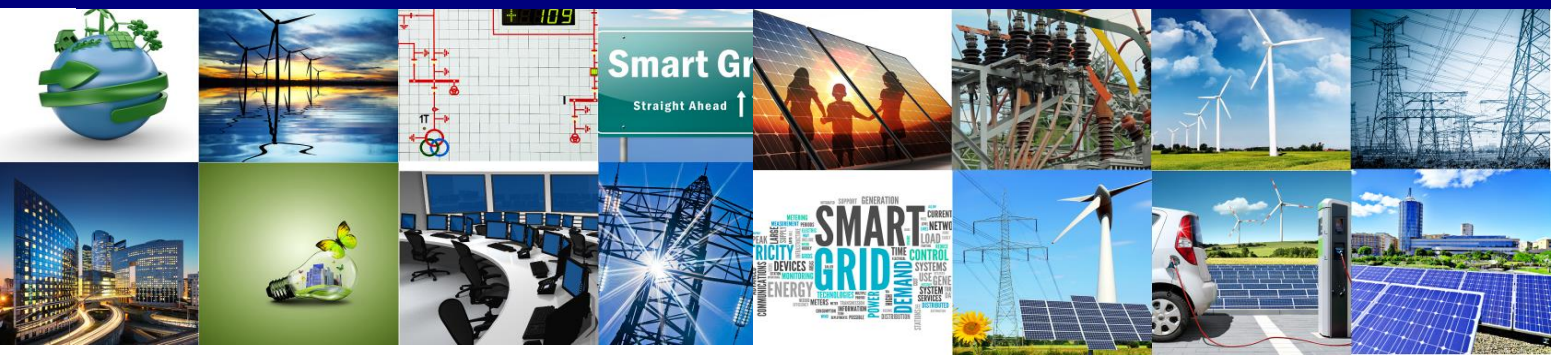
Project No. 609687

FP7-ENERGY-2013-IRP

ELECTRA

European Liaison on Electricity Committed Towards long-term Research Activities for Smart Grids



WP 1

Coordination and Networking

Deliverable 1.3

Report on National funding and strategy in the Smart Grids area

in collaboration with EERA Secretariat

27/03/2018

ID&Title	**D1.3** Report on National funding and strategy in the Smart Grids area	**Number of pages:**	219

Short description (Max. 50 words):

This document summarizes the results of the activities performed within the ELECTRA work package “Coordination and Networking” (WP1) developed in order to outline a scenario and state of the art of the European strategies, priorities, on-going programs, results obtained and stakeholders involved (with particular reference to Industry) in the Smart Grid and the energy sector for the evolution of the European Energy system towards a Smart Energy System

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Accessibility

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Owner / Main responsible:		
Task 1.1 Leader:	Ornella Celi (RSE)	
Reviewed by:		
WP 5 Leader: WP 9 Leader:	Andrei Morch (SINTEF) Graeme Burt (USTRATH)	23/03/2018
Final Approval by:		
ELECTRA Technical Committee TOQA appointed Reviewer:	Luciano Martini (RSE)	27/03/2018

Authors

Name	Last Name	Organization	Country
Ornella	Celi	RSE	Italy
Michele	De Nigris	RSE	Italy
Luciano	Martini	RSE	Italy
Carlo	Tornelli	RSE	Italy
Giorgio	Graditi	ENEA	Italy
Helfried	Brunner	AIT	Austria
Henrik	Bindner	DTU	Denmark
Seppo	Hänninen	VTT	Finland
Laurence	Cornez	CEA	France
Maria	Nuschke	IWES	Germany
Mihai	Calin	DERLab	Germany
Marita	Blank	OFFIS	Germany
Bengt	Lüers	OFFIS	Germany
Evangelos	Rikos	CRES	Greece
Irina	Oleinikova	IPE	Latvia
Andrei	Morch	SINTEF	Norway
Michal	Kosmecki	IEN	Poland
Grzegorz	Krot	IEN	Poland
Filipe	Soares	INESC	Portugal
Emilio	Rodríguez	TECNALIA	Spain
Abdullah	Nadar	TUBITAK	Turkey
Özgür	Kahraman	TUBITAK	Turkey
Graeme	Burt	USTRATH	UK
Steven	Blair	USTRATH	UK
Chris	Caerts	VITO	Belgium
Nikoleta	Andreadou	JRC-ISPRA	EU

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Consisting of:

Coordinator	
Ricerca Sul Sistema Energetico – (RSE)	Italy
Participants	
Austrian Institute of Technology GmbH - (AIT)	Austria
Vlaamse Instelling Voor Technologisch Onderzoek N.V. - (VITO)	Belgium
Belgisch Laboratorium Van De Elektriciteitsindustrie - (LABORELEC)	Belgium
Danmarks Tekniske Universitet - (DTU)	Denmark
Teknologian Tutkimuskeskus - (VTT)	Finland
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Joint Research Centre – European Commission (JRC-ISPRA)	EU

Executive summary

EU strategy sets ambitious goals for the energy systems of the future, characterized by a substantial increase in the share of renewable electricity production and Research and Innovation as also highlighted in the Energy Union Package, are two fundamental drivers to reach the EU goals.

The European R&D activities in the field of Smart Grids have developed in recent years, but still are not completely coordinated among each other to achieve the Energy Union targets. Hence, the contribution that the EERA Joint Programme on Smart Grids (JP SG) is giving to the ELECTRA IRP and vice versa, aims at maximizing synergies and identifying research priorities in order to lead to common European objectives.

The EERA JP SG and ELECTRA worked together to foster the establishment of a significant coherence across national research efforts, critical to the stable operation of the EU power system of 2020 and beyond.

ELECTRA Integrated Research Programme on Smart Grids brings together the partners of the EERA Joint Programme on Smart Grids (JP SG) to reinforce and accelerate Europe's medium to long term research cooperation in the Smart Grids area and to drive a closer integration of the research programmes of the participating organisations and of the related national programmes.

The *"Coordination and Networking*" work package (WP1) constitutes the heart of the coordination activity of the ELECTRA IRP with the EERA JP SG, other EERA JPs and IRPs, the Advisory Board, European and National projects, grid stakeholders, such as ENTSO-E, EDSO4SG, the ETIP SNET and others initiatives such as the IEA Technology Collaboration Program ISGAN and the new Global Initiative MISSION INNOVATION. To this respect an important contribution has been given in 2017 by ELECTRA IRP to the activities developed within the Mission Innovation *Innovation Challenge Smart Grids (IC#1)*- (see chapter 18), bringing the European view on Smart Grids under technical, business and policy points of view.

The main instruments that have been used in the different working groups to ensure coordination of ELECTRA IRP with external key groups and EU grid stakeholders are technical meetings and workshops where, through the exchange of information and sharing of strategy and priorities, possible cooperation area/topics can be identified. Moreover, the contact with other relevant European and national projects and activities brings the advantage of exchanging information, knowledge and lessons learnt about reciprocal R&D efforts.

To this deal it was important to outline a scenario and state of the art of the European strategies, priorities, on-going programs, obtained results and stakeholders involved in the Smart Grids and energy sector.

This deliverable - prepared within the ELECTRA WP1 – and with the contribution of 14 Countries aims at summarizing the present scenario in the Smart Grids area in most of the Countries represented within the ELECTRA IRP and constitutes an important step towards the exchanging process in the Smart Grid sector for the evolution of the European energy system towards a Smart Energy System.

Terminology

Definitions

ELECTRA	European Liaison on Electricity Committed Towards long-term Research Activity
AB	Advisory Board
AMI	Advanced Metering Infrastructure
CA	Consortium Agreement
DER	Distributed Energy Resources
D&D	Demonstration & Deployment
DoW	Description of Work
DSO	Distribution System Operator
EC	European Commission
ERA	European Research Area
EERA	European Energy Research Alliance
EERA JP SG	EERA Joint Programme on Smart Grids
EDSO4SG	European Distribution System Operators for Smart Grids
EEGI	Industrial Initiative on Electricity Grids
ETIP SNET	European Technology and Innovation Platform on Smart Networks for the Energy Transition
ENTSO-E	European Network of Transmission System Operators for Electricity
EU	European Union
EV	Electric Vehicle
ExCo	Executive Committee
FP7	Framework Program 7
FTE	Full Time Equivalent
GA	Grant Agreement
IEA	International Energy Agency
IC	Innovation Challenge
ICT	Information and Communication Technology
ICB	International Coordination Board
IRENA	International Renewable Energy Agency
IRP	Integrated Research Programme
ISGAN	International Smart Grid Action Network
JP	Joint Programme
JP SG	Joint Programme on Smart Grids
JRC	Joint Research Centre
KPI	Key Performance Indicator
MI	Mission Innovation
PC	Project Coordinator

PLC	Power Line Communication
PM	Person Month
R&I	Research and Innovation
RES	Renewable Energy Sources
R&D	Research and Development
SC	Steering Committee
SET- Plan	European Strategic Energy Technology Plan
SIRFN	Smart Grid International Research Facility Network
SPC	Sub-Programme Coordinators
SRA	Strategic Research Agenda
TC	Technical Committee
TCP	Technology Collaboration Program
TPC	Technical Programme Coordinator
TWG	Temporary Working Group
TSO	Transmission System Operator
WEF	World Economic Forum
WP	Work Package
WoC	Web-of-Cells

Abbreviations

MS	Milestone
R	Internal Report
D	Deliverable

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1. Introduction

ELECTRA WP1 activity is performed within task T1.1 "*Coordination of ELECTRA IRP with national Smart Grids roadmaps and programmes, coordination among IRPs, the EERA Joint Programme and other stakeholders"*, which foresees a broad and ambitious approach in order to coordinate the ELECTRA IRP and its activity with the major Smart Grids R&D activities in Europe.

Work Package 1 (WP1) constitutes the heart of the coordination activity of the ELECTRA IRP with the EERA JP on Smart Grids (JP SG), external projects and initiatives as well as interactions with targeted grid stakeholders. In particular, the main objectives of WP1 are:

- Coordination between the ELECTRA IRP and the EERA JP Smart Grids
- Coordination with other IRPs and EERA Joint Programmes
- Interaction with the ELECTRA Advisory Board (AB)
- Coordination with EU grid stakeholders
- Coordination with relevant EU-level projects and initiatives
- Coordination with national programmes

The EERA JP on Smart Grids R&D activity spans from studies, simulations and analyses till the assessment and validation at laboratory scale of the main findings, promoting EERA JP SG involved research institutes to focus and contribute in specific complementary areas of R&D, and to consolidate the results of national programs in direct support of the European strategic energy objectives. A strong support to this approach is provided by the ELECTRA IRP that is certainly instrumental to the achievements of the EERA JP SG goals and outcomes.

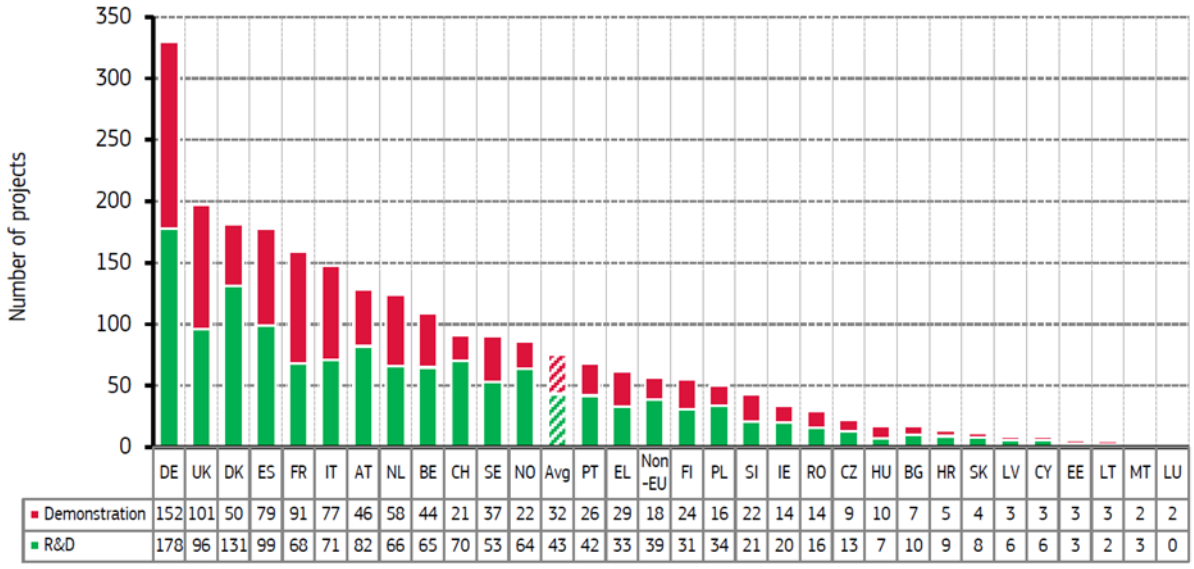
Research and development in the field of Smart Grids is fundamental to develop technology solutions for the design, integration, operation, management and optimization of the power systems of the future, characterizes by an increasing integration of renewables (aiming at a 100% generation from RES). All the ELECTRA IRP Members have ongoing programmes, initiatives and activities in the Smart Grids research field and it is important to highlight and share their knowledge and experiences, identifying common trends and targets towards the European ones.

This document aims at summarizing the results of the analysis carried out - within the ELECTRA IRP work package "Coordination and Networking" (WP1) – in order to outline the scenario and state of the art of the European strategies, priorities, on-going programs, results obtained and stakeholders involved (with particular reference to Industry) in the Smart Grids and energy sector for the evolution of the European energy system towards a Smart Energy System.

In particular, while a first scenario and state of the art was depicted in 2015 (Deliverable D.1.3 relevant to the first half of the ELECTRA Projects), the present documents, released at the end of the ELECTRA Project, reports the updated scenario and state of the art at 2017, taking into account new initiatives and projects recently developed in the field of Smart Grids both at national and international level.

The different participating countries have been contacted and asked to provide their contribution to this important strategic document. Most of ELECTRA participants adhered to this request and hence the contributions from the different partners were collected and examined, sharing comments with each Country representative.

JRC, thanks to its Data Base on European Projects and initiatives in the field of Smart Grids, contributed to have a vision on Europe as a whole, with a large number of both Research and Demonstration projects on Smart Grids developed (as a reference fig Figure 1-1 reports the number of Smart Grids projects in selected European countries in 2017).



	DE	UK	DK	ES	FR	IT	AT	NL	BE	CH	SE	NO	Avg	PT	EL	Non-EU	FI	PL	SI	IE	RO	CZ	HU	BG	HR	SK	LV	CY	EE	LT	MT	LU
Demonstration	152	101	50	79	91	77	46	58	44	21	37	22	32	26	29	18	24	16	22	14	14	9	10	7	5	4	3	3	3	3	2	2
R&D	178	96	131	99	68	71	82	66	65	70	53	64	43	42	33	39	31	34	21	20	16	13	7	10	9	8	6	6	3	2	3	0

Figure 1-1: Number of Smart Grids projects in Europe - 2017

(source "*Smart Grid Projects Outlook 2017 – Facts, figures and trends in Europe*"- JRC)

1.1 Structure of the document

The present document is structured in different Chapters**,** each one dedicated to a specific Country (**Chapters from 2 to 16).**

In particular, to standardize the contributions of the different countries and have a common reference, a template was circulated to all partners and the following items have been defined:

- Landscape of Smart Grids R&D
- Evolution towards Smart Grids (main figures, strategy, plans and key challenges)
- Industry (main industry actors, where in the value chain)
- Public Research Stakeholders
- National R&D strategy
- National priorities (examples of programs, centres, large projects and their thematic focus)
- Funding bodies and programs
- Description of national SET Plan Structure for Smart Grids
- Table "*Supported Smart Grids R&D and Innovation projects"*
- Special attention was meant to be given to Smart Grids projects, so it was asked to include - at the end of each chapter - a table with the most relevant recent Smart Grids projects, sub-divided in R&D activity and DEMO/industrial projects.

A picture of Europe as a whole is given in **Chapter 17**, which reports Smart Grid Projects at National level - both Research and Development (R&D) and Demonstration and Deployment (D&D) – analysed by the Joint Research Centre (JRC) on the base of the JRC Smart Grids Data Base 2017. By this way, the document gives a vision of R&D projects described in detail by each country together with the overall picture of Smart Grid R&D in the EU.

An important global initiative (Mission Innovation) has been recently launched in the clean technology sector, deeply involving R&D in the Smart Grids sector: a snapshot of this global

initiative is given in **Chapter 18**. This global initiative of 22 Countries and the European Union to dramatically accelerate global clean energy innovation, foresees 7 Innovation Challenges, the first of which - IC#1 - is the Innovation Challenge on Smart Grids. Currently IC#1 can count on 18 Countries and the European Union with the participation of a significant number of ELECTRA members and, in particular, about half of the Countries contributing to this document.

In **Chapter 19** National R&D projects are analysed in order to have a picture of what is happening in R&D area in the different countries - with special reference to medium-long term research - and how ELECTRA interacts with R&D projects at National level.
Elaborations are made to emphasize the relation between the different National R&D projects and the Strategic Energy Technology Plan (SET-Plan) themes and to identify R&D trends of the participating Countries in the recent years of activity.
The detailed contributions relevant to R&D projects of the different participating countries are reported in: **ANNEX I** "*NATIONAL R&D PROJECTS relevant to ELECTRA objectives and activities*"

Final considerations are reported in **Chapters 20 and 21**, where an analysis of the results of the contributions given by the different participating countries and evaluations on the main items covered by the document are made.

2 Austria

2.1 Landscape of Smart Grids R&D in Austria

In Austria, around 60% of the electricity is produced by hydro power. There is a significant share of large hydro power plants (e.g. along the river Danube) and pump storages (located in the Alps region) as well as a lot of small and medium scale hydro plants in the mountains. So the share of renewable based electricity generation in Austria is already very high. Nevertheless, it is going to be expected that additional renewables (mainly wind, small hydro and photovoltaics) need integrated into the networks, mainly in distribution networks. Austrian distribution grids are operated by ~120 distribution network operators (including a high number of municipal utilities and small local network operators). The distribution network in Austria typically is designed with three voltage levels:

- High voltage 110 kV
- Medium voltage: 10 kV (mainly urban) to 30 kV
- Low voltage: 0.4 kV

There is only one transmission system operator in Austria operating the 220 kV and 380 kV power systems. The overall electricity consumption in Austria is around 69 GWh (in 2016) with a peak demand of 11.5 GW (in 2017) compared to an overall generation capacity of 25.2 GW (in 2016).

2.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

The main driver for the Austrian Smart Grid research and related projects is the massive integration of renewable-based distributed generation in particular into the distribution system level in mainly rural areas. The focus of the related smart grid projects is to increase the hosting capacity of the existing medium and low voltage distribution networks for distributed energy resources (DER), including distributed generation (DG), demand response (DR), storage and e-vehicles as well as the interaction of transmission and distribution networks. Additionally there is a strong focus on how to integrate new actors, roles and service providers (prosumers, active consumers, aggregators…) in the future power systems in order to support the energy transition in Austria. In the last two years the above mentioned focus has been extend towards inertia and frequency in order to investigate and developed solutions for inertia and enhanced frequency support by inverter based distributed energy resources.

With the support of the ministry for transport innovation and technology as well as the climate and energy fund (see below), individual Austrian projects have been strategically pooled in recent years to generate a critical mass. This has increased European and international visibility of projects and strengthened Austria's position in the implementation of the European Commission's Strategic Energy Technology Plan (SET-Plan). The focus is on an integrated approach for planning and operating distribution grids, which can be divided into two sub-aspects:

- Distribution grid planning, design, and operation to optimise integration of distributed electricity generation
- Integration of customers into a smart grid
- System service provision by distributed energy resources including transmission and distribution system interaction

2.3 Industry (main industry actors, where in the value chain)

Several hundred companies, including several sub-suppliers, working in all areas in power systems and related components are located in Austria. Additionally more and more service providers including aggregators based in Austria are entering the energy market. In Austria there is a small share of companies having production lines as well but a lot of international companies do have development centres in Austria (e.g. Siemens, ABB, Schneider, EATON, IBM).

The innovative expertise of Austrian companies with global potential can be found in ICT, e-mobility, and the energy and transport infrastructure. Austria, as a technology location, has been able to claim top spots internationally in a number of technological fields, demonstrating that Austrian industry is in a strong position, particularly for the development of Smart Grids. Austrian technology providers have acquired extensive knowledge of planning, setting up, and managing energy grids and have developed technological equipment (switched-mode transformers, protection technology, grid automation and control technology, IT solutions, inverters, etc.). Participation in research projects in particular helps promote the long-term protection of Austrian jobs in innovation in the area of building system expertise.

Table 2-1: **Technological Strength of Austria´s electrical and electronic industries**

(Source FEEI)

The Technology Platform Smart Grids Austria (www.smartgrids.at) is an established platform in Austria whose members consist of the relevant stakeholders for the development of Smart Grids. Representatives from the energy sector, industry, and research are active within the platform. The platform also considers it essential for stakeholders not involved in the platform, such as ministries, authorities, and international experts, to participate in helping shape topics for the platform's work. In its role as a network, the technology platform aims to position Austria as a leading smart grid market. Its focus in the medium term is to develop and implement a coordinated and target-oriented research and development strategy.

2.4 Public research stakeholders

Austria's research landscape in the field of Smart Grids is characterised by seamless cooperation between university and non-university researchers on one hand and in-depth cooperation among researchers, industry, and infrastructure operators on the other hand. Players in Austria's smart grid research community are well connected to international partners. Austrian research institutions are among the pioneers in the field and, together with professionals, have successfully developed Smart Grids from the very beginning. The main public research stakeholders in the field of Smart Grids in Austria are:

- Austrian Institute of Technology (www.ait.ac.at)
- Technical University Wien – TU Wien (www.tuwien.ac.at)
- Graz University of Technology (www.tugraz.at)
- Universities for applied research

  - FH Salzburg
  - FH Kufstein
  - FH Joanneum
  - FH Oberösterreich
  - Technikum Vienna
- Energy Institute at the Johannes Keppler University Linz

In order to boost the cooperation between the individual organizations there are several bilateral agreements as well as a joint effort within the Technology Platform Smart Grid Austria.

2.5 National R&D strategy

The government programme 2008 – 2013 contains among other things a commitment to a reduction in greenhouse gas emissions of 20%, strives to increase the proportion of renewable energy from the complete energy usage to 34 %, plans an energy efficiency improvement of 20 % and wants to increase the alternative fuel proportion in the transport sector to 10% before 2020. The achievement of these intermediate goals is a prerequisite in order to achieve the goal of a climate friendly and energy independent Austria by 2050. In late 2017, the newly elected Austrian government announced to provide a climate and energy strategy for Austria in 2018.

The Climate and Energy Fund was brought to life in 2007 by the federal government in order to support putting its climate strategy into action – short, middle and long term. The owner is the Republic of Austria, represented by the environmental ministry and ministry of infrastructure (ministry for transport, innovation and technology - bmvit). The strategies of the Austrian federal government in the areas of research and technology, environmental protection and energy provide the basic essentials that are reflected in the programmes of the Climate and Energy Fund. Important cornerstones for all of the measures are the sustainability and efficiency. The overriding importance of all actions remains the requirement to implement the reduction of national greenhouse gas emissions as quickly and sustainably as possible.

The Climate and Energy Fund law formulates three target areas on which the sponsorship strategy of the climate fund is orientated.

- Research and development in the area of sustainable energy technologies and climate research,
- Boosting projects in the area of public local and regional transport, environmentally friendly goods transport and mobility management projects and
- Boosting projects for supporting the market penetration of sustainable energy technologies relevant to the climate.

From 2007 until 2017 a promotion volume of 1.1 billion Euro has been able to be implemented via more than 110.000 projects funded in 195 calls. In doing so the Climate and Energy Fund has set itself to achieve a broad effectiveness of its initiatives: The building up of the model regions and demonstration projects thereby promises a high multiplication effect which is achieved with a comparatively small outlay.

As above mentioned one of the owners of the climate and energy fund is the **ministry for transport, innovation and technology – bmvit**. Based on the already existing research projects and model regions in the field of Smart Grids, in 2013 bmvit initiated a strategy process called Smart Grid 2.0, which was finalised in 2016. The bmvit's **Smart Grids 2.0 strategy process** was a platform for creating foundations for decision-making and implementation components on which a

consensus can be reached – based on findings of research, technology, and innovation (RTI) initiatives and with the broad-based involvement of stakeholders.

Austria plays already an important role in the development of smart energy systems and the joint implementation of demonstration projects by energy providers, networks operators, industry and research institutions. With the strategy process Smart Grids 2.0 bmvit actively supported this development in cooperation with the energy sector, industry and research. Aim is to analyse the results and experiences gained so far and to derive mid-term strategies and concrete action plans for Austria. Over the course of the bmvit's Smart Grid 2.0 strategy process, the various stakeholders defined a common smart grid vision for Austria, which is described as follows:

- By developing distributed and regional smart energy systems and highly networked infrastructures,
- Austria is setting an example in Europe of successful innovation policy and can draw on successful international partnerships (such as DACH) and broad experience in integrating renewable energy.
- Smart Grids, as an enabler of Austrian technology and system solutions, attract attention to Austrian technology providers in European and global markets (Austria holds a pole position).
- Austria's scientific community is becoming a frontrunner in research (already among the top in European SET-Plan initiative grids) and training.
- The development of sustainable energy systems that are highly efficient, optimised for resources, renewable, distributed, synergistic, resilient, participatory, and market-based ensures a sustainable energy supply.

Three initiatives were launched as the pillars of the strategy, which are supported by additional national working groups and international research programmes (see also Figure 2-1). The outcomes will be incorporated into the federal government's RTI strategy.

- **Technology Roadmap Smart Grids Austria**[1]
  The primary aim of the technology roadmap is to define the short- and medium-term development steps (2020) that must be completed by key stakeholders – the energy industry, technology providers, and the research community – so that Smart Grids can be implemented.
- **Strategic Research Agenda for Intelligent Energy Systems**[2]
  The Strategic Research Agenda determines the need for research in smart grid technologies with the goal of optimizing the entire energy infrastructure between now and 2035. It aims to consider all relevant topics across sectors and to identify synergies in light of the transition to integrated energy and ICT infrastructures. It consolidates individual topic areas into one single research agenda. (published April 2016)
- **Workshop Series for the developing the elements of an implementation strategy**
  Aim of the workshops is to discuss different issues concerning Smart Grids with the involvement of relevant players in Austria. The strategy process acts as an open space for established and new players in order to design the basis for decisions and elements for the implementation.

[1] https://www.smartgrids.at/files/smartgrids/Dateien/Dokumente/05%20Roadmap_Management_Englisch.pdf
[2] https://nachhaltigwirtschaften.at/resources/e2050_pdf/reports/1604_strategic_research_agenda_2016.pdf (German only)

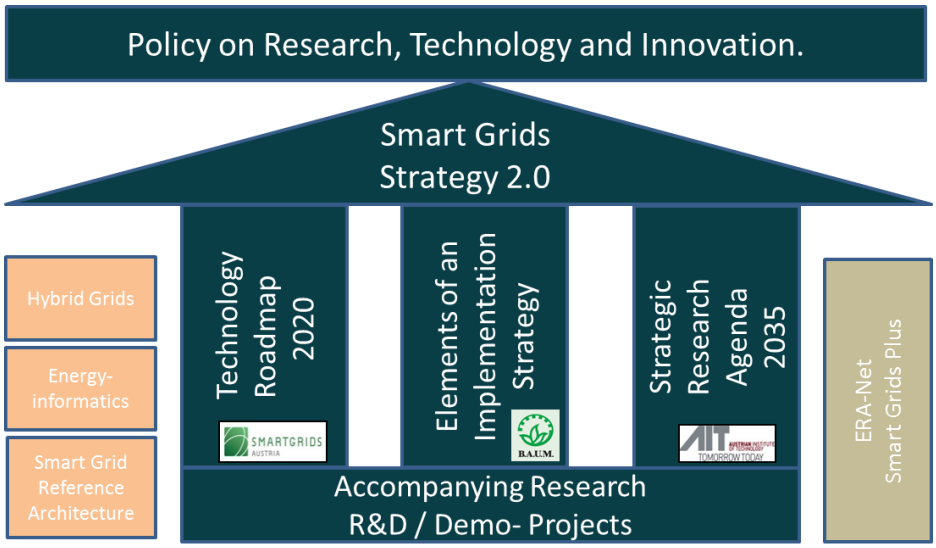


Figure 2-1: Strategy Process Smart Grid 2.0 hosted by the AustrianMinistry for Transport, Innovation and Technology

The strategy process Smart Grids 2.0 was part of a broader Smart Energy strategy process including the innovation area Smart Cities as well. The results are going to be incorporated the governmental policy on research, technology and innovation.

Additionally a strong link between the Austrian research strategy and related research programs with the European research strategy is given via the ERA-Net Smart Grid plus initiative. The Austrian ministry for transport, innovation and technology is actually the project leader of the initiative. ERA-Net Smart Grids Plus is an initiative of 21 European countries and regions aiming to enable the right technologies, market designs and customer adoption in order to achieve the Smart Grids vision and goals of Europe: an electric power system integrating renewable energies and flexible consumer and production technologies that can help shape an electricity grid with a high security of supply, coupled with low greenhouse gas emissions, at an affordable price.

ERA-Net Smart Grid Plus is enhancing synergies between national Smart Grids programs, creating a coherent collaboration network that can further serve the Smart Grids European Research Area Network and beyond. It will coordinate additional national and regional RDD (Research, Development & Demonstration) budgets according to the implementation of the relevant European RDD agendas.

Based on the Energy Research Strategy published by the Austrian Council for Research and Technology in 2010, the Federal Ministry for Transport, Innovation and Technology, in conjunction with the Climate and Energy Fund, launched a consultation procedure in the spring of 2016, to support the alignment of future activities in the area of energy research and energy innovation with the current objectives. Content-related as well as strategically relevant issues were discussed by representatives from research, business, administration and interested members of the public. As a result of the so-called future of energy dialogue 2050, in March 2017 Austrian ministry for transport, innovation and technology published an energy research and innovation strategy3. Aim was to align future energy research and innovation policy with the challenges of energy supply and current targets. To achieve this, six interacting topic areas have been identified, which are shown in Figure2.3. Technical aspects of Smart Grids (electricity system) are included in the area energy systems and networks. Sector coupling is a significant priority here, i.e. linking electricity, heating and mobility systems so that renewable energies can be used as effectively as possible in an

[3] https://nachhaltigwirtschaften.at/resources/e2050_pdf/E-Forschung_Kurzfassung_englisch_v2.pdf

integrated way. In this kind of holistic system concept the physical world of energy with its sectors of electricity, heating and mobility and associated infrastructures (networks) should be merged (convergence), and developed in conjunction with the economic organizational aspects (transformation); these should all be aligned at the various cellular, decentralized, central and international levels (coherence).

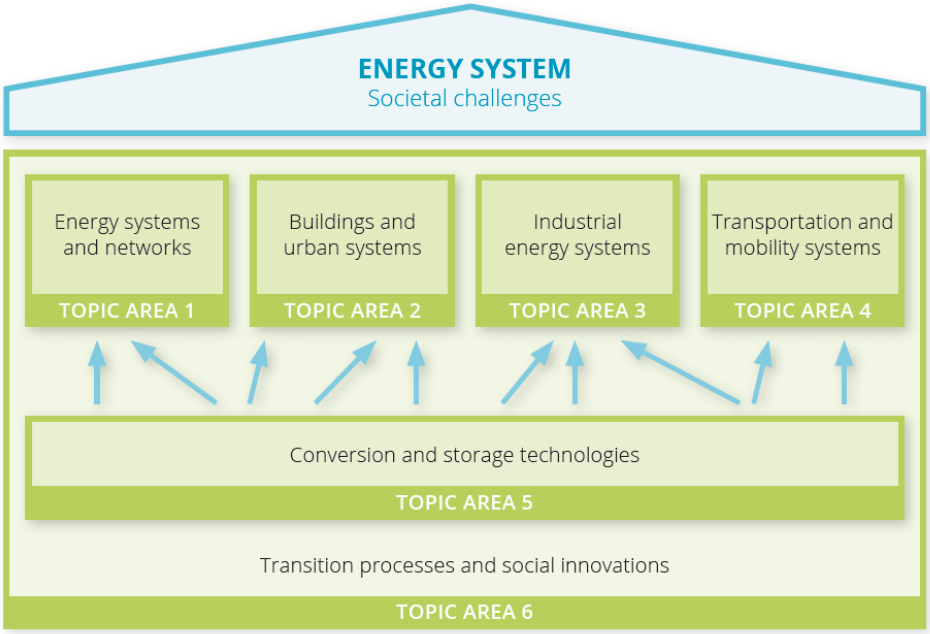


Figure 2-2: Topic areas for Austrian energy research

Key issues related to energy systems and networks are:

- Further development of the electricity systems with particular regard to distributed and cellular approaches
- Transformation of the heat and gas networks, for instance development of appropriate environmentally friendly renewable resources, differentiated network management or diversification of supply options to meet customer needs (green energy services, cooling, mobility, etc.)
- Creation of an innovative environment for user integration/development

2.6 National priorities (examples of programmes, centers, large projects and their thematic focus)

Several model regions have been established in Austria in the course of the research projects being conducted here. The smart grid technologies that have been developed were field tested in these regions. Current model regions and demonstration projects in Austria are:

Smart Grids Pioneers

- Smart Grids Model Region Salzburg (EEGI Core Project)
- Smart Grids Pioneer Region Upper Austria
- Smart Grids Pioneer Region Vorarlberg
- Smart Services for the Greater Linz Area
- Smart Grids Pioneer Region Styria

Smart cities/smart (urban) regions:

- Smart City Salzburg – Smart District Gnigl
- Smart City Demo Vienna Aspern
- Smart City Rheintal
- Smart City Villach

Details about the individual model regions and demonstration projects can be found in the Technology Roadmap Smart Grids Austria, published in May 2015.

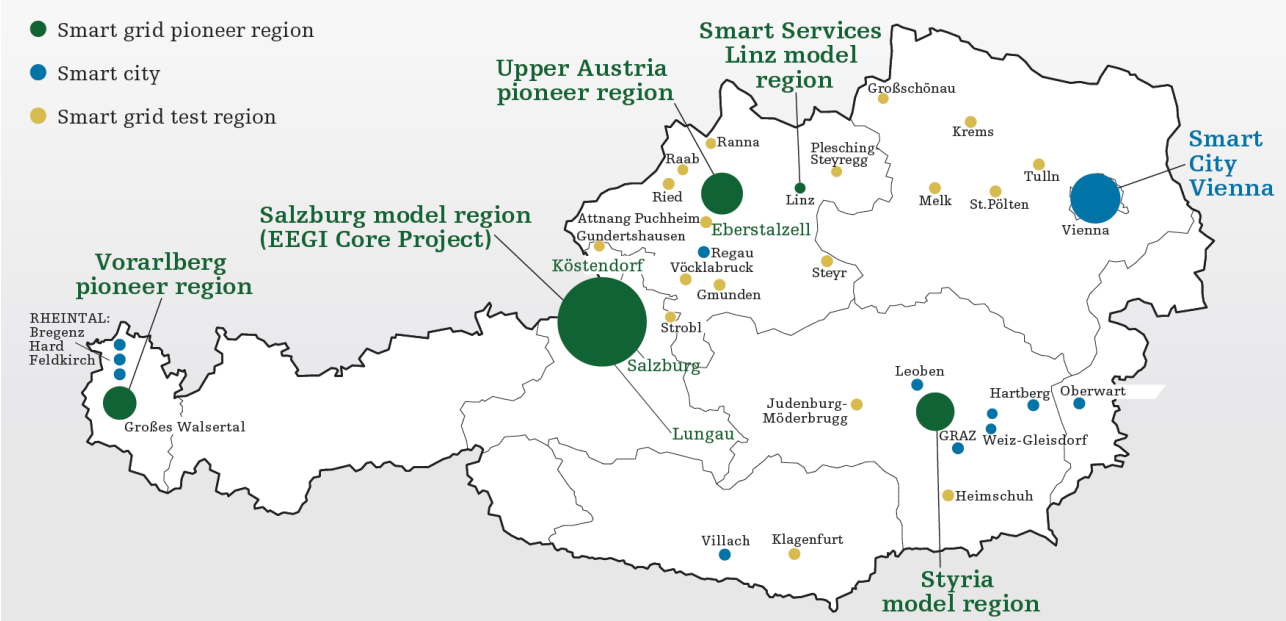


Figure 2-3: Smart Grid and Smart City Model Regions in Austria

2.7 Funding bodies and programs

As described in chapter 2.5, the main funding agency including the support of research in the field of power systems is the Climate and Energy Fund aiming in a “Zero Emission Austria“. The Climate and Energy Fund was brought to life in 2007 by the federal government in order to support putting its climate strategy into action – short, middle and long term. The specific programmes and related content is described in an annual work program provided by the climate and energy fund.

The program for 2017 includes:

- Programme for research
  - Austrian Climate Research Programme
  - Energy Research Programme
  - Vorzeigeregion Energie (large scale energy model regions)
  - Smart Cities Initiative
  - Energy Transition 2050
- Programme for traffic
  - Electromobility for Austria
  - Multy_Modal_Mobile and sustainable logistics
- Programme on market penetration
  - From research into market

- Buildings as power plants
- Austria towards a sustainable energy system
- Supporting renewable energies

The research area of Smart Grids is mainly covered by the energy research and the related annual calls (including a specific part on intelligent networks).

The overall budget for the energy research programme in 2015 was 20 Million Euros. The programmes support both small scale research projects (up to 2 Million Euros) and so called flag ship projects with a funding request > 2 Million Euros.

In 2017 a program for supporting large scale energy model regions in Austria has been launched. For the next 8 years the Climate and Energy Fund is going to invest up to 120 Mio. €. Aim is to develop best practices enabling 100% renewable energies with innovative energy technologies made in Austria and to demonstrate the feasibility in specific regions. The three selected model regions including 228 partners and >395 Mio. € investment are:

- Green Energy Lab - Accelerating user-centric integrated solutions for the renewable energy system of tomorrow (aim is to increase the days with 100% renewable heat and electricity provision by factor 5 until 2025)
- WIVA P&G –Hydrogen Initiative (demonstrating the shift of Austrians energy supply toward a strongly hydrogen based energy system)
- NEFI – New Energy for Industry (decarbonization of producing and energy intense Industry)

Starting with Q2/2018 and within the next 5 years, the three selected energy model regions are going to submit full proposals for all individual projects within the model regions.

2.8 Description of national SET Plan Structure for Smart Grids Research

In Austria two ministries are responsible for the coordination of the SET-plan activities, namely the federal ministry for transport innovation and technology and the federal ministry for science, research and economy. Both federal ministries are members in SET-plan Steering Group.

Table 2-2 - Supported Smart Grids R&D and Innovation projects in Austria with ELECTRA IRP relation

R&D project (for details see Annex I)	Company	Total budget (Million EUR)
Leafs- Integration of Loads and Electric Storage Systems into advanced Flexibility Schemes for LV Networks	Austrian Institute of Technology– Lead; partners from Industry, DSOs and Universities	2,2
DeCAS - Coordination of ancillary services covering different voltage levels and the integration in future markets	AIT-Lead, Industry, DSOs, Universities from Austria	1,8
ABS4TSO – Advanced balancing services for transmission system operators	TSO lead, AIT, University, Industry	2,7
BatterieSTABIL – Battery storage in multi-modal operation for ancillary services and system stabilisation	DSO lead, AIT, University	1,1

R&D project (for details see Annex I)	Company	Total budget (Million EUR)
FACDS – Power system stabilization and optimization by applying “Flexible AC Distribution Systems	DSO lead, AIT, University, Energy Supplier, Industry	1,7
DG DemoNet Smart LV Grid - Control concepts for active low voltage network operation with a high share of distributed energy resources	AIT – Lead, Industry, DSOs, Universities	2,2

3 Belgium

3.1 Landscape of Smart Grids R&D in Belgium

Belgium's electricity generation was 71.5 terawatt-hours (TWh) in 2014. This is a decline of almost 24% compared to the 93,8 TWh in 2010 which is mainly due to a series of (long-term) outages of Belgium's nuclear power plants in the last years. The Belgian energy mix is for a large part **nuclear** based (~47% in 2014) and is as well heavily depending on **imports** (21,5% of demand in 2014). These imports grew by 120% since 2009, partly to compensate nuclear power outages, partly to replace domestic natural gas sourced electricity by cheaper imported wind and solar sourced electricity.

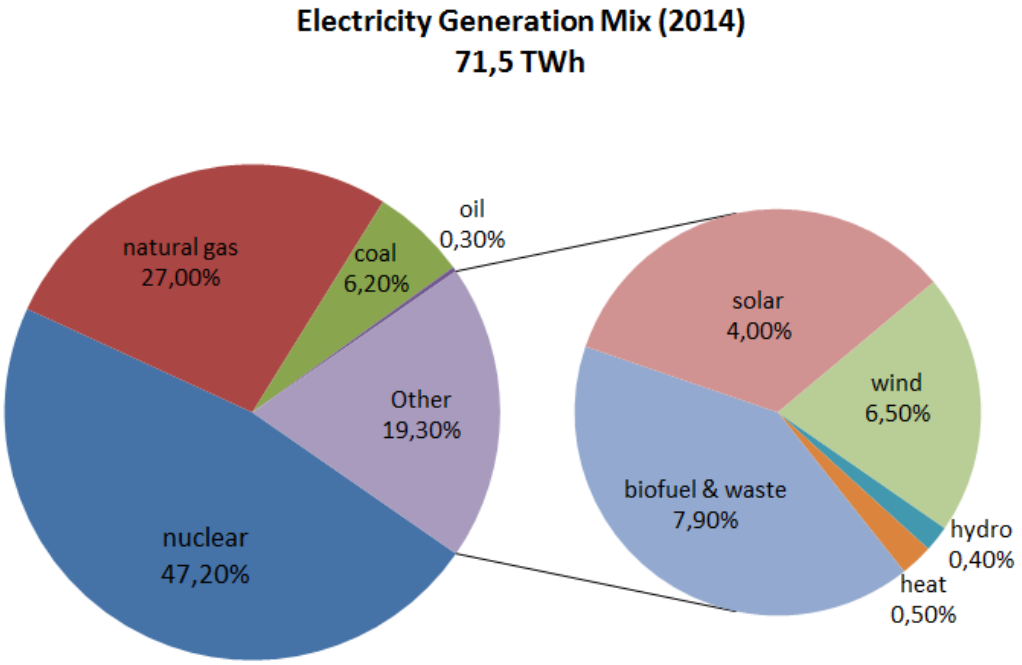


Figure 3-1: Belgium's 2014 Electricity Generation Mix

3.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

Security of supply remains the key challenge in the Belgian power system. Already in 2003, a **nuclear phase-out** plan was agreed that stipulated the closure of the oldest three nuclear power plants – accounting for 30% of the nuclear capacity – in 2015. After a lifetime extension of several units, the schedule for the nuclear phase-out now foresees the closure of all nuclear units by 2025 the latest, according to current legislation. The nuclear phase-out requires the replacement of 5.9 GW of available capacity in a system with peak demands of about 12-13GW. Several investments in interconnection cables to the UK (1GW) and Germany (1GW) will increase the import capacities in the next years.

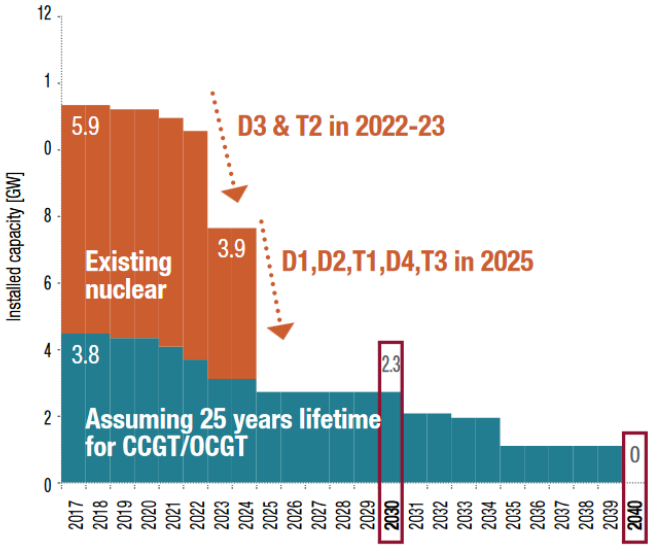


Figure 3-2 Development of Belgium's existing CCGT/OCGT and nuclear capacities
(Source: Electricity Scenarios for Belgium towards 2050)

According to a recent study of EnergyVille (*Energy Transition in Belgium – Choices and Costs*), replacements for domestic capacities are vital for the security of supply in the Belgian power system. The study confirms that with the closure of the nuclear plants and the increasing intermittent renewable production, electricity imports and gas plant based generation play a crucial role in the energy system. To fill this gap and replace capacities (as shown in Figure 3-3), Elia estimates the need for additional investments in flexible capacities to up to 3.6 GW.

In the meantime, a series of (long-term) outages in the nuclear power plants caused a dramatic drop in the domestic electricity generation which has put the security of supply topic very high on the agenda. To ensure security of supply (especially in cold winter months), the system operator makes an annual estimate adequacy assessment, eventually leading to the contracting of Strategic Reserves (currently 0 MW, but expected to increase). Additional national awareness campaigns to save electricity have been proposed. In order to give incentives, for additional capacity providers in times of scarcity, the tariffs for imbalances can be increased up to 4500 Euro/MWh.

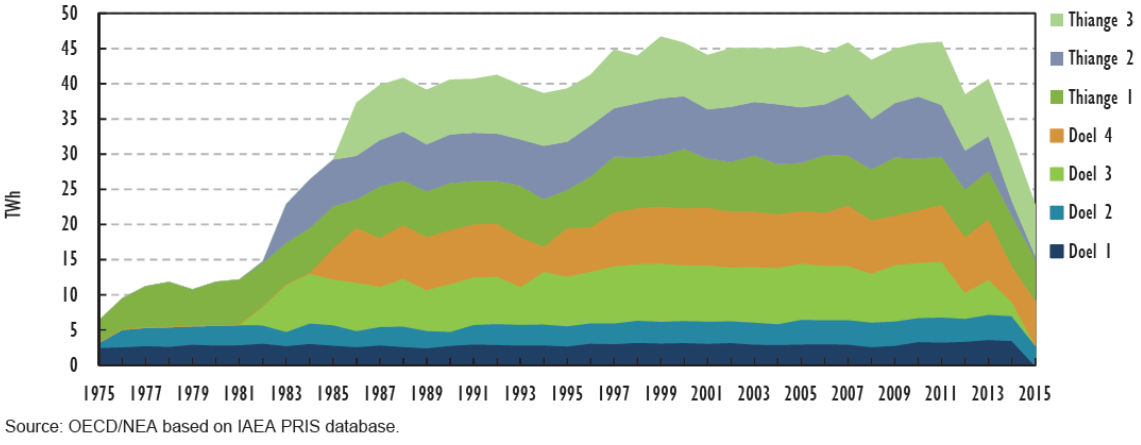


Figure 3-3: Electricity generated in nuclear power plants showing the effects of the unforeseen outages in the period 2011-2015

Between 2009 and 2014, a strong support program boosted the share of renewable electricity from 7.8% in 2009 to 19% in 2014, but at a high cost (subsidies for renewable electricity amounted to EUR 1.7 billion in 2013, with a large share of solar photovoltaics). Subsidy schemes have been

changed abruptly which had an immediate effect on the further growth of renewable generation. Yet in 2016 again a growth was observed (171MWc in 2016 versus 100 MWc in 2015).

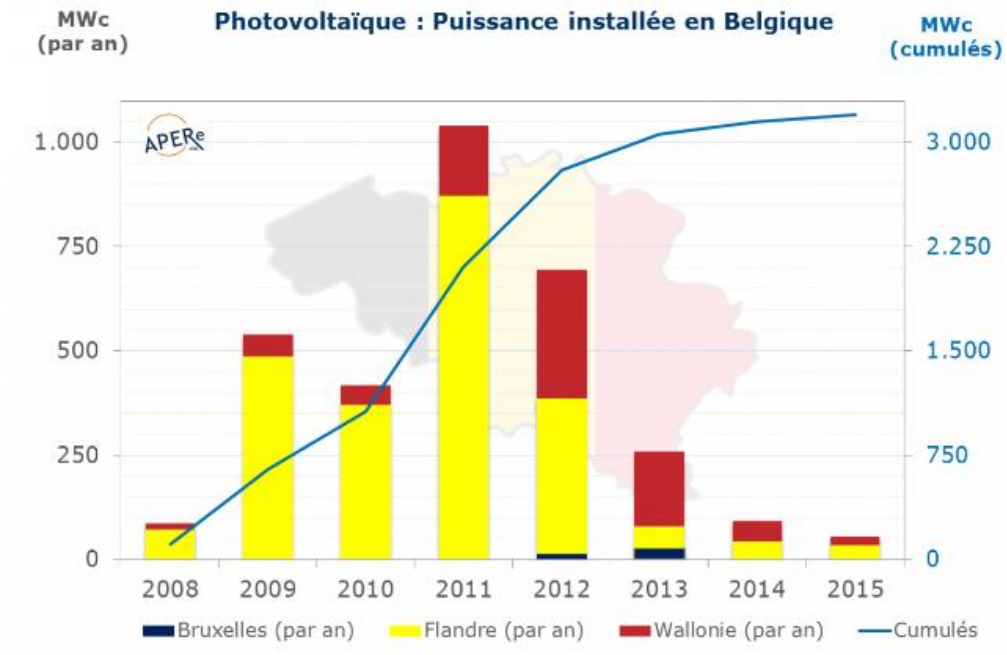


Figure 3-4: Evolution of solar power installations
(Source : Observatoire photovoltaïque - association for the promotion of renewable energy)[4]

3.3 Industry (main industry actors, where in the value chain)

The Belgian high-voltage electricity network is owned and operated by Elia, the TSO. In 2015, the transmission system had a total length of 3 655 km, of which 891 km at 380 kV level, 302 km at 220 kV level and 2 462 km at 150 kV level.

The Belgian medium and low voltage distribution grid is regionalized. The Flemish DSOs (12 in total) are fully owned by local public authorities (intermunicipalities); two operating companies (Eandis and Infrax) carry out the grid management for 11 of the 12 DSOs. These Flemish DSOs invest around EUR 500 million per year in networks for extension, renovation and replacement.

In the Walloon region, 13 DSOs operate. Seven of the merged at the end of 2013 and created ORES Assets which is responsible for almost 80% of distribution in the Walloon region. The six DSOs are held by municipalities and provinces only. These Walloon DSOs invest about EUR 200 million per year in networks for extension, renovation and replacement.

In the Brussels-Capital region, there is one DSO – Sibelga – which invests about EUR 70 million per year in network extension, renovation and replacement.

Market concentration is very high in Belgium, even though it is gradually improving. Engie (formerly Electrabel), who also controls the nuclear power plants, is the historical incumbent and still held 66% of generating capacity in 2014 (coming from 85% in 2007). EDF Luminus has the second-largest capacity (12% of the total at the end of 2014), followed by E.ON (7%), T-Power (3%) and Enel (3%). Although the concentration of domestic electricity generation is still very high, the fact that Belgium is well interconnected and about 21,5% of the electricity is imported, has helped to increase competition in electricity supply.

[4] http://www.apere.org/observatoire-photovoltaïque

3.4 Public research stakeholders

The Flemish government finances Energy Technology Research, Development and Demonstration (ETRDD) via a number of the **Strategic Research Centres**:

- VITO (Flemish Institute for Technological Research)
- IMEC (Interuniversity Microelectronics Centre, the Research Institute for Microelectronics and Nanoelectronics)
- iMinds (ICT Research Centre)

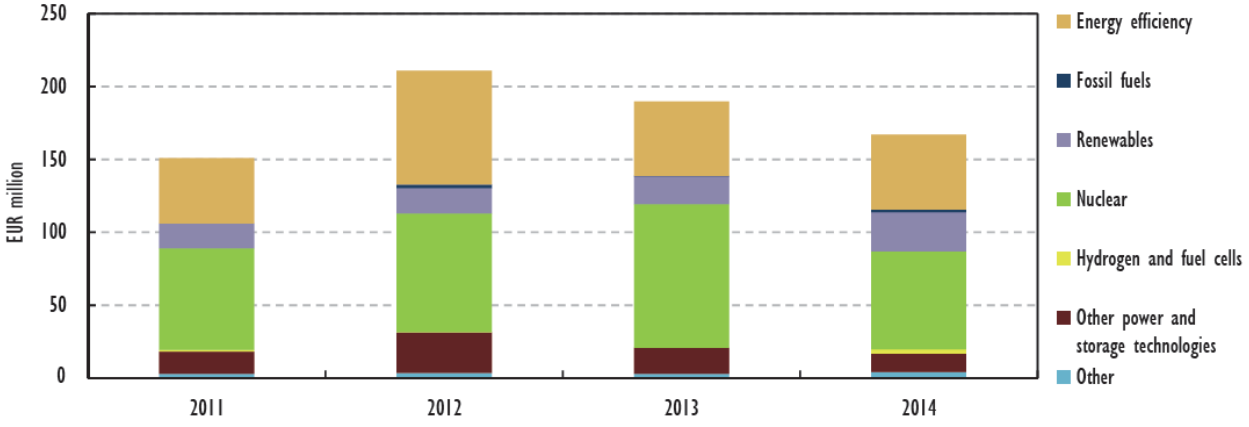
VITO, the University of Leuven (KULeuven) and IMEC have bundled their expertise in the field of sustainable energy and intelligent energy systems in the Research Centre **Energyville**.

The Belgian Energy Research Alliance (**BERA**) is an association of all important research partners active in energy research in Belgium. The members include all universities and the most important energy research centers. BERA is a member of EERA (European Energy Research Alliance) and through its members also a member of 12 EERA Joint Programs (JP's).

Smart Grids Flanders (**SGF**) is a networking platform that is devoted to bring together relevant players from industry, research and government for knowledge sharing, networking and project support.

3.5 National R&D strategy

The European Strategic Energy Technology (SET) Plan is an important reference framework for Energy Technology Research, Development and Demonstration (ETRDD) in Belgium. But energy policy responsibility in Belgium is complex and is divided between the federal government and the three regional governments. In 2013, total public spending on ETRDD amounted to EUR 190 million. From 2011 to 2014, public funding allocations focused on **nuclear energy** (47% of the total) and **energy efficiency** (29%), with smaller amounts budgeted for **electricity generation/networks** (11%) and **renewable energy** (11%).



Notes: Includes demonstration.

Source: IEA (2015), "RD&D Budgets", *IEA Energy Technology RD&D Statistics* (database), www.iea.org/statistics/.

Figure 3-5: Total Belgium public spending on ETRDD (Energy Technology Research, Development and Demonstration)

In May 26th, 2016, the **Flemish Energy Cluster** was launched by nine organizations (Smart Grids Flanders, Agoria, Voka, Vlaamse Confederatie Bouw, Passiefhuis Platform, Living Tomorrow, iMinds, UGent and EnergyVille) representing the energy, building and ICT industry and research, to realize an international competitive 'Smart Energy Region Flanders'. The Flemish Energy Cluster confirms that energy is becoming a priority in the innovation policy. Through this initiative, the Flemish government will support major industrial initiatives to accelerate the energy transition. It aims at a unique system integration of multiple novel energy components by combining energy, building and ICT sector, coming together in innovative living lab projects.

The formal start given on December 19th 2016, and branded as **Flux50**. Flux50 will be responsible for setting up and coordinating living labs in five 'innovator zones': (1) energy harbors, (2) microgrids, (3) multi-energy solutions at district level, (4) energy cloud platforms and (5) intelligent renovation. In May 2017, Flux50 launched a first Feasibility Study Call. 14 feasibility study projects were deemed eligible for funding and are currently being finalized. A second call closed in October 2017 and 14 submissions, totaling 33 partners, are currently (December 2017) under evaluation. The first innovation trajectories/living labs per innovator zone will start early 2018.

In 2017, the Flemish Minister for Finance, Budget and Energy has put forward an energy vision to realize the energy transition in Flanders until 2050 (**"De Stroomversnelling"**). The vision serves as input to develop the Belgian energy and climate roadmap for 2018. It confirms the commitment to reduce CO_2-emission by 80-95%. Five working areas are defined: 1) Energy Efficiency, 2) Renewable Energy, 3) Flexibility, 4) Financing, 5) Governance. With respect to flexibility/Smart Grids, the energy vision emphasizes the roll out for digital meters or smart meters. It is the outspoken goal to equip the majority of residential consumers with digital meters. Starting from 2019, the digital meters will be installed in several steps with a target of 200,000 digital meters per year. According to the energy vision, this will enable Flanders to create new markets and services to tap flexibilities in a technology-neutral way. The resulting market entry of new technologies like batteries, new smart appliances and smart grid operation is the envisioned way forward.

Atrias, an initiative of the 5 large DSOs in Belgium (Eandis, Infrax, ORES, Sibelga en RESA), acts as a neutral consultation platform for the system operators, suppliers and regional regulators, and will prepare the Belgian energy market for new developments in the energy domain. The focus of Atrias is on the development and optimization of the processes in the energy market. Normalization and standardization of procedures for the exchange of information between market parties are part of it. Aim is to realize a central Clearing House for the Belgian market, a technical platform for structuring and exchanging market data between Belgian energy actors.

The adaption of the regulation of the market processes, called MIG6, fitted to the new meter architecture and meter data streams will not be finished before the start of the Flemish smart meter rollout, therefore the current version (MIG4) will be used.

3.6 National priorities (examples of programmes, centers, large projects and their thematic focus)

In 2014, the Federal Planning Bureau decided on a Reference Scenario in the *Energy Outlook for Belgium towards 2050.* The key messages of this are:

- **Energy efficiency will improve largely**, driven by EU energy and climate policies, and binding targets for 2020 on reducing GHG emissions and increasing the share of renewables

- **Renewable energy** growth will continue; beyond 2020, the development of renewables will focus on electricity generation, and renewable energy will account for 54% of total net generation in 2050.
- The **planned nuclear phase-out** and the implicit ban on new investments in coal for power generation will **change the diversity of electricity supply** beyond 2025. The power sector will then rely on **natural gas and various renewable sources**. Moreover, the high share of renewables will entail considerable capital investments to **cope with the variability of wind and solar**, and to **ensure generation adequacy**.

In 2017, an updated vision was formulated by the Flemish Minister for Finance, Budget and Energy as part of the "**Stroomversnelling".** A first explicit priority that was formulated is to start **a Smart meter rollout.**

Flemish region:

In the past 4 years the Flemish DSOs Eandis and Infrax have conducted 2 pilot projects on smart electricity and smart gas meters (about 50.000 meters in total). In 2017 the Flemish government then decided for a segmented rollout of the digital meters from 2019 on. Installations in new or deep refurbished buildings, new installations with RES, new prepayment meters and planned replacement of old analog or dysfunctional meters will be served first. When replacing the electricity meter, the old gas meter, if present, will be replaced at the same time by a new digital gas meter. The Flemish government opted for a 'lean and mean' meter, focusing on the metering functionality. Advanced tariff functions or prepayment functions will be realized in the back-end; energy management functions will be implemented in the back-end and/or in additional equipment (for instance a customer energy management system) on premise.

In September 2017 a pilot on pre-payment meters has been initiated in two cities in Flanders. Contrary to the previous pre-payment meter setup, the regular digital meter will be used for the pre-payment use case.

Brussels region:

A pilot project with 5,000 digital meters is currently (2017) running in the Brussels region. The Brussels Government is drafting the legal frameworks to roll out digital meters and their features in the years to come. The government wants to speed up the deployment of smart meters from 2018 on, especially when replacing old dysfunctional meters or installing new meters.

The Walloon region:

The Walloon Energy Minister confirms that digital meters are the only logical choice for the future in terms of progress and efficiency. Within the Walloon Government, however, there is still no official decision about a rollout of digital meters on a large scale.

3.7 Funding bodies and programs

In Flanders, Energy Technology Research, Development and Demonstration (ETRDD) programs are funded by the Research Foundation Flanders (FWO, basic research) and the Institute for Innovation by Science and Technology (IWT), recently transformed into VLAIO (Vlaams Agentschap voor Innovatie en Ondernemen). Both FWO and VLAIO carry out bottom-up programs without thematic restrictions. FWO funding instruments range from fellowships (PhD and post-doctoral), research grants and research projects to funding for international mobility and

international collaboration (e.g. through ERA-NET). In addition, the Flemish government finances ETRDD via a number of the Strategic Research Centers:

- VITO (Flemish Institute for Technological Research)
- IMEC (Interuniversity Microelectronics Centre, the Research Institute for Microelectronics and Nanoelectronics)
- iMinds (ICT Research Centre).

In the Flemish region, public funding increased by 40% of its level in 2007 (EUR 25 million) to more than EUR 35 million in 2013. At its peak in 2011, funding exceeded EUR 45 million. **Energy efficiency** is traditionally the largest recipient, while projects on **renewable energy and power and storage** also receive substantial public funding.

In 2016, the Flemisch government engaged in a commitment to stimulate the cooperation between universities-industry-government (the triple helix model) via a cluster pact. The energy, ICT and building sector are cooperating in the **energy cluster "Flux50.com"**. Flux50 coordinates different programs to generate a common approach which facilitates the adaptation of innovative solutions and business models in order to realize the economic opportunities of the transition towards a sustainable energy system. As mentioned din point 3.5 Flux50 is organized in five innovator zones:1) Energy Harbors, 2) Microgrids, 3) Multi-energy Solutions, 4) Energy Cloud Platforms and 5) Intelligent Renovation. Roadmaps, technological and legislative challenges are discussed with stakeholders from industry, research and government and a common approach resulting in demonstration projects, a supporting (low) regulated framework and about 10 M€ yearly financial support are scheduled to boost real life implementations of innovative concepts that support the energy transition via viable economic activities. Currently the first 14 feasibility studies are being concluded and most subjects are related to developing low carbon districts were citizens are sharing energy systems like photovoltaics, batteries, electric vehicles and charging points and make use of adapted financial models and IT services to control energy flows and apply demand response scheme's in order to optimize local use of renewables and market interactions.

In the Walloon region, the implementation of energy research is made through calls for proposals organized and managed by the Public Service of Wallonia. In the Walloon region, public funding increased from EUR 25 million in 2007 to nearly EUR 45 million in 2013 or by around 80%. At its peak in 2012, funding exceeded EUR 60 million. Similar to the Flemish region, energy efficiency is the main recipient of public funding, while renewable energy (specifically solar and bio-energy) and power and storage receive most of the remainder.

3.8 Description of national SET Plan Structure for Smart Grids Research

The European Strategic Energy Technology (SET) Plan is an important reference framework for Energy Technology Research, Development and Demonstration (ETRDD) in Belgium. But energy policy responsibility in Belgium is complex and is divided between the federal government and the three regional governments.

The Flemish ETRDD strategy is determined in co-operation with Flemish stakeholders in energy technology, organized in three platforms: Generaties (renewable energy), Smart Grids Flanders and WaterstofNet (program office of the Flemish industrial cluster on hydrogen and fuel cells). A **SET-Flanders strategy** (October 2012) has been developed in line with the SET Plan, which defined a **Strategic Research Agenda** for **five Renewable Energy topics** (bio-energy, solar energy, wind energy, wave and tidal energy and geothermal energy) and **three Grids and Storage**

topics (Smart Grids, Smart Cities and Energy Storage and Balancing). Between May 2012 and May 2014, the Flemish Research Council coordinated a foresight exercise to identify areas in which Flanders has good opportunities to develop a leading position in science, innovation and economic growth, and that lists *New Energy Demand and Delivery* as one of the seven key transition areas for Flanders. [Foresight 2025]. The Flemish innovation strategy for energy technology is as well acknowledged as an important element in the realization of "**Vision 2050**", a long-term vision for Flanders published by the Flemish government in September 2015. This has been finalized in 2016 in the "Stroomversnelling" vision document.

In parallel, the federal government has initiated work to prepare an energy vision and a subsequent energy pact covering the next 20-25 years to render Belgium's energy system more sustainable and climate-friendly. This long-term energy vision and energy pact can be seen as a national energy strategy and energy action plan and will be jointly developed by the federal and the regional governments. Once the energy vision is adopted, stakeholders will be invited by the governments to join in the drafting of an inter-federal energy pact. The energy pact will contain concrete measures for implementing the energy vision. It will incorporate global trends in energy demand, costs and technology development. It will also incorporate the EU long-term energy and climate targets.

The table below provides a sample of the most important running or recently concluded national projects. The SALK project that has been awarded to the EnergyVille association deserves a special mention. This multi-disciplinary project – which also receives EFRO cofounding - will boost the collaboration of the EnergyVille partners and will result in 14 demos related to Building Integrated PV technology, 4th generation district heating and cooling networks and multi-energy ICT and market platform infrastructure.

Table 3-1: Supported Smart Grids R&D and Innovation Projects in Belgium

R&D project	Company	Total budget (Million EUR)
SMILE-IT (Flanders) *Multi-agent Reinforcement Learning*	VUB (coordinator), VITO, KULeuven, UGent, Univ. Antwerp	2,5 (not only Energy)
GREDOR (Wallonia)	University of Liege (Coordinator), ORES, Tractebel Engineering SA, Elia System Operator S.A., EDF Luminus, Tecteo RESA, University of Mons	4,8
CALLIA (ERA-NET) *Local balancing and trading platform*	VITO, REstore	0,903 (Flemish budget)
SALK-(EFRO) - EnergyVille *BIPV, District Heating and Cooling Networks, and multi-energy ICT platform (*)*	VITO, KULeuven, IMEC, UHasselt	10 (Flemish budget)
Demonstration & Deployment project	**Company**	**Total budget (Million EUR)**
LINEAR (Flanders) *Residential Demand Response*	VITO, KULeuven, IMEC, LABORELEC, iMINDS, EANDIS, INFRAX, EDF, Fifthplay,	9,5

	Proximus,Viessmann, Telenet, Siemens, Miele	
Flux50 : feasibility studies being concluded ; living lab projects to start early 2018	Multiple (depending on the specific project and topic)	10/year

(*) SALK-EFRO SmarThor: Multi-energy optimization

SmarThor focuses on Energy as a Service in a multi-energy approach. For example: hot water is a service to consumers and whether the supplier is producing hot water by using a gas boiler, waste heat, heat pump, CHP or solar collector is controlled by a multi-energy market platform.

EnergyVille is preparing the SmarThor ICT Platform to apply such a multi-energy market platform to the Thor Park in Waterschei, Genk. SmarThor is the combination of Smart and Thor and integrates energy generation and usage, both thermal and electric, of the entire Thor Park into one ICT platform and is based on Internet of Things Solutions. By means of advanced regulation and control algorithms, the SmarThor ICT Platform balances both demand and supply, and will enable in the future to interchange energy remainders by means of a virtual electricity heat and cold market.

SmarThor ICT Platform

It is important to optimally use our generated energy: energy remnants and heat waste flows should be avoided, or when this is not an option, recuperated as much as possible. A first step in doing so is to measure these energy flows and analyze them to make better use of them.

The SmarThor ICT platform makes us of the latest developments in cloud technology and Internet of Things to gather all relevant data. It not only measures the energy production of solar panels but also the energy use of heat pumps, gas boilers, charging stations, offices and lighting. By means of self-learning techniques the computers look for specific relations between these data and set up automatic and self-learning patterns that take into account weather forecasts and changes in user behaviour. A smart thermostat can for example take into account the expected sunrays that enter through the windows or the outdoor temperature. To optimally use the free warmth of the sun and save energy, the smart thermostat could turn down the heating in advance without losing any of the desired inside temperature or comfort.

SmarThor ICT Platform 2.0

The first version of the SmarThor ICT-platform monitors the energy production and use of EnergyVille I and will be gradually expanded towards IncubaThor and Thor Central. It is expected that EnergyVille II and T2-Campus, which will open in 2018, will join the network, generating a virtual electricity-, heat and cold market at Thor Park.

A second version of the platform is foreseen for the beginning of 2018. This second version will also manage charging stations, heat pumps and gas boilers by means of solar energy forecasts, consequently making sure the electricity demand is adjusted to the availability of sustainably generated energy.

Based on the gathered data, the 4th generation heating network, which enables buildings at Thor Park to interchange and store heat and cold, will be further developed. The water in the underground coal tracks of the mine could be an interesting form of storage as well. They can for example store cooling wastes in summer which can be used again during winter to heat the buildings.

By using Internet of Things technologies, smart systems, regardless their location, can be linked to the Smart Thor ICT Platform. The platform can therefore be further used in future experimental projects which test the impact of new solutions in domestic houses or companies.

The SmarThor project is part of the SALK project 936 “Towards a Sustainable Energy Supply in Cities” which was facilitated thanks to the funding of EFRO, the Flemish Government, the Province of Limburg and the research facilities KU Leuven, VITO, imec and UHasselt in the research collaboration EnergyVille.

4 Denmark

4.1 Landscape of Smart Grids R&D in Denmark

The total installed wind turbine capacity is 5245 MW in 2016 up from 5076MW in 2015. The capacity offshore is nearly 1271 MW (2016). The total electrical output from wind is 46 PJ (12.8TWh) and wind generation accounts for 37.5% of national electricity demand in 2016 and 41.8% in 2015. The difference mainly coming from difference in wind in the two years. The sector employs 32898 people and has a turnover of approx. 13.1 billion EUR of which about 57 percent is for export.

Denmark has a long-term vision for an energy system independent of fossil fuels which has been agreed upon by the vast majority of the national Parliament. By 2050 the total energy system should be decarbonized with an important milestone on the way for wind power to supply 50 % of the Danish power consumption by 2020. In 2035 the Danish heat and power sector should rely on renewable sources.

4.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

The government has published a Smart Grid strategy (April 2013) emphasizing the importance of a market based approach and the need for activation of flexible consumption. It further stresses the integration of the different parts of the energy sector in particular the integration of the district heating and gas system with the electricity system. The market based approach was further underlined in the results of the so-called ‘Market Model 2.0’ project headed by the Danish TSO Energinet.dk (September 2015). Energinet.dk has also recently published the report ‘Energikoncept 2030’ (November 2015) that further elaborates on the integration of the different parts of the energy system in order to achieve a high overall efficiency and economic operation considering the increasing share of variable renewable energy.

The e-meters are being rolled out and it should be completed by 2020. In 2017 the first customers could be billed based on a 1h price from the energy retailers.

4.3 Industry (main industry actors, where in the value chain)

A total of more than 500 companies, including several sub-suppliers, working in all areas of the wind industry, are located in Denmark. Denmark is home to some of the world’s largest and most innovative wind companies, and the Danish skills within Smart Grids have created a competitive, globally leading wind industry. The major Danish based manufacturers of large commercial wind turbines of 1 megawatt or larger are Siemens Gamesa Wind Power and Vestas Wind Systems A/S. The Danish Smart Grids industry does also have a voice in the European Smart Grids Technology Platform (TP-Wind).

The electricity sector is actively leading the development of the electricity system at both the transmission and distribution level. This has led to formation of a strong group of companies that supply solutions for the implementation of intelligent control solutions for the power system.

4.4 Public research stakeholders

The significant part of the universities in Denmark is involved in smart grid and smart energy research. In particular DTU, Aalborg University, Aarhus University and Southern Danish University have considerable activities in the field. These activities are often involving are other partners and they are participating in the partnership for Smart Energy Networks. Other participants in this network include so-called GTS institutes that are private not-for-profit independent consulting firms that develop and sell state-of-the-art technological services to private enterprises and public authorities. Electricity sector and company associations are also participating in the partnership.

4.5 National R&D strategy

Denmark is aiming at a fossil free energy system by 2050. In order to enable this, a number of technology strategies have been prepared. One of those strategies is concerned with Smart Grids (Smart Grid-strategi–fremtidens intelligente energisystem, Energistyrelsen, April 2013). The strategy outlines the importance of adapting the electricity markets to the future situations with high penetration of wind energy and participation of the consumption side in the balancing of the system as well as of the importance of maintaining the security of supply and ensuring economic operation of the entire electricity system. The strategy further highlights the advantages by integrating the electricity system with other parts of the energy system in particular the gas system and the district heating system that can provide flexibility and storage to enable large amounts of wind power. The work has been continued in the partnership for Smart Energy Networks that currently (2015/2016) is in the process of preparing an RD&D road map.

4.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

Denmark has ambitious goals to ensure the expansion of wind power. Initiatives to expand renewable energy production within the field of Smart Grids from the current political Energy Agreement include:

- 600 MW offshore wind turbines at Kriegers Flak and 400 MW offshore wind turbines at Horns
- 500 MW offshore wind turbines in coastal areas
- New planning tools will encourage an increase in net capacity of 500 MW onshore wind power.
- Earliest grid connection in 2019 and completion no later than 2022.

4.7 Funding bodies and programmes

The Danish funding bodies for R&D within the field of Smart Grids all operate on the basis of competitive funding and there is not a programme for Smart Grids R&D. Based on a bottom-up approach, there is no earmarking of Smart Grids funding as such and different technologies and renewables are competing within the same funding programmes, which makes good applications even more important. Political agreements are setting the overall frame for the Danish R&D priorities, but the relatively broad calls for proposals imply that proposals on different energy technologies are competing against each other within the same calls. The ambition of the funding programmes in Denmark is multi-faceted. The overall aim is to support investments in secure green energy supply, create economic growth and at the same time change the way of producing and consuming energy. The different programmes target different elements in the entire value

chain with the specific aim of strengthening Denmark as a world leading wind power hub. Below the most important funding programmes are described.

Innovation Fund Denmark - The Fund offers grants for activities within strategic research, technology and innovation. The budget is 360 MDKK/48M€ in 2018 of which 250MDKK/33M€ is available for energy research. The Fund offers grants for activities within strategic research, technology and innovation. The establishment of Innovation Fund Denmark, which is a merger of *The Danish National Advanced Technology Foundation, The Danish Council for Technology and Innovation and The Danish Council for Strategic Research*, is the biggest reform of the Danish research and innovation system in the past two decades. In addition companies and universities will provide funding for participating in projects. With the establishment of Innovation Fund Denmark, there is a significant simplification of the research and innovation system, and a stronger focus on demand. Innovation Fund Denmark will be responsible for the future societal partnerships, where companies, universities and public authorities will work together on challenges facing society today.

EUDP - Development and Demonstration – energy, preferably public–private projects with commercial potential. The budget is 370MDKK/50 €m in 2018. The main objective of the EUDP is to ensure the development and demonstration of new energy technologies, which can reduce dependency on fossil energy, and which can contribute to minimizing the CO2 burden and the environmental impact of energy consumption. Applications can be submitted for funding for projects regarding all types of energy technologies which meet the above objective.

4.8 Description of national SET Plan Structure for Smart Grids Research

Responsibility:

The Danish Energy Agency (DK Energistyrelsen - *ENS*) is responsible for the Danish coordination of SET-plan activities. The agency has a member and a Sherpa in the SET-plan Steering Group. ENS is an agency under the Ministry for Climate, Energy and Buildings. The Danish Agency for Science, Technology and Innovation has the second seat in the SET Plan Steering Group. ENS is also the Danish representative in the EII Wind Implementation Team.

Coordination:

Denmark is an active part of the SET-plan through the participation of ENS in the SET-plan Steering group and DTU in EERA, ETIP-SNET and the EII Wind Implementation Team. The Chairman of ETIP SNET is Henning Kruse from Siemens, who is also a member of the EEI Wind Team. The Danish Full participant in EERA JP Smart Grids, DTU Smart Grids, has regular meetings with the agencies. The aim of these meetings is to discuss the work and the perspective in the SET-plan, including the industry and research initiatives (EII and EERA). All the Danish members of EERA JP Smart Grids (as well as all other relevant public research organization with activities related to Smart Grids) work together in the Danish Consortium for Smart Grids Research. At these meetings EERA and ETIP SNET priorities are also being discussed.

Implementation with the ELECTRA IRP:

The coordination efforts mentioned above will continue and reinforced. The meetings should bring clarity to the coordination and financing of Smart Grids research in Denmark and should clarify how and to which extent SET-plan priorities are reflected in national programmes (SET-plan priorities in national priority lists).

More and more national collaboration is done in alignment with European and international collaboration, including also the SET Plan Road maps. Neither the SET-plan, ETIP SNET, EERA JP Wind or the EWI are mentioned in key documents outlining the ELECTRA IRP deliverable - project no. 609795 research priorities or activities in publications from ENS5. However, in reality the priorities of the SET-plan, the ETIP SNET SRA as well as EERA JP Wind influences the Danish Priorities for Smart Grids research due to the high level of participation in EU projects and the overlap of organisations and people between the SET-plan and national level. Likewise, as a leading nation in international Smart Grids research Danish priorities and focus areas are de facto included in the priorities of JP Wind, EWI and ETIP SNET. In the specific calls international collaboration is often encouraged and included as a criterion when evaluating proposals.

Table 4-1-Supported Smart Grids R&D and Innovation projects in Denmark in 2016-7

R&D project	Company	Total support budget (Million EUR)
EnergyLab Nordhavn - nye energiinfrastrukturer i byer	Danmarks Tekniske Universitet	10.2
EcoGrid 2.0	Dansk Energi	6.4
Super Supermarkeder	Clean	0.4
Smart Energy Butikscentre	Teknologisk Institut	0.8
EPIMES	DTU Electrical Engineering	0.8
Smart Adaptive Load Shedding	Institut for Energiteknik-AAU	0.3
Parker	DTU Electrical Engineering	1.3
Multi-DC	DTU Electrical Engineering	1.9
Analysis of power consumption at hour level	DTU Management	0.7
ACES (Across Continents Electric Vehicles Services)	DTU Electrical Engineering	0.7
DSO’s role in electricity market	Radius	0.6
Combined operation of integrated energy systems	DTU Electrical Engineering	1.4

5 Finland

5.1 Landscape of Smart Grids R&D in Finland

Finland consumed 85.1 terawatt hours (TWh) of electricity in year 2016. Of this consumption, 22.3 per cent was covered by net imports and 77.7 per cent (66.1 TWh) by Finland's own production. Combined heat and power generation (CHP) covered 24,2 per cent of the consumption, nuclear power 26.2 per cent, hydropower 18.4 per cent, and condensing power 5,3 per cent. The share of wind power was 3,6 %, see Figure 5-1 and Figure 5-2. Finland imported the power from Sweden, Russia and Estonia. Finland's dependence on imports is way too high. Although the smooth running of the imports shows that the Nordic power market functions well, Finland still needs domestic power generation investments - not only for reasons of self-sufficiency and security of supply, but also and above all to replace lost capacity.

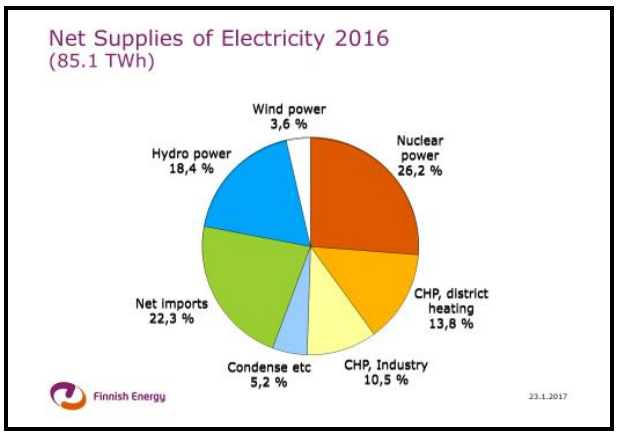


Figure 5-1: Net supplies of electricity 2016 [ref_FIN1]

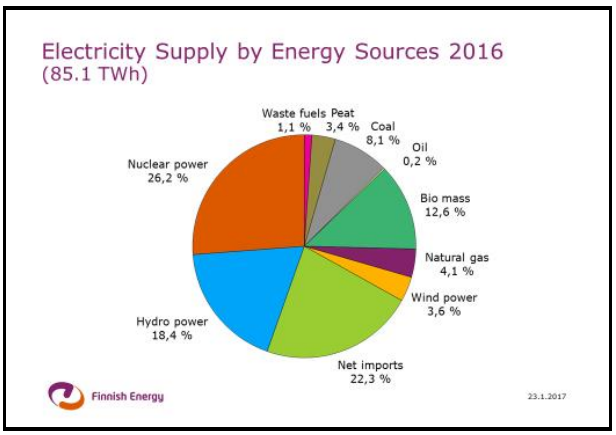


Figure 5-2: Electricity supply by energy sources 2016 [ref_FIN1]

Electricity is produced in Finland in a versatile way with various different energy sources and production methods. The most important energy sources for electricity generation are nuclear power, hydropower, coal, natural gas, wood fuels, and peat. The share of wind power is small, but growing in coming years since feed-in tariff is valid until the total wind generation capacity exceeds 2.5 GWA. Feed-in tariff system is also valid for biogas power plants until the total biogas generation capacity exceeds 19 GWA. The same concerns also for power plant using the wood fuel until the total its generation capacity exceeds 150 GWA. The share of hydropower and consequently fossil fuels, mainly coal, in electricity generation varies considerably according to the amount of hydropower available on the Nordic market from Norway and Sweden.

In Finland, there are approx. 120 companies producing electricity and about 400 power plants, more than half of which are hydroelectric power plants. Finland's electricity generation is fairly distributed compared with many other European countries. Our diverse and distributed structure of electricity generation increases the security of electricity supply.

Almost one-third of electricity is produced in combined heat and power generation, in which case the energy content of the fuel is utilized to its full potential. Up to 90% of the energy of the fuel can be converted into electricity and heat. Taxation and market prices of fuels impact strongly which energy sources are used for CHP. The renewable energy sources consist of mainly hydro power and biomass. Biomass is mainly used for CHP, district heating and small-scale combustion. Because the black liquor (a side product from paper and pulp industry) has a significant share in renewable energy sources, the economy of paper and pulp industry is important also for Finland's 20-20-20 targets. The amount of the hydro power has not increased due to a lack of available

resources. During the last ten years the heat pumps have also become a significant energy source. Electricity generated in Finland (66.1 TWh) was last year 78 per cent greenhouse gas emissions free or carbon neutral, which is a new record. The share of renewable energy sources was 45 per cent of all electricity production and that of domestic fuels 50 per cent, see Figure 5-3.

Finland is part of the joint Nordic electricity market in which free competition prevails. The wholesale electricity prices remained at a low level in the Nordic market in 2016. The low electricity market price has put many investment plans concerning production in a new light. Investment prospects are watered down particularly because there seems to be no sign of a market price rise, at least in the near future.

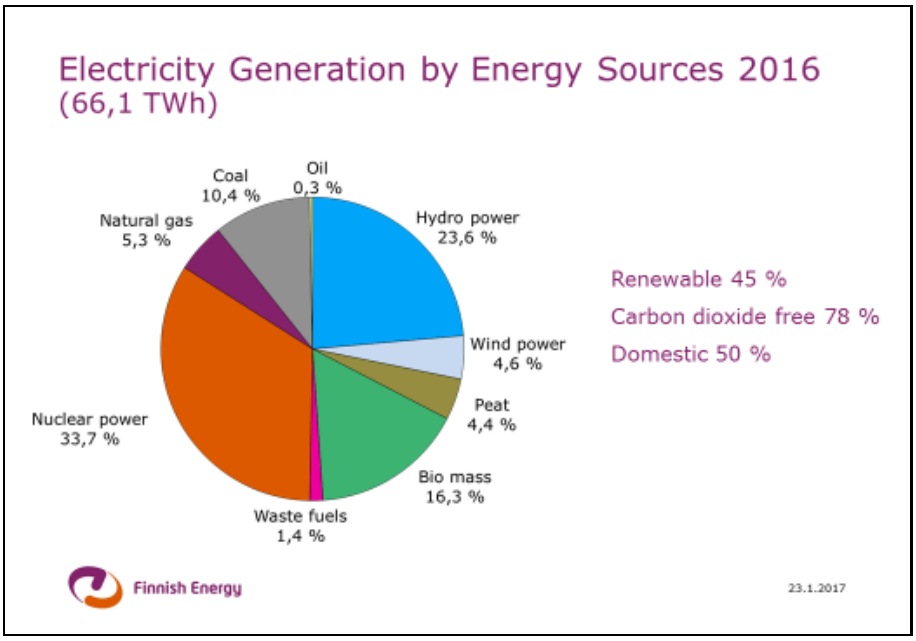


Figure 5-3: Electricity production by energy sources
[ref_FIN1]

The vision of the Finnish Energy is the carbon-neutral electricity and district heating in 2050. According to the vision, direct emissions from electricity and district heat production will considerably reduce. At the same time, low-emission electricity and district heat are used for reducing the use of fossil fuels in transport, industry and heating. The key guiding factor is the price signal from the emissions trading, encouraging investment in low-carbon production.

5.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

A smart grid may be described as a ‘tuned’ electricity network. Current networks are supplemented with a data network and smart monitoring of energy use. A smart energy meter is, therefore, an integral part of the smart grid. Two-way communications are an essential feature of a smart grid. Along with distributed production, energy will flow in both directions, unlike today. Similarly, data transfer takes place from the network company to the customer and vice versa. Data transfer also enables network management when the operating methods of the network change. A smart grid is often described as the internet of energy. This is a result of the huge increase in the use of information technology. Transferring to Smart Grids will not take place overnight, but it is a long development process. Instead of a revolution we can talk about evolution.

Smart metering

In Finland, the electricity network is already fairly intelligent. Examples of the intelligence of the grid include automatic fault location and separation, optimization of network use, and remotely read meters. The smart energy meter and two-way data transfer between the customer interface and the grid play a key role in the smart grid. Finland has Europe's one of the cheapest prices of the electric energy which tells about a cost-efficient energy system. In central Europa the consumers pay for the electricity two times more than in Finland.

The starting point was that in 2009, the Council of State decreed on rolling out smart metering, and now, consequently, the coverage is reaching 100% of consumption sites. The Finnish smart-metering systems are run as business networks by DSOs. The DSO is legally responsible for providing customer usage data, which is managed in the subsequent refining steps by the DSO or the providers of the energy services. The data, initiating in the smart meter, is first transferred via a mobile operator's network into the AMI Headend system (AMI Advanced Metering Infrastructure), and then on into other information systems. The data is processed, stored, refined, combined with other data – like customer and invoicing data – and eventually delivered to the given market participants [ref_FIN2].

Datahub

In spring 2015, Finnish TSO Fingrid launched a project to clarify information exchange on the electricity retail markets and make it more efficient. In 2020, data sent between electricity consumers, sellers and distribution companies will be stored in a Datahub, where it will be equally available to all market operators. Datahub is a centralised information exchange system for the electricity retail market, which will contain data from 3.5 million electricity metering points in Finland. The information contained in the Datahub will be used by approximately 100 electricity suppliers and over 80 distribution network companies serving electricity consumers.

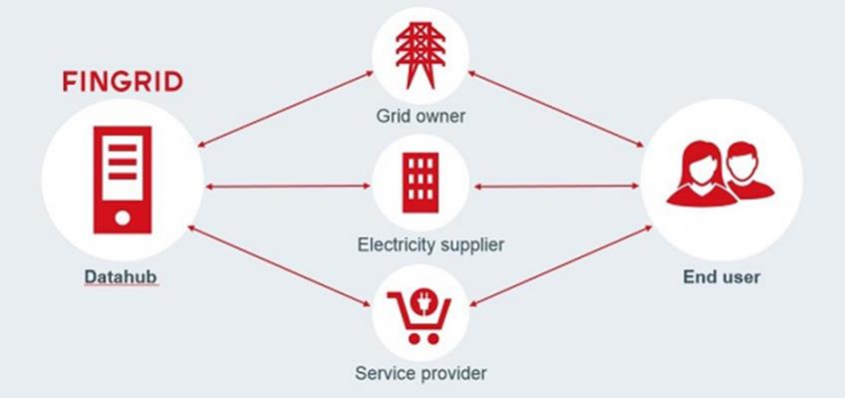


Figure 5-4: Datahub principle [ref_FIN3]

Datahub enables the customer to participate actively to electricity market by using different kinds of service providers. Customer can get new services to follow up his consumption or to participate into demand response. Precondition to these services is that the customer is reliably individualized and recognized in Datahub and this way the requirements for data protection can be fulfilled. The parties retrieving data from the Datahub must have a valid contract with the customer or authorization from the customer to his information. Identifying the customer is done by using the existing identifications such as identification code or company code.

Concentrating all essential electricity use information in one place, the Datahub will speed up, simplify and improve the actions of all parties. Furthermore, the centralised solution provides all parties with equal, simultaneous access to the information. Changing suppliers, moving to a new

address, and other changes affecting the consumer's electricity contract form just one case in which information needs to be exchanged. For example, imbalance settlement relating to the distribution network will be conducted in the new system. Datahub can also process and refine information saved in it. Smart, remotely read electricity meters are widely used in Finland, and a lot of information is generated for every metering point daily. This information, as well as any mobile applications introduced in the future, can enable all-new services for electricity consumers. For example, an app could be provided with which the consumer can monitor the electricity consumption figures of both the town home and holiday home, even if these two metering points were in different parts of the country [ref_FIN3].

Reliability of distribution networks

According to the Electricity Market Act (2013) the distribution network must be designed, built and maintained so that, except for certain exceptions, the outage of the distribution network will cause the user of the network no more than 36 hours of lasting interruption of the electricity distribution and no more than 6 hours in the urban area, in the case the network is damaged as a consequence of the storm or of the snow load. The Electricity Market Act requires network companies to develop its networks gradually. The companies must fill the requirement of reliability with 50% of the users of the distribution network by the end of the year 2019, with 75% of the users by end of the year 2023, and except for certain exceptions with all users by end of the year 2028.

5.3 Industry (main industry actors, where in the value chain)

Fingrid Oyj is the enterprise which takes care of the functioning of the nation-wide high-voltage grid, the backbone of electricity transmission. Fingrid transmit electricity continuously from electricity generating companies to distribution network companies and industrial companies. Fingrid takes care of the cross-border connections and promote the functioning of the electricity market. The investments aim at ensuring the main grid's system security and an adequate transmission capacity in the present as well as the future. Fingrid has a 1.2 billion euro investment program for the years 2017–2027. In the latter half of the present decade and start of the 2020's, grid investments will focus mainly on renewing aging transmission lines and substations [ref_FIN4].

The majority of Finland's 80 distribution network companies are owned by municipalities or limited companies controlled by municipalities. Overall, Finland's fifteen largest electricity network companies covered approx. 70 per cent of the distribution networks, electricity users and company turnovers. The smallest electricity network companies in Finland operate within the area of a single municipality, serving a few thousand customers. According to the Electricity Market Act, main investments of the distribution companies will be allocated to the improvement of the reliability of the distribution in the rural areas. It has been estimated that the total value of investments will be about 7 billion euros by 2028. This contains cabling of overhead lines in the countryside, among others, network automation, and moving the overhead lines from the forests alongside the roads, and other smart grid solutions

Concerning the technology providers and manufacturers the largest international companies having activities in Finland are ABB, Siemens, Alstom, Empower, ENSTO and ICT companies and tele-operators like NOKIA, ELISA, DNA and TELIA.

5.4 Public research stakeholders

The partners of Smart Grid and Energy Market project conform the Finnish Smart Grid Platform consisting of 20 industrial partners and 8 research institutes and universities. The main research stakeholders are VTT Ltd, Aalto University, Tampere University of Technology, Lappeenranta University of Technology, University of Vaasa, Oulu University, University of Eastern Finland.

5.5 National R&D strategy

Finland has no special politically agreed smart grid R&D strategy, but the national climate and energy targets presented in the "Finland´s National Programme for Europe 2020 –Strategy" published by Ministry of Finance [ref_FIN5] contain many initiatives, which touch also Smart Grids.

- The 2020 target for renewable energy, 38% of end-use energy consumption (36.8% in 2013)
- The EU's renewable energy obligation for the transport sector is 10%, but Finland has nationally decided on the higher target of 20% for 2020.
- Finland's National Renewable Energy Action Plan set a target of 25 TWh for the use of forest chips in production of electricity and heat in 2020.
- A wind power production target of around 9 TWh will be set for 2025. The target set earlier, for 2020, is 6 TWh.

Ministry of Economic Affairs and Employment nominated the Smart Grid working group 2016. The 21 members of the group represent the interest groups of the branch widely. The working group has published an interim report at the autumn 2017 and its final report will be ready at the autumn of 2018. The goal of the Smart grid working group is to create a common vision for the future of a smart electricity system and to explore and propose concrete measures through which the smart electricity system can both facilitate the of customers' possibilities to actively participate in the electricity market and promote the maintenance of security of supply. As a main principle, the working group considered the control of the customer's electricity consumption to be a competitive business activity. The time-based control and compulsory time-of-use pricing by distribution network companies will be eliminated in a controlled manner once a sufficient amount of cost-effective automated consumption control services are available for the customers. Owning and operating storages should also be primarily a task of market players, not monopolies.

The working group has a positive view on the opportunities created by the energy communities for their customers. The benefits brought by aggregators which form larger entities out of customers' electricity production, consumption and storage are regarded positively. The energy communities and aggregators are both new roles to the electricity market, as a result of which their determination and the rules and regulation concerning their operations need to be specified in further detail. The working group has a positive view on replacing the flat-rate of the electricity distribution charge with a power component that provides customers with better opportunities for affecting their distribution charges. Harmonizing the pricing structures of distribution charges could bring clarity to the situation at the transition stage. Before implementing changes, there is need to investigate their effects on different customer groups. Communication and advice are considered to be vital at the transition stage. Future themes of the working group include questions related to information exchange, the functions of next generation power meters, developing the retail market and regulation that supports flexibility [ref_FIN6].

5.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

The national priorities in smart grid research have been in smart grid architectures and distribution infrastructure. Also the intelligent management and operation of network using ICT as well as active resources and their market integration and new business models have been the targets of active development. Finnish research stakeholders have also actively participated in EU funded FP7 and Horizon 2020 research project. The main domestic research projects with regard to Smart Grids are presented in the following.

Smart Grids and Energy Markets (SGEM) 2009-2015 (about EUR 52 million):

The aim of the Smart Grids and Energy Markets (SGEM) research program was to develop international smart grid solutions that can be demonstrated in a real environment utilizing Finnish R&D infrastructure. At the same time, the benefits of an interactive international research environment accumulated the know-how of world-leading ICT and smart grid providers.

The main general objectives of the research program were as follows:

- Create an innovation foundation for new solutions, products and services to enable the implementation of the Smart Grids vision
- Demonstrations of solutions in real environment, not limited to Finnish grids, was an essential part of the research
- Relevance of the research was measured on global basis, i.e. the targeted solutions are applicable on the international market
- Cultivate the competence accumulation in the research and business environments to secure the long term competitiveness
- International research cooperation was a pre-requisite to achieve the objectives

Flexible Energy Systems – FLEXe 2015-2016 (about EUR 13.7 million)

FLEXe program created novel technological and business concepts that enhanced the radical transition from the current energy systems towards sustainable systems which combine smartness, flexibility, environmental performance and economic success with customer acceptance and engagement. The FLEXe consortium consisted of 18 companies and 10 research institutions or universities. The consortium consisted of the strong industry and research players and covered a broad spectrum of competences and including the whole value chain for the energy system.

The Distributed Energy Systems (DESY) 2012-2014 (about EUR 1 million)

The Distributed Energy Systems (DESY) program consisted of:

- DESY Research carried out by research institutes and universities,
- DESY Joint Research connected to parallel projects of companies, and
- DESY Demonstrations.

A fully implemented DESY program increased the production of renewable energy and, especially, promoted the use of hybrid energy technologies, including energy storage, to a new, higher level via optimal solutions. The distinct need for reliable information was recognized regarding the performance of hybrid renewable energy systems, dimensioning methods and optimal operation. This, in turn, provided reliable information on the applicability and feasibility of new distributed energy systems. It also identified the bottlenecks in implementing renewable energy systems and to encourage product development in companies.

Improved Modelling of Electric Loads for Enabling Demand Response by Applying Physical and Data-Driven Models (RESPONSE) 2015-2018 (about EUR 1 million)

The aim of the project is to develop enhanced models for load and control response forecasting required by dynamic on-line optimization of demand response (DR) actions and network operation in a future sustainable energy system.

5.7 Funding bodies and programs

The main domestic public funding bodies are Tekes and Academy of Finland which provide funding among others for smart grid research.

Tekes – the Finnish Funding Agency for Innovation

Tekes is the most important publicly funded expert organization for financing research, development and innovation in Finland. Tekes boosts wide-ranging innovation activities in research communities, industry and service sectors. Tekes works with the top innovative companies and research units in Finland.

The Tekes programmes and initiatives are topical entities targeted at financial and expert service areas. Tekes has no special programmes addressed to Smart Grids, but to the following ongoing and recently finished programmes cover also Smart Grids:

- Green Growth – Towards a Sustainable Future 2011–2015: The aim of the Green Growth programme is to support the generation of innovations enabling significant leaps in energy and material efficiency and to create foundation for the development of new value networks based on green growth. ref_FIN7]
- EVE – Electric Vehicle Systems 2011–2015: The aim of the Electric Vehicle Systems programme is to create a community of electric vehicle and support system developers in order to develop new technology, business and service competence.
- Smart Procurement 2013–2016: The programme will speed up the introduction of innovations through procurement excellence and the development of markets (about EUR 40 million coming from Tekes). [ref_FIN7]
- Witty City 2013–2017: The aim of the Smart City programme is to provide people with better living and working environments and companies with opportunities to bring new products and services on the market (about EUR 40 million coming from Tekes). [ref_FIN7]
- Smart Energy 2017–2021: Smart Energy is a national Team Finland program managed by Tekes and Finpro. It supports the role of Finland as forerunner and test-bed of smart energy solutions. It supports company innovations and networks targeting to exports. It challenges the energy industry to utilize digitalization, IoT, artificial intelligence and internet of energy etc. [ref_FIN7]
- ERA NET Smart Grid Plus 2016-2019: Programme will advance the integration of Smart Grids system technologies, stakeholder adoption and market processes to help Europe make progress towards achieving its short-term 2020, medium-term 2035 and long-term 2050 energy targets. Cross-sectorial and interdisciplinary system innovation will be essential to realising these targets. Tekes funding available is EUR 1,35 million. [ref_FIN7]

Academy of Finland

The Academy of Finland's mission is to fund high-quality scientific research, provide expertise in science and science policy and strengthen the position of science and research. Smart grid research projects are funded by "New Energy Research Programme".

"The New Energy Research Programme" is a four-year research programme (2015–2018) funded and coordinated by the Academy of Finland. Through the programme, funding is provided to multidisciplinary research conducted by research projects and consortia with a view to supporting national cooperation and networking. A research consortium is a collaboration of independent fixed-term projects working under a joint research plan by combining different methods and research fields with a view to achieving greater added value than is achieved by normal project collaboration.

"*A Climate-Neutral and Resource-Scarce Finland" programme* goals are:

- How can we improve resource efficiency and support the move towards a circular economy, which will serve to boost exports and competence-based growth in Finland?
- What are the requirements for climate neutrality and resource efficiency in society?
- In what ways can the public sector best support the overall transition so as to maintain a well-managed move towards a climate-neutral and resource-scarce society?

Another goal of the programme is to find ways to ensure that businesses, employees, the public sector and consumers possess the resources and skills that best promote adaptation to climate change and the transition to a climate-neutral and resource-scarce society,[ref_FIN8].

5.8 Description of national SET Plan Structure for Smart Grids Research

Energy Efficiency and Growth Unit of the Ministry of Employment and the Economy and TEKES, the Finnish Funding Agency for Technology and Innovation are members (2 people) of European Community Steering Group on Strategic Energy Technologies. They are responsible for the coordination of SET-plan activities in Finland. In order to improve the coordination the Ministry of Employment and the Economy is preparing a national steering group consisting of the above mentioned persons and the representatives of industry and VTT Ltd.

The objective of the national steering group is to promote the competitive ability of Finland's economic life in the frame of reference of the SET-Plan in order to develop energy technologies and energy systems. So far there is no special steering group of SET Plan issues for Smart Grids in Finland.

Table 5-1- Supported Smart Grids R&D and Innovation projects in Finland

R&D project	Company	Total budget (Million EUR)
Smart Grids and Energy Markets (SGEM)	Coordinator: Cleen Oy Funding: Tekes and companies	54
Flexible Energy Systems - FLEXe	Coordinator: Clic Innovation Ltd Funding: Tekes and companies	13,7
The Distributed Energy Systems (DESY)	Coordinator: VTT Ltd and Cleen Ltd Funding: Tekes+companies	1
Improved Modelling of Electric Loads for Enabling Demand Response by Applying Physical and Data-Driven Models (RESPONSE)	Coordinator: TUT, Tampere University of Technology Funding: Academy of Finland	1

R&D project	Company	Total budget (Million EUR)
eCharge – EV systems and grid integration	Coordinator: VTT Ltd Funding: Tekes	1,3
Demonstration & Deployment project	**Company**	**Total budget (Million EUR)**
Smart Grid pilot area in Sundom, Vaasa	ABB	--

References

[ref_FIN1] Finnish Energy Industries, ”Statistics and publications”, webpage of Finnish Energy Industries, 11.12.2017, https://energia.fi/ajankohtaista_ja_materiaalipankki/materiaalipankki/energiavuosi_2016_-_sahko.html#material-view

[ref_FIN2] http://energia.fi/sites/default/files/dokumentit/sahkomarkkinat/Sahkoverkko/smart_metering_cyber_security_project_summary_2013_final.pdf

[ref_FIN3] http://www.fingrid.fi/en/customers/datahub/Pages/default.aspx

[ref_FIN4] http://www.fingrid.fi/en/grid_projects/Pages/default.aspx

[ref_FIN5] http://ec.europa.eu/europe2020/pdf/csr2015/nrp2015_finland_en.pdf

[ref_FIN6] On the way towards a flexible and customer-driven electricity network – An interim report by the Smart grid working group. http://urn.fi/URN:ISBN:978-952-327-243-9

[ref_FIN7] https://www.tekes.fi/en/programmes-and-services/tekes-programmes/smart-energy/

[ref_FIN8] http://www.aka.fi/en/research-and-science-policy/academy-programmes/current-programmes/new-energy/

6 France

6.1 Landscape of Smart Grids R&D in France

The 20-20-20 challenge has motivated a lot of initiatives to increase the production (about 20 000 MW), to integrate more renewable energy in the grid (up to 20% more), to reduce the CO2 emissions (20% less).

The ADEME[5] (French Environment & Energy Management Agency) has proposed a scenario in 2030 time frame where the distribution is greatly improved:

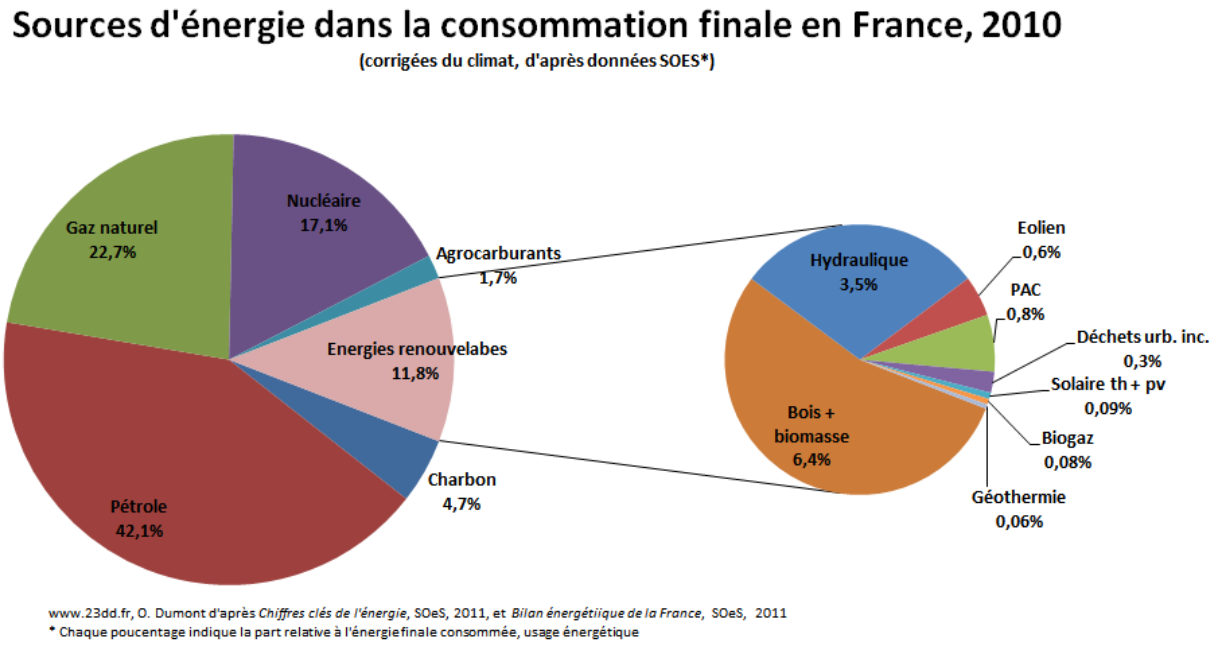


Figure 6-1: Energies sources in 2010 in the final consumption in France[6]

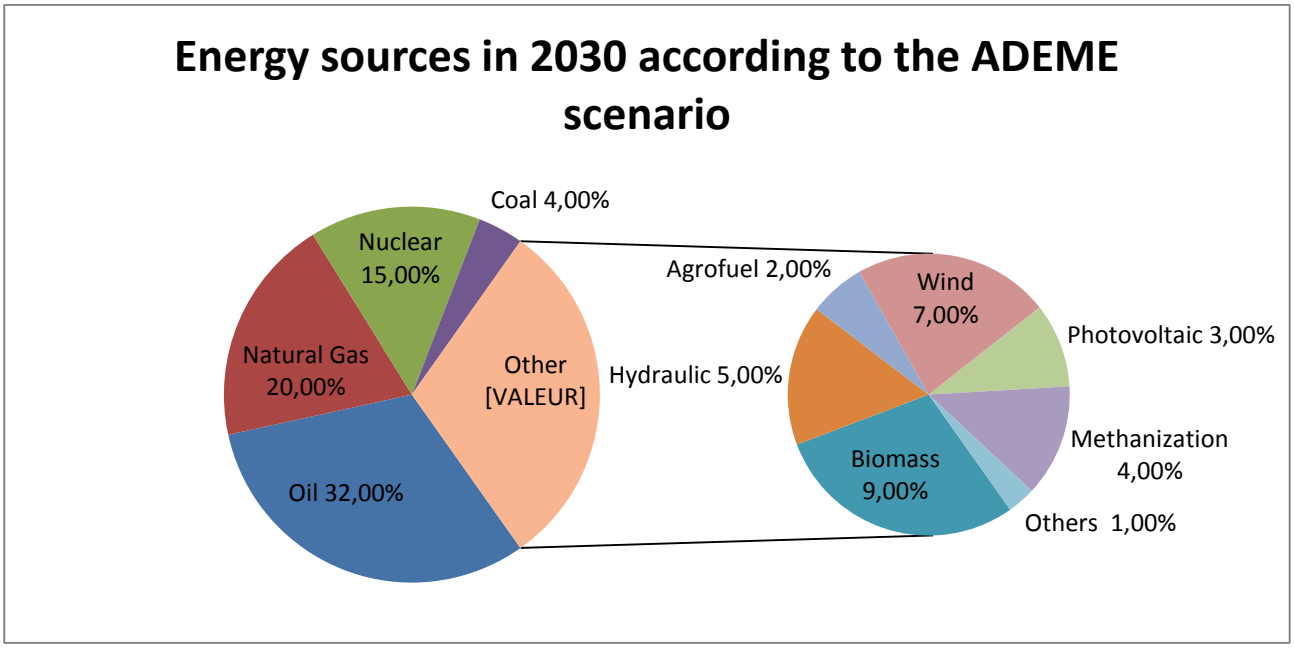


Figure 6-2: energy source in 2030 according to the ADEME scenario[7]

[5] Agence de l'Environnement et de la Maîtrise de l'Énergie (http://www.ademe.fr/en)
[6] http://23dd.fr/

6.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

To reach the repartition in the energy sources shown in the above figure, the government has proposed in May 2014[8] a structuration in 10 plans supported by industrials and research centers (Table 6-1).

Table 6-1: French work plan for Smart Grid

1	Create a group to federate the Smart Grids actors in France and ensure its promotion	RTE
2	Organize the international promotion	ERDF
3	Create a “smart grid” academy to build an training offer fitting with the Smart Grids challenges	Instituts Carnot
4	Structure to help start-ups	SmartGrids France
5	Optimize the impacts in terms of job creation and benefits. Minimize the environmental foot print	RTE
6	Enlarge the Smart Grids by an large-scale deployment in France	ERDF
7	Put in place into universities an innovation platform / an experimental smart grid	CEA
8	Improve the efficiency of the French participation on normalization	Schneider Electric
9	Define the R&D strategy in the Smart Grids sector	Instituts Carnot
10	Organize an ideas competition to allow the creation or the deployment of innovation solutions	SmartGrids France

For example, to use flexibilities in the consumption, EDRF has proposed Linky (French Smart Meters). In 2010 only 300 000 were installed and in 2016 the number should around 3 million to be 35 million in 2021 (an interactive map is proposed to visualize its deployment[9]) as the Figure 6-3 shows it.

This installation should modify the next research projects.

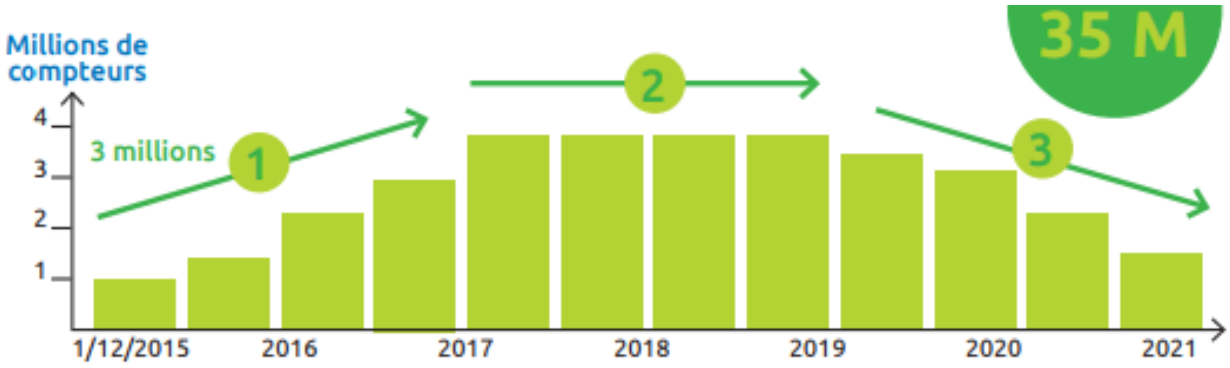


Figure 6-3: Smart Meter deployment
(source: http://www.enedis.fr/sites/default/files/Dossier_smart_grids.pdf)

[7] http://23dd.fr/
[8] https://eco2mix.rte-france.com/uploads/media/images/alaune/FDRoute.pdf
[9] https://selectra.info/energie/guides/compteurs/linky

6.3 Industry (main industry actors, where in the value chain)

The Figure 6-4[10] proposes an overview of the actors involve in Smart Grids projects in the PACA region (Provence-Alpes-Côte d'Azur). This region is the most dynamic in the Smart Grid strategy.

The main actors Enedis (previously ERDF), RTE are warped by a multitude of enterprises to propose a complete value chain (Figure 6-5). The other regions in France have more or less the same value chain with the same multitude of enterprises.

Figure 6-4: A complete value chain in the French PACA region supported by a multitude of enterprises

In the context of Smart Grid, a large set of SME are developing their activities (Figure 6-5).

[10] http://www.paca.developpement-durable.gouv.fr/IMG/pdf/2014-06_Plaquette_Filiere_Smart_Grids_pour_les_Alpes-Maritimes_CCINCA_FR.pdf

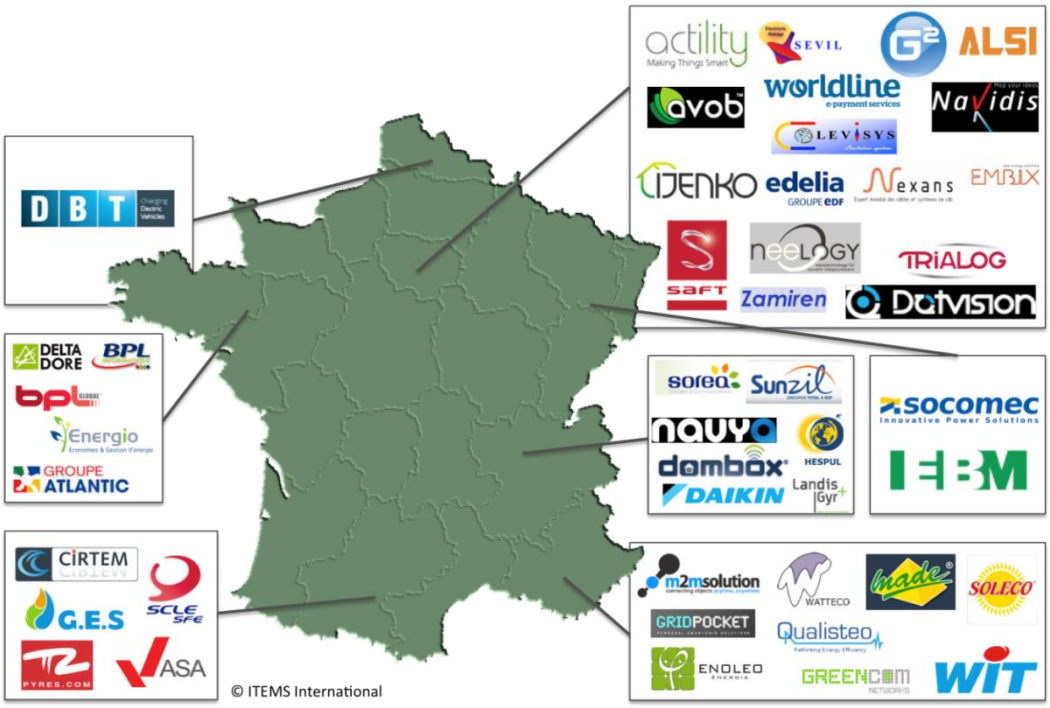


Figure 6-5: main French SME involved in smart grid developments11

6.4 Public research stakeholders

The main public research institutes dealing with Smart Grids innovations are CSTB[12], CNRS[13], CEA[14], INRIA[15] but they are helped by another public structures.

Figure 6-6: Public stakeholders supporting the PACA (Provence-Alpes-Côte d'Azur) projects **(the ones dedicated for research are located in red circle)**

[11] http://smartgridsfrance.fr/tpe-pme/
[12] http://www.cstb.fr/
[13] http://www.cnrs.fr/index.html
[14] http://www.cea.fr/english
[15] https://www.inria.fr/en/

6.5 National R&D strategy

In the new structuration of the french strategy on “Smart Grid”, the roadmap done in May 2014[16] (French document) gives the main topics. This roadmap has been presented to the president by Dominique Maillard, pilot of the Smart Grids plan which was elaborated the help of key actors (Table 6-2):

Table 6-2: key actors elaborating the Smart Grids roadmap to France

ABB	***G2ELAB / GRENOBLE INP***
ACCENTURE	*GE DIGITAL ENERGY*
ACTIA SODIELEC	*GIMELEC*
ADEME	*IBM*
ALCATEL-LUCENT	*IJENKO*
ALSTOM GRID	*ITEMS INTERNATIONAL*
BPI FRANCE	*ITRON FRANCE*
CAPGEMINI	*MINES PARIS TECH*
CEA	*NEXANS POWER ACCESSORIES*
CISCO / GITEP	*NORDEX FRANCE*
COFELY ONEO	*OMEXON / VINCI ENERGIES*
CRE	*REUNIWATT*
DERVAUX SA	*RTE*
DGCIS	*SAGEM COM*
DGEC	*SCHNEIDER ELECTRIC*
DIRECT ENERGIE	*SEIFEL*
ECOSYS GROUP	*SIEMENS SAS*
EDF	*SMART GRID FRANCE*
ENERDATA	*SOCOMEC*
ENERDIS	*TELECOM BRETAGNE / IRISA*
ERDF	*THE COSMO COMPANY*
ERICSON	*URMETZ*
EVOLUTION ENERGIE	*SUPELEC*

This roadmap proposed in 2014 coverted to consolidate the place of French industries as leader in the energy market in three steps:

- The short-term objective (2014) was to federate actors into a “label” with the help of an operational structure to coordinate actors, promote actions and thus increase business. This framework has allowed the creation of the SmartGrids France[17] which federate 10 energy and ICT French business and research clusters:

[16] https://eco2mix.rte-france.com/uploads/media/images/alaune/FDRoute.pdf
[17] http://smartgridsfrance.fr/

Figure 6-7: the 10 Energy and ICT French business and research clusters.

- The mid-term objective (2017) was to enlarge existing demonstrations to have an efficient deployment in a targeted region where the concentration of solution should create a pool of available jobs. The objective was to create 10 000 direct jobs (this feature excludes the operators, universities, research centers) and reach 6 billion of euros in annual turnover. Currently, the sector employs 15 000 persons for an annual turnover estimated at 3 billion of euros.
- The long-term objective (2020) is to refine the R&D strategy in Smart Grids, promote the innovative solutions of small enterprises through an “Open Innovation” platform, integrating solution by operators.

To support these objectives, the roadmap insists on the normalization aspect to reach the interoperability needed to ensure durable products.

The public support to achieve this roadmap takes different aspects: legal, human resources mobilization and financial (the help should be comprised between 75 M€ and 135 M€ between 2015 and 2017 in addition of the investments already planned).

This first national roadmap has produced 17 new recommendations in extension to the ones produced in 2014. For the moment, any new national strategy was proposed to follow this first one.

6.6 National priorities (examples of programmes, centers, large projects and their thematic focus)

The next figure compared the number of projects in the different French regions.

Figure 6-8: Location of Smart Grid projects in France[18]

The multitude of projects dedicated to Smart Grids are inventoried into many website. The more relevant are:

- http://www.smartgrids-cre.fr/index.php?p=france (140 national projects are detailed)
- http://smartgridsfrance.fr/ (21 national projects are detailed)
- http://www.enedis.fr/les-demonstrateurs-smart-grids (23 national projects are sketched)

[18] http://www.smartgrids-cre.fr/index.php?p=france

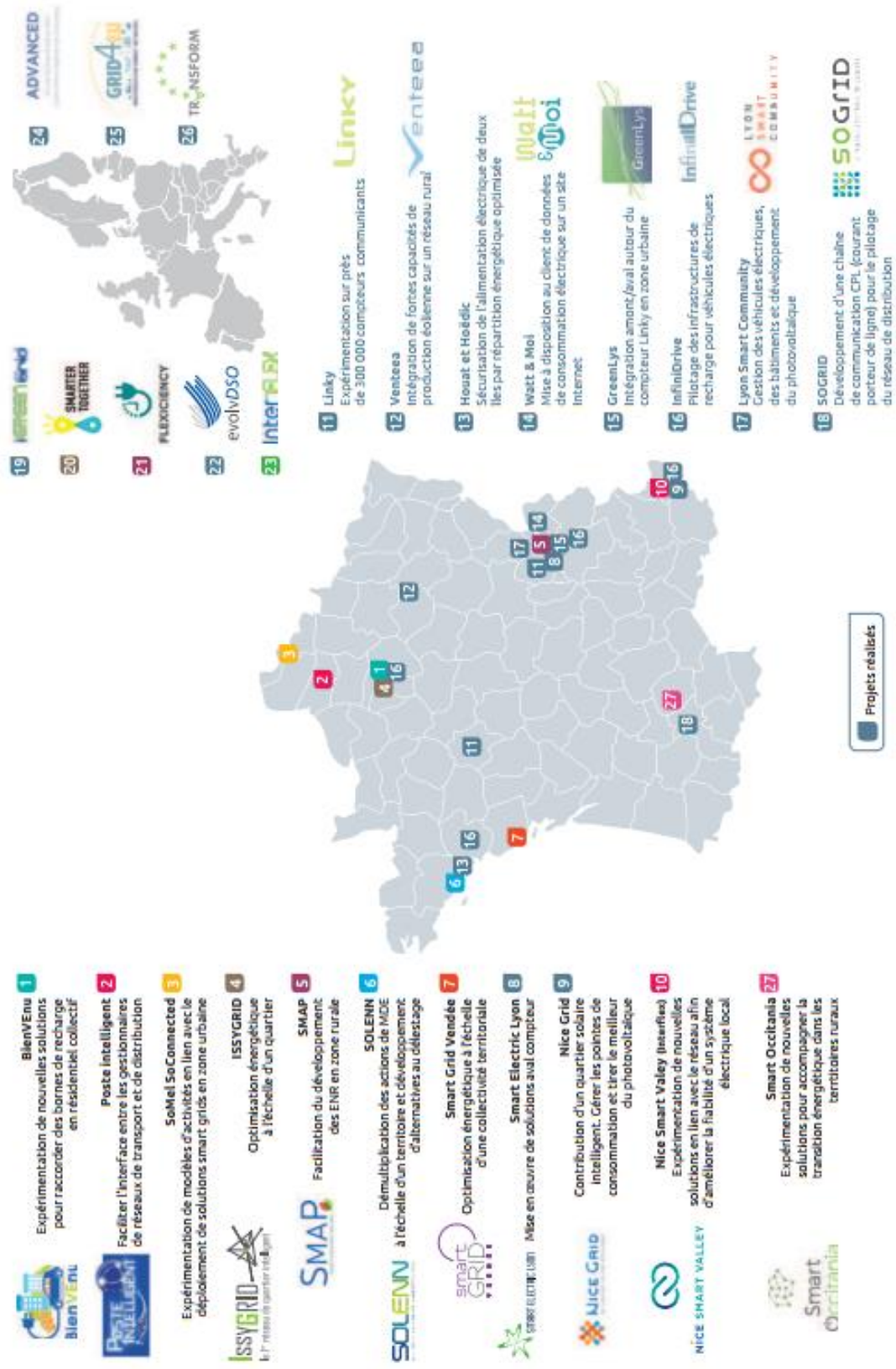


Figure 6-9: main French demonstrators19

[19] http://www.enedis.fr/sites/default/files/fiche_Demonstrateurs.pdf

6.7 Funding bodies and programs

The website of the European commission[20] gives some features to understand the funding supporting the Smart Grids initiatives in France: the sources and the beneficiaries in the both topic of R&D and demonstrators or deployment. These features have been recorded from 2008 to 2013 for funding repartition (JRC has stopped to communicate the features) and from 2010 to 2015 for investment per organization type. The two next figures show the evolution.

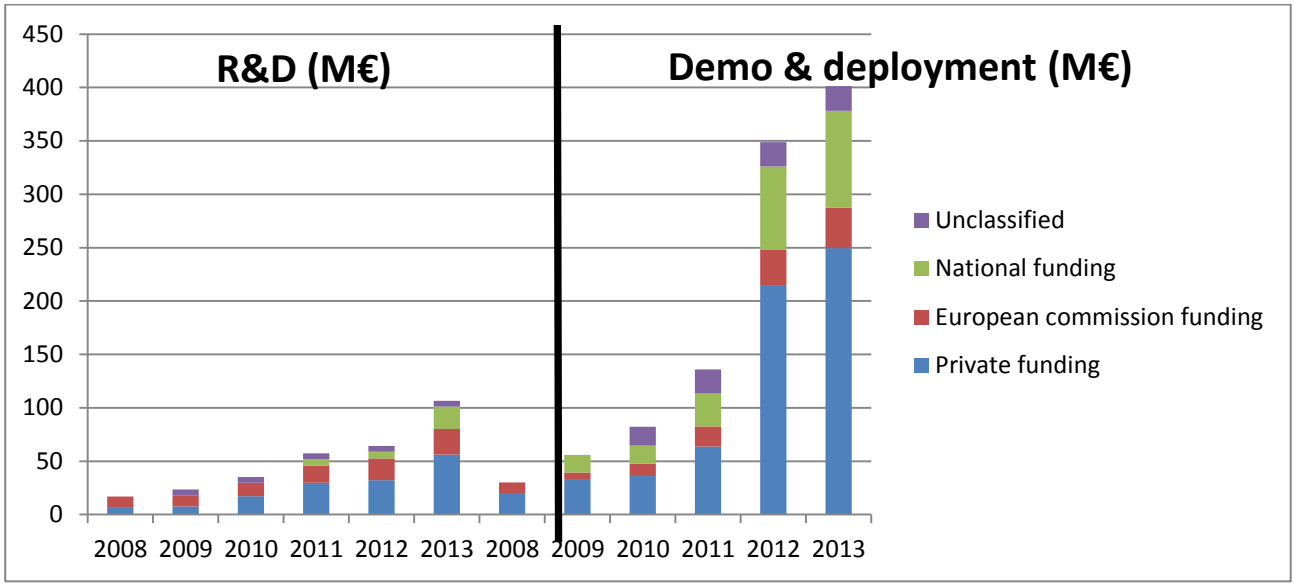


Figure 6-10: Evolution of R&D and Demo & deployment Funding
(cumulative, the chart assumes the budget spent in the starting year)

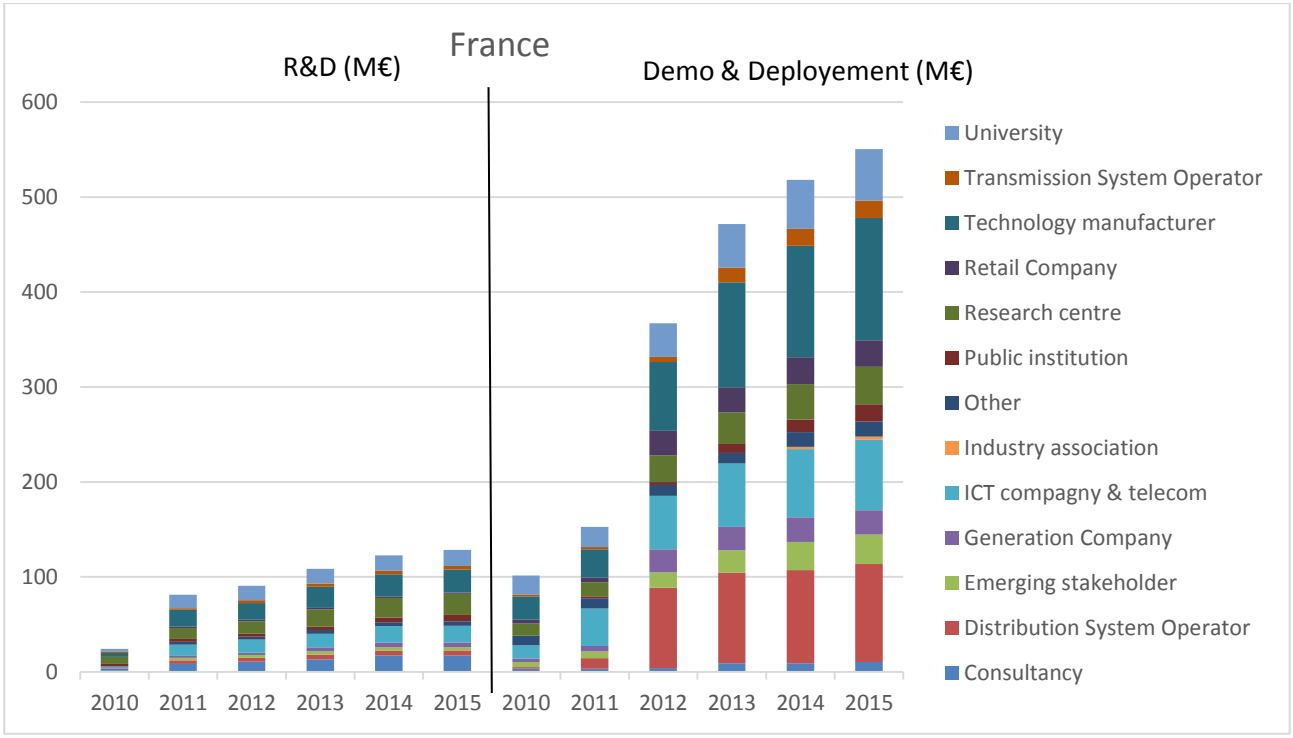


Figure 6-11: R&D and Demo & deployment Investments per organization type
(cumulative, the chart assumes the budget is spent in the starting year)

[20] http://ses.jrc.ec.europa.eu/smart-grids-observatory

6.8 Description of national SET Plan Structure for Smart Grids Research

In the ADEME's report done in 2008[21], the group of experts (AREVA, EDF R&D, GDF – suez, RTE, ERDF, INES, SUPELEC, Université de Paris Sud, Armines, FNCCR, DGA) have expressed different vision to build the French Smart Grid Strategy.

Visions in the 2020 time frame:

The visions elaborated for 2020 are based on the observation that achieving European goals for renewable energy, transposed into French law following the Grenelle environmental conference, calls for installing 25 000 MW of wind energy capacity and 5 400 mw of photovoltaic solar panels in France by 2020.

Four new pathways appear to provide enough flexibility for grids and electrical systems, up to additional capacity of **about 20 000 MW5.**

• **Improved forecasting models** for wind farm generation and for photovoltaic elements and panels (building-integrated or not).

• **Optimised integration of decentralised generation** in grids. This optimisation involves coordinated development of decentralised generation and grid infrastructure.

• **Evolution of distribution grids** (architecture, equipment, network control tools, degree of smart operation) in order to allow strong penetration of decentralised generation, in particular from renewable resources.

• **Interconnection of European transmission grids**, in order to pool the centralised storage capacity of major hydropower installations.

Beyond 20 000 MW, the above four pathways will not be technically, economically and environmentally sufficient, and new margins of flexibility will have to be found, via **dispersed storage, storage coupled with large-scale intermittent generating capacity, dynamic load management, and smart systems.**

Visions in the 2050 time frame:

By reason of the inherent inertia of the components of the electricity system, the experts framed the following assumptions for the 2050 visions.

• These visions **prolong the 2020 visions**, on the assumption that, given the time lag for deployment of technology in the networks and the long-term financial commitments linked to this deployment, these technological options will not be called into question in 2050.

• The major shifts compared to the 2020 visions are tied to different **regulatory regimes** (Internet or Enlightened Regulation) on the one hand, and **significant changes in grid environments** on the other hand (for example, generalization of positive-energy buildings and plug-in hybrid and/or fully electric vehicles. More precisely, the internet regulation option, under which market mechanisms aims to govern the relationships between system actors, the number of actors increases sharply and the intervention protocols concerning the different actors are broadly defined; the Enlightened Regulation option, is characterized by fewer actors than under the

21 http://www.ademe.fr/sites/default/files/assets/documents/84680_roadmap_for_smart_grids_and_electricity_systems.pdf

Internet option, stricter protocols for their intervention in the system and a greater diversity of mechanisms governing relationships between actors (not simply market dynamics).

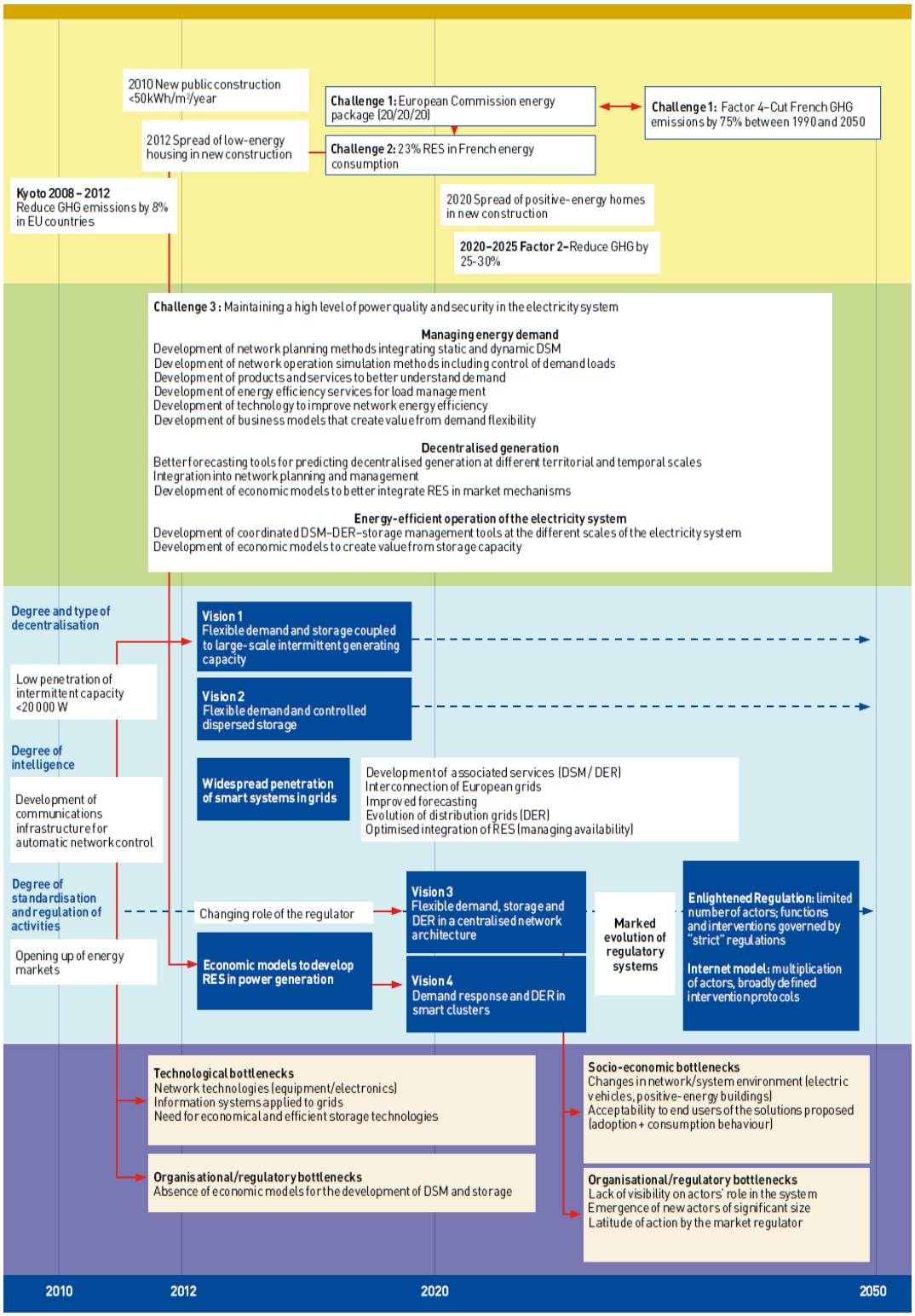


Figure 6-12: French Smart Grids Strategy in the 2020 and 2050 time frames (source ADEME's report)[22]

22

http://www.ademe.fr/sites/default/files/assets/documents/84680_roadmap_for_smart_grids_and_electricity_systems.pdf

7 Germany

7.1 Landscape of Smart Grids R&D in Germany

The total installed capacity is 89.934 MW with a new capacity of 7.165 MW installed in 2013. The total electrical energy output from renewable generation is 161 TWh and accounts for 27,4% of gross national electricity demand in 2014, see the following figure23.

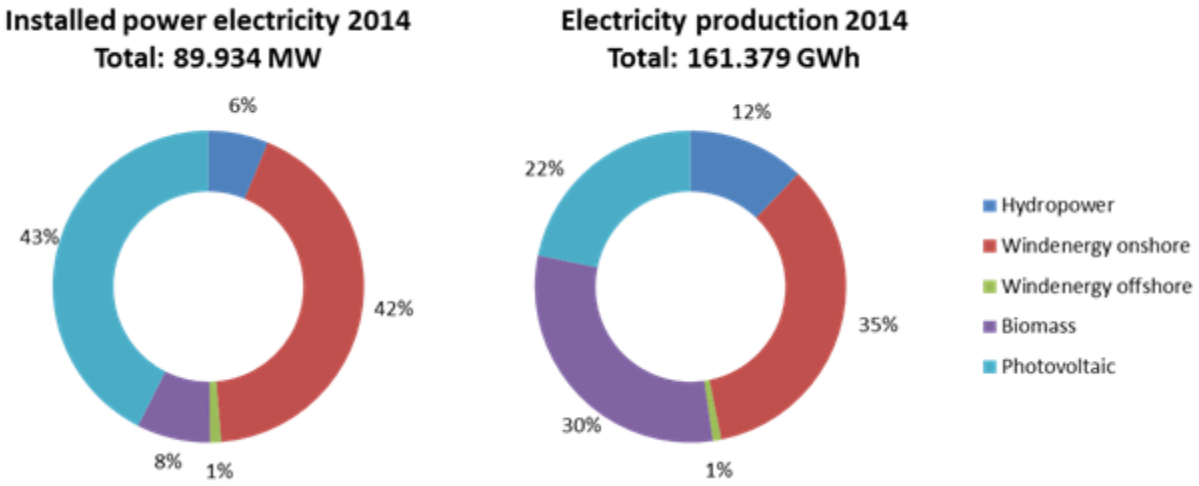


Figure 7-1: Installed power electricity and electricity production in Germany

7.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

Germany has a long-term vision for an energy system relying predominantly on renewable energy resources. Hence the federal government passed the EEG bill and several amendments with the ambitious aim to raise the share of renewable energy sources in the gross electricity demand to 40-45% by 2025 and to 55-60% by 2035.

The renewable energy sector employed 371.400 people in 2013 and had a turnover of approximately 14,2 billion EUR. [ref-GER2, ref-GER3].

7.3 Industry (main industry actors, where in the value chain)[24]

German manufacturers have considerable expertise in manufacturing of wind turbines, the production of individual components and modules, such as generators, gears and rotor blades and service/maintenance. With a share of more than 59% in installed wind turbines Enercon is the market leader. Alongside specialised manufacturers of wind energy turbines, many medium-sized companies of classic engineering have developed new business segments in Germany's wind industry. Steel tube towers, concrete footings or castings are required for the construction of wind energy just as much as site surveys, certifications and type-approval tests. German manufacturers of small wind turbines have achieved greater professionalism in production over the

[23] Own depiction, data obtained from [ref-GER1]
[24] Data obtained from [ref-GER4]

past few years. Small turbines from Germany are now the most reliable of their type in a global comparison, especially in the 1 – 20 kW range.

German companies in the PV industry are represented throughout the world, in the area of production and at all other levels of the value chain. The export quota of the German PV industry was around 65 per cent in 2013. At the end of 2013, 60,000 full-time workers were employed in roughly 5,000 companies in the German PV industry. Of those companies, 200 were involved in the manufacturing sector, producing cells, modules and other components. SolarWorld is one of the biggest manufacturers of cells and modules and SMA Solar Technology is the market leader for converters.

The German biogas industry has taken a pioneering role in the area of generation and utilisation of biogas. Germany is both the market and technology leader and has been able to acquire substantial expertise, particularly in the area of gasification based on organic waste and renewable sources. German companies in the biogas industry, e.g. MWM, cover the entire value chain of biogas technology – from planning and financing to the operation and maintenance of biogas plants and feed-in of biogas into the natural gas grid – and have many years of experience in process biology and is associated laboratory services. The export quota of the German biogas industry amounted to around 45 per cent in 2013. Thus German production accounts for more than half of the total European energy extracted from biogas.

German companies, like Voith Hydro, have been developing, installing and operating hydropower plants for more than 100 years. A significant proportion of further development in hydropower technology is being provided by German companies. Their current projects include work on innovative turbine concepts and technical solutions for hydropower plants with drop heights of less than 10 m. German companies are also playing an important role in the research and development of turbines and power plants to exploit marine energy, for example, as part of the construction of the first wave power plant with a permanent connection to the national grid in Scotland, and the first commercial wave power plant in Spain, in operation since 2011.

The German geothermal industry covers the entire range of geothermal technologies: From near-surface geothermal energy to hydrothermal and petro-thermal, deep geothermal energy for generating heat, refrigeration and power. The first geothermal power plant in Germany started operation in Waren an der Müritz in 1984 and is still providing heat for 1,800 households today, three decades later. Since the start of the 21st century, electricity projects using geothermal heat have also been developed in Germany. The market leaders are Stiebel Eltron, Viessmann and Junkers Bosch Gruppe.

7.4 Public research stakeholders

With its Energy Concept from 28 September 2010, the German government initiated the Energiewende – Germany's energy transition. In order to optimally handle the high share of fluctuating electricity fed into the power grid, processes, concepts and materials shall be researched and developed within the "Future-proof Power Grids" funding initiative. The funding initiative represents a part of the German federal government's 6th Energy Research Programme. The German federal ministries for Economic Affairs and Energy (BMWi) as well as for Education and Research (BMBF) are therefore supporting projects that provide solutions for utilisation in intelligent distribution grids, transmission grids, grid planning and management. The funding initiative is therefore helping to improve the environmental compatibility, economic viability and resource efficiency of the electricity grids and the security of the electricity supply in Germany. The federal ministries involved are intensifying their research activities by providing at least 150 million

euros for the initiative. The "Future-proof Power Grids" funding initiative supports the cooperation between industry and academia throughout the value added chain and facilitates international research collaborations, for example as part of the European Strategic Energy Technology Plan. [ref-GER5]

7.5 National R&D strategy

The restructuring of Germany's energy supply planned by the government to take place up to 2050 on the basis of high efficiency and the widespread use of renewable energy can only be achieved if there are substantial technological innovations in almost all components of the energy system. For these reasons, energy research is a strategic element of energy and economic policy as we undertake our energy transition. The new orientation of energy policy is thus also resulting in new principles for the Federal Government's energy research policy, particularly regarding applied research.

In view of this, the Federal Ministry for Economic Affairs and Energy is bringing together its measures in the field of non-nuclear energy research, and is systematically developing the Sixth Energy Research Programme. This covers the entire energy chain, from energy provision and conversion to transport and distribution, including storage, and its use in various sectors. [ref-GER6]

The 6th Energy Research Programme defines the principles and priorities for Federal Government funding for innovative energy technology and creates a basis to ensure that the modernisation of the energy supply in Germany is organised in an ecologically sound, reliable and economical manner. The funding policy targets technologies which meet the needs of the energy transition. In addition to the areas mentioned above, i. e. energy efficiency and renewable energy, the funding also focuses on new grid technologies and energy storage. [ref-GER8]

7.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

The 6th Energy Research Programme of the Federal Government [ref-GER8] is used in order to support companies and research establishments with regard to research and the development for the future energy supply. The development of this programme is at the responsibility of the Federal Ministry for Economic Affairs and Energy. Furthermore, this ministry is responsible for the project funding for applied research in and technological development of renewable energy. The Federal Ministry of Education and Research is responsible for fundamental research for energy technologies.

The main objective of the 6th Energy Research Programme is to develop innovative energy technologies enabling the energy transition and to ensure the modernisation of the energy supply in Germany in an ecologically, economical, as well as reliable way. Between the years 2013 and 2016 the German government is funding projects with a total budget of about €3.5 billion.

The following fields are covered by the 6th Energy Research Programme [ref-GER6, ref-GER7].

- Wind power
- Photovoltaics
- Deep geothermal energy
- Solar thermal power plants

- Hydropower and marine energy
- Power plant technology and CCS
- Fuel cells and hydrogen technologies
- Energy storage
- Power grids
- Integration of renewable energy
- Energy-optimised buildings and neighbourhoods - distributed and solar energy supply
- Energy efficiency in industry and commerce, trade and services
- Key energy industry elements of e-mobility
- Systems analysis
- Inter-systemic technologies for the energy transition (in preparation)

In Table 7-1 a summary of supported R&D projects in Germany is given. A more detailed overview can be found in [ref-GER12]. Furthermore, for the funding initiative for power grids example projects are listed in Table 8-2.

7.7 Funding bodies and programs

The Funding program "Smart Energy Showcases - Digital Agenda for the Energy Transition" (SINTEG) aims at the development and demonstration of solutions for climate-friendly, secure and efficient energy supply with a high penetration of fluctuating wind and solar resources. The focus lies on the integration of power generation, production, storage and grids to Smart Grids. Table 7-2 gives an overview of the showcases that are funded. [ref-GER9, ref-GER10]

With the research initiative for the Energy transition, the Federal Ministry of Education and Research supports research, industry and private users to bring results from fundamental research to practical applications. The funded projects are dedicated to four central topics (see Table 8-2).

The Kopernikus projects are set up for up to ten years. The ministry provides up to 210 Million *Euro for the first funding phase until 2018. Until 2015 two more phases will be funded with 280* Million Euro. The Kopernikus projects are part of the energy-research program of the federal government "Forschung für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung" (Research for an environmentally friendly, reliable and affordable energy supply). [ref-GER-11, ref-GER-12] Funding bodies and programs.

Federal and State Governments

Federal and state governments are the main sponsors of research in Germany alongside industry. Many Federal Ministries support specific research projects. Funding and subject programmes play a central role here. Researchers can submit applications for fixed-term projects. Calls for proposals are primarily directed at associations of companies, higher education institutions, large research institutions and other R&D establishments. Direct project funding is related to a concrete area of research.

Indirect Project Funding

In contrast to this, indirect project funding is independent of the respective field and is oriented, for example, towards developing and strengthening research infrastructure, research cooperation, innovative networks or exchanges of staff between research institutions and industry. The

participating ministries advertise their respective current focal points. So-called project management organisations support R&D funding projects with regard to both their content and organisation and are usually based at research centres. They advise applicants and support the projects until their conclusion. A few examples of project management organisations are:

Foundations: public and private foundations enable research through the provision of funding. The range of different foundations is very wide. Many of them specifically aim to promote young talent.

German Federation of Industrial Research Associations (AiF): the German Federation of Industrial Research Associations (AiF) offers various opportunities for project funding.

German Research Foundation (DFG): the DFG is the largest research funding organisation in Germany. It supports research in higher education and public research institutions, but does not run any research establishments itself.

The funding database (Förderdatenbank) of the Federal Government provides access to comprehensive and current information on the funding programmes of the Federal Government, the German states and the European Union: www.foerderdatenbank.de (in German only).

The publicly accessible databases of the Federal Ministry of Education and Research (BMBF) contain data on over 110,000 research projects. This is the most comprehensive source of information on Germany's research landscape.

7.8 Description of national SET Plan Structure for Smart Grids Research

The Federal Ministry for Economic Affairs and Energy supports the implementation of the SET-Plan with its focus on the development of key technologies. The objective is to better integrate and utilize synergies between European member states. The BMWi encourages the engagement of the deployment SET-plan amongst the member states and hosted a conference of the European Commission and the European member states with the topic "Energy Research in Europe: Germany's Contribution to the SET-Plan" in March 2012. [ref-GER13]

The European Energy Research Alliance (EERA) also supports the implementation of the SET-plan. Leading European research establishments, to which several German associations, institutions, organisations and universities belong, have the objective of jointly strengthening the research activities to enable future energy supply. The combination of research funding on both the national and European side as well as the utilization of synergies can integrate the activities and resources for the goals of the SET-plan within EERA. Therefore, the energy research funding in Germany will increasingly focus on the European level since the success of the SET-plan depends on the integration of national funding programs. The funding of research and innovation according to the roadmap of the SET-plan and its implementation cannot only be financed by programmes of the European Commission. Thus, international cooperation with different funding bodies will have an increasing importance. For the implementation of the SET-plan the so-called Berlin model has been suggested by the German government. The core element of this model is an efficient multi-national funding of research projects with close collaboration of national funding programmes and organizations. First bi-national joint research based on this model projects with Finland and Austria/Switzerland have been successfully started. Furthermore, bi-lateral projects with Greece with topics regarding e.g. photovoltaics, storage technology or European integration of national grids have been initialised together with other bi-national cooperation. [ref-GER15, ref-GER16]

Table 7-1 Summary of supported R&D projects in Germany
(excerpt from [ref-GER14])

Topic	Funds 2014 (Million Euro)	Number of projects 2014
Wind Power	53.06	242
Photovoltaics	53.34	260
Solar thermal power plants	9.25	77
Storage	39.78	240
Grids	33.62	285

Table 7-2 Example for supported Smart Grids R&D and Innovation projects in Germany

R&D project	Company	Total budget (Million EUR)
Proaktives Verteilnetz (Proactive distribution system)	RWE AG, RWTH Aachen, TU Dortmund, Venios GmbH, BTC AG, OFFIS	6.5
NETZ:KRAFT	Fraunhofer IWES, 50Hertz Transmission GmbH, TenneT TSO GmbH, Amprion GmbH, Transnet BW GmbH, EnergieNetz Mitte GmbH, MITNETZ Strom GmbH, HanseWerk AG, DREWAG Netz GmbH, Avacon AG, ENERCON GmbH, Energiequelle GmbH, SMA Solar Technology AG, ÖKOBIT GmbH, PSI AG, Dutrain GmbH, GridLab GmbH, Friedrich- Alexander-Universität Erlangen-Nürnberg, Universität Kassel, DERlab e.V.	12
Kopernikus projects • P2C: Storage of renewable energies by converting into other energy carriers such as hydrogen • ENSURE: Development of power grids that are adapted for a large integration of renewable energies • SynErgie: New orientation of industry processes toward fluctuating energy supply • ENavi: Interaction of renewable and conventional energy to ensure a security of supply	More than 260 research institutes and companies	120

Demonstration & deployment project	Company	Total budget (Million EUR)
Smart Energy Showcases - Digital Agenda for the Energy Transition" (SINTEG) • C/sells: Großflächiges Schaufenster im Solarbogen Süddeutschland • Designetz: Baukasten Energiewende - Von Einzellösungen zum effizienten System der Zukunft • enera: Der nächste große Schritt der Energiewende • NEW 4.0: Norddeutsche EnergieWende • WindNODE: Das Schaufenster für intelligente Energie aus dem Nordosten Deutschlands	More than 200 companies and stakeholders	230

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[ref-GER1] Bundesministerirum für Wirtschaft und Energie (BMWi) http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/erneuerbare-energien-in-zahlen-2014.pdf?__blob=publicationFile&v=3, access 11/18/2015

[ref-GER2] Statista GmbH: http://de.statista.com/statistik/daten/studie/186954/umfrage/beschaