances. - Possible New Cross Border Interconnections via BtB Systems	
As-is Status in Turkey: Van HVDC BtB System is under construction for Iran interconnection, there is no HVDC cables/lines project.	
Prioritization: Long-term	Technical Domain: Advanced Network Management

Recommendation 32	Implementation of Enhanced Ancillary Services
New technologies are changing the way the energy system works. As the energy system relies more and more on renewables, and more and more energy use are electric (for example because of e-mobility and electric for heating/cooling) the electricity system becomes more decentralized and interactive. Flexibility markets help energy networks to monitor energy flows and create market signals to motivate changes in energy supply and demand, integrating smart meters, smart appliances, renewable energy resources and energy efficient resources accordingly. On the other hand, due to the more integration of renewables power system inertia will decrease. Therefore, synthetic inertia response shall be provided from renewables. For the security of system all ancillary services shall be activated and enhanced.	
As-is Status in Turkey: Frequency and reactive power control are active as ancillary services.	
Prioritization: Long-term	Technical Domain: Advanced Network Management

Recommendation 33	Use of Advanced Storage System
Due to integration of high levels of renewable generation, electric system flexibility need will be increased to enable electricity supply-demand balance. Advanced grid storage systems can be used to enable electricity supply-demand balance. Key factors for using advanced storage system in improving grid flexibility include: increasing the ramp range and rate to follow the variation in net load and	



This project is funded by the European Union



Recommendation 33	Use of Advanced Storage System
the ability to better match the supply of renewable resources with demand	
As-is Status in Turkey: There is no advanced storage system. However, in order to eliminate the constraints created by the increasing renewable energy on the network, it has been decided to install energy storage systems, including HEPPs with pumped storage²⁴⁴.	
Prioritization: Long-term	Technical Domain: Advanced Network Management

Recommendation 34	Interoperability of Existing Systems
Interoperability readiness is becoming extremely important including automating information exchanges and business processes for system operators and utilities. Almost every new system or application will be required to securely interact with other applications or systems considering applicable industry standards as well as ENTSO-E cyber security rules.	
As-is Status in Turkey: There is lack of interoperability of existing systems.	
Prioritization: Mid-term	Technical Domain: Cross-cutting

3.8.3 Other Recommendations on Implementation Roles and Responsibilities

TEİAŞ plays a key role in developing the Turkish power system and achieving the integration of renewable and full usage of domestic energy goals, in compliance with the government policies. TEİAŞ and the other energy market players share a common vision for tackling the main challenges.

TEİAŞ is aware of the need to accelerate new technological smart grid investments. Development of new grid equipment technologies, modelling methods and grid architecture can enable TEİAŞ to fulfil their mission in an evolving energy system.

Investing and operating new technological smart grid performed by TSOs is complementary to the work performed by universities, research institutes or equipment manufacturers. TEİAŞ is more focused on the integration of new technologies to the expansion and operation of Turkish power systems.

However, the integration of new technologies to the Turkish power systems alone will not be sufficient and must be complemented by the emergence of new business models and practices, strengthen the institutional capacity of TEİAŞ.

Increased penetration of renewable energy into the electric network and full usage of domestic energy resources brings certain roles and responsibilities into the agenda of TEİAŞ such as:



This project is funded by the European Union



- Ensure efficient use of SE and consequently EMS software's such as load flow, automatic contingency analysis, etc. as a priority action and the then use of the other programs through interoperability of systems.
- Provide efficient use of separate Wind Desk established in the National Load Dispatch Centre SCADA/EMS system for monitoring and analysing wind power generation. And upgrade SCADA /EMS to include Solar Desk
- In order to enable large renewable energy penetration according to security and energy reliability criteria, update the grid codes to be enhanced ancillary services, as well as considering distributed generation for synthetic inertia, secondary and tertiary reserves, automatic voltage control, curtailment, and control and monitoring of renewable energy facilities.
- Balancing in distributed systems (ancillary services, operation criteria, reverse power flows and demand response management, storage, curtailing and smart metering processes linked to the balancing,
- the implementation of new solutions based on intensive usage of information and telecommunication technologies for data exchange with DSOs, distribution generation and/or consumption, signals among sensors and metering.
- Increase cooperation and coordination among DSOs, public institutions and organizations.
- Increase number of critical appraisal qualified staff and expert and strengthen the institutional capacity of TEİAŞ.
- Cost-benefit analysis shall be performed in justification of the cost of Smart Grid investment, considering societal benefits not only include improvements in quality of life of the consumers through better reliability and sustained access to electricity, it also has impacts on the environment. Accordingly, separate investment program and regulatory incentives shall be considered for smart grid investments.



This project is funded by the European Union

4 Annex

4.1 Annex-1: Europe 2020 Headline Indicators²⁴⁵

The key objectives of the Europe 2020 strategy are expressed in the form of five headline targets at the EU level:

- Increasing the employment rate of the population aged 20-64 to at least 75 %.
- Increasing combined public and private investment in R&D to 3 % of GDP.
- Climate change and energy targets:
 - Reducing greenhouse gas emissions by at least 20 % compared to 1990 levels.
 - Increasing the share of renewable energy in final energy consumption to 20 %.
 - Moving towards a 20 % increase in energy efficiency.
- Reducing school drop-out rates to less than 10 % and increasing the share of the population aged 30-34 having completed tertiary education to at least 40 %.
- Lifting at least 20 million people out of the risk of poverty and social exclusion.

The EU headline targets have been translated into national targets, as defined in the National Reform Programmes. These reflect each Member State's situation and the level of ambition they are able to reach as part of the EU-wide effort for implementing the Europe 2020 strategy.

The following table shows the recent info (between 2014-2018) related to these targets:

²⁴⁵https://ec.europa.eu/eurostat/statistics-explained/index.php/Europe_2020_headline_indicators#The_Europe_2020_strategy



This project is funded by the European Union



Europe 2020 headline indicators, EU-28, 2008 and 2014-2018

Topic	Headline indicator	2008	2014	2015	2016	2017	2018	Target
Employment	Employment rate age group 20-64, total (% of population)	70.2	69.2	70.1	71.1	72.2	73.2	75.0
	Employment rate age group 20-64, females (% of population)	62.7	63.5	64.3	65.3	66.5	67.4	:
	Employment rate age group 20-64, males (% of the population)	77.8	75.0	75.9	76.9	78.0	79.0	:
R&D	Gross domestic expenditure on R&D ⁽¹⁾ (% of GDP)	1.83	2.03	2.04	2.04	2.06	:	3.00
Climate change and energy	Greenhouse gas emissions ⁽²⁾ (Index 1990 = 100)	90.7	77.5	78.1	77.8	78.3	:	80.0
	Share of renewable energy in gross final energy consumption (%)	11.3	16.2	16.7	17.0	17.5	:	20.0
	Primary energy consumption (Million tonnes of oil equivalent)	1 697	1 511	1 537	1 547	1 562	:	1 483
	Final energy consumption (Million tonnes of oil equivalent)	1 180	1 066	1 088	1 110	1 123	:	1 086
Education	Early leavers from education and training, total ⁽³⁾ (% of population aged 18-24)	14.7	11.2	11.0	10.7	10.6	10.6	< 10.0
	Early leavers from education and training, females ⁽³⁾ (% of population aged 18-24)	12.7	9.6	9.5	9.2	8.9	8.9	:
	Early leavers from education and training, males ⁽³⁾ (% of population aged 18-24)	16.7	12.7	12.4	12.2	12.1	12.2	:
	Tertiary educational attainment, total ⁽⁴⁾ (% of population aged 30-34)	31.1	38.0	38.7	39.2	39.9	40.7	≥ 40.0
	Tertiary educational attainment, females ⁽⁴⁾ (% of population aged 30-34)	34.3	42.3	43.4	43.9	44.9	45.8	:
	Tertiary educational attainment, males ⁽⁴⁾ (% of population aged 30-34)	28.0	33.6	34.0	34.4	34.9	35.7	:
	People at risk of poverty or social exclusion ⁽⁴⁾⁽⁵⁾ (Million people)	116.1	120.8	117.8	116.9	111.9	:	96.2 ⁽⁶⁾
Poverty and social exclusion	People at risk of poverty or social exclusion ⁽⁴⁾ (Million people)	:	122.0	119.0	118.1	113.0	:	:
	People at risk of poverty or social exclusion ⁽⁴⁾⁽⁷⁾ (% of population)	23.7	24.4	23.8	23.5	22.4	:	:
	People living in households with very low work intensity ⁽⁷⁾ (% of population aged 0-59)	9.2	11.3	10.7	10.5	9.5	:	:
	People at risk of poverty after social transfers ⁽⁷⁾ (% of population)	16.6	17.2	17.3	17.3	16.9	:	:
	Severely materially deprived people ⁽⁷⁾⁽⁸⁾ (% of population)	8.5	8.9	8.1	7.5	6.6	6.0	:

⁽¹⁾ 2017 data are provisional.

⁽²⁾ Total emissions, including international aviation, but excluding emissions from land use, land use change, and forestry (LULUCF).

⁽³⁾ Break in time series in 2014 (switch from ISCED 97 to ISCED 2011).

⁽⁴⁾ The indicator 'People at risk of poverty or social exclusion' corresponds to the sum of persons who are: at risk of poverty after social transfers, severely materially deprived or living in households with very low work intensity. Persons are only counted once even if they are present in several sub-indicators.

⁽⁵⁾ Data refer to EU without Croatia.

⁽⁶⁾ The overall EU target is to lift at least 20 million people out of the risk of poverty and exclusion by 2020. Due to data availability issues, the target is evaluated only for the EU without Croatia.

⁽⁷⁾ EU without Croatia data for 2008.

⁽⁸⁾ Data for 2018 are estimates.

eurostat

4.2 Annex-2: Italy - Selection Process and Results: A Key Performance Indicator Approach²⁴⁶

The selection of the projects was based on a comparative assessment of different proposals to be presented by DSOs (by November 2010), according to a key- performance indicator (PI) scheme which considers both the benefits and the costs of the projects. Selection process and

In order to develop the most fruitful Indicator of the Benefits (IB), the proposed IB is a combination of quantitative and qualitative indicators. The quantitative indicator (P_{smart}) is defined as the increase in DG production that can be connected and injected in the grid without network refurbishment in safe conditions of voltage, current and frequency thanks to the “smart investments” in the network. The qualitative indicator (technical score, A_t) is defined as judgement and perception about a technical solution proposed in the project.

P_{smart} represents the maximum benefit to be achieved with the project, in fact the first objective of smart investments should be to remove the network constraints so as to accept a larger amount of DG. For this reason, the projects will allow a full exploitation of the SHC of the networks, that represents the maximum generation (P_{smart}) that is possible to connect above the minimum load threshold with no network expansion; P_{smart} is calculated as follow:

$$P_{smart} = \frac{EI_{post} - EI_{pre}}{8760}$$

where:

- EI_{post} is the yearly electricity produced by DG that can be injected in the network after the projects [MWh];
- EI_{pre} is the yearly electricity produced by DG that can be injected in the network before the projects [MWh].

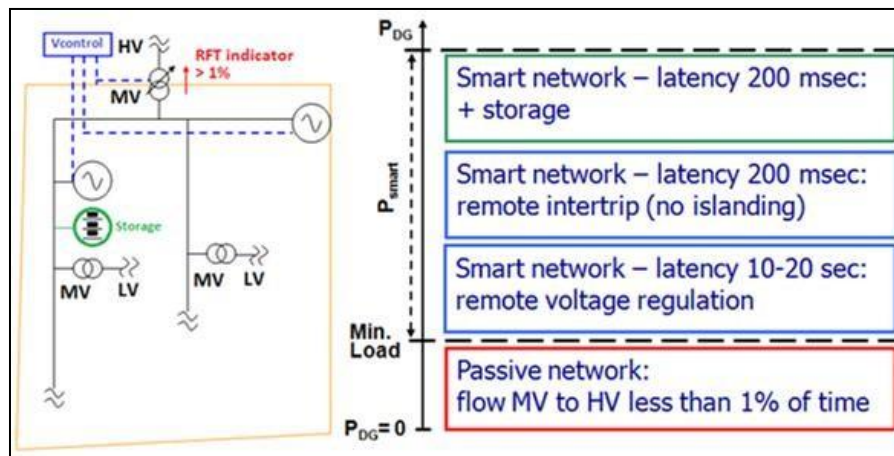


Figure 56: P_{smart} : SHC at Network Level.

²⁴⁶ Delfanti M, Schiavo L, Olivieri V, THE ITALIAN REGULATORY FRAMEWORK FOR DEVELOPING SMART DISTRIBUTION GRIDS



This project is funded by the European Union



As regards the technical score, it is divided into four parts, as stated below.

- *A₁. Size:* considers the number of active users involved, the size of the area involved in the pilot and the effects of the project on increasing production from renewable energy and DG.
- *A₂. Degree of innovation:* considers the degree of innovation that the pilot is able to introduce into the distribution system, with reference to the ability of aggregation of DG and renewable energy aimed at voltage regulation and uniformity of the diagram production, use of communication systems, control and management of distribution networks.
- *A₃. Feasibility:* considers the timing of the project and the impact on quality of supply. A project that could lead to a decrease in steady levels of continuity is considered not feasible or poorly viable.
- *A₄. Replicability on a large scale:* considers those elements that are more sensitive and the requirement of reproducibility on a large scale of the technical solutions proposed in the pilot project.

The maximum score for each part is shown below.

Table 15: Benefit Score (A_j).

A1	SIZE	N. generation plants/storage	6
		Increase of electricity production injected into the grid	12
		Increase of ratio "electricity production / electricity consumption"	8
		N. primary substations involved in the project	4
		Max A1	30
A2	INNOVATION	Participation of disperse generation to voltage regulation	6
		Presence of control system (SCADA)	6
		Bidirectional communication and demand response	6
		Presence of storage systems and active power modulation	12
		Participation of DSO to ancillary service market	10
		Max A2	40



This project is funded by the European Union



A3	FEASIBILITY	Project schedule	4
		Quality improvements	6
		Max A3	10
A4	REPLICABILITY	% of costs on not regulated subjects (DG and storage)	2
		Standard protocols	8
		Consistency between investment costs and expected benefits of the project	10
		Max A1	20
Max Project			100

A key-performance indicator is calculated as follow:

$$PI = \frac{P_{smart} \cdot \sum_{j=1}^4 A_j}{C}$$

where C is the cost of each project.

The selected projects, rank-ordered on the basis of their PI, are shown in the table below.

Table 16: Selected Smart Grid Projects.

Position rank	Primary Substation (PS)	P_{smart} [MW]	Project Benefit (A_j)	C [k€]	PI
1	P1. A2A - PS Lambrate	53170.69	65	733	4715
2	P2. ASM Terni	16176.47	68	800	1375
3	P3. A2A - PS Gavardo	7701.00	65	755	663
4	P4. ACEA D.	44934.25	73	4.970	660
5	P5. ASSM Tolentino	6211.44	66	689	595



This project is funded by the European Union



Position rank	Primary Substation (PS)	<i>Psmart</i> [MW]	Project Benefit (A_j)	C [k€]	PI
6	P6. ENEL D. - PS Carpinone	36996.85	96	6.242	569
7	P7. Deval - PS Villeneuve	12951.76	68	1.616	545
8	P8. A.S.SE.M. S. Severino Marche	3661.41	64	642	365

The eight selected projects have common characteristics (innovative IPR, voltage control in presence of reverse flow, standard protocols), and specific features with respect to the type of environment (urban, rural), the size of the project, and the developed technologies.

As regards the size of the project, some projects consider a few MV lines related to a single HV/MV transformer, other projects consider all MV lines; one project considers two PS with the possibility of network reconfiguration.

Table 17: Impact on MV Grids (Size of the Projects)

	TOT	P1	P2	P3	P4	P5	P6	P7	P8
DG plants/storage	49	7	4	5	5	8	8	6	6
Thermoelectrics	1	-	1	-	-	-	-	-	-
Cogeneration	4	3	-	-	-	1	-	-	-
Biogas	2	-	-	-	1	-	1	-	-
Biomass	2	-	-	-	1	1	-	-	-
Photovoltaics	15	4	2	-	2	3	1	-	3
Hydroelectric	23	-	1	5	-	3	5	6	3
Storage systems	2	-	-	-	1	-	1	-	-
Number of PS	9	1	1	1	2	1	1	1	1
Number of MV lines	80	32	7	4	4	12	5	11	5
Total investment [M€]	16.5	0.8	0.8	0.8	5.0	0.7	6.2	1.6	0.6

Tables below shows the technologies developed in the projects; all projects develop a bidirectional communication system and the automation of MV networks, and consider the participation of DG plants, almost everyone projects



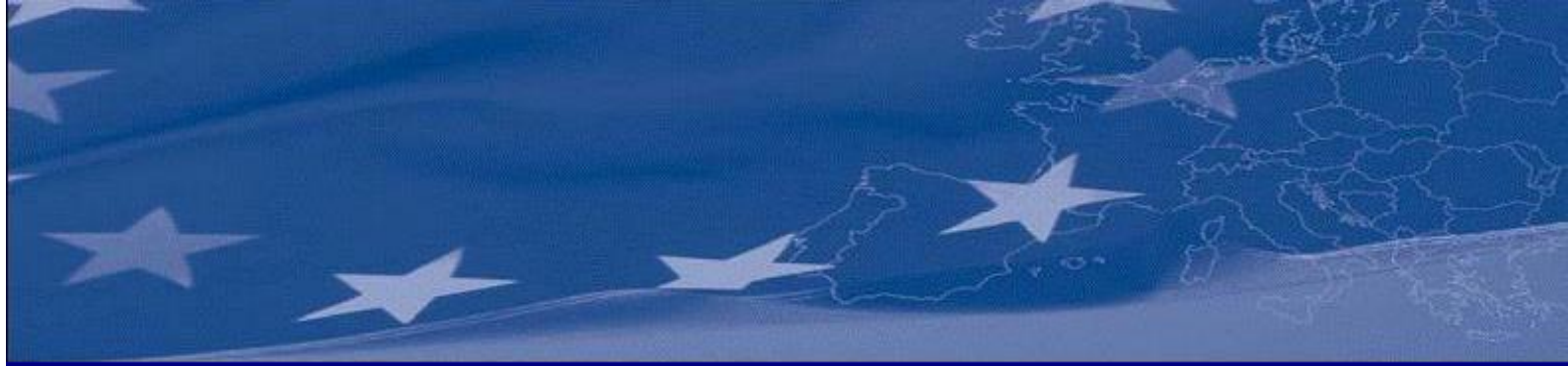
This project is funded by the European Union



consider the participation of DSO to ancillary service market, many projects develop a storage system and a recharging infrastructure for electric vehicles, one project develop a demand response system.

Table 18: Technical Solutions of Selected Projects.

Innovation	P1	P2	P3	P4	P5	P6	P7	P8
Bidirectional communication	YES	YES	YES	YES	YES	YES	YES	YES
Participation of generation plants	YES	YES	YES	YES	YES	YES	YES	YES
SCADA in PS and on field measurements	YES	YES	YES	YES	YES	YES	YES	YES
Automation of the MV grid	YES	YES	YES	YES	YES	YES	YES	YES
Participation of DSO to ancillary service market	YES	YES	YES	NO	YES	YES	YES	YES
Presence of Storage systems	NO	NO	NO	YES	NO	YES	NO	NO
Infrastructure for electrical mobility	NO	YES	NO	YES	NO	YES	YES	NO
Demand response	NO	NO	NO	NO	NO	YES	NO	NO



This document has been produced with the financial assistance of the European Union. The content of this publication is the sole responsibility of the Hulla & Co Human Dynamics GmbH & Co KG and can in no way be taken to reflect the views of the European Union.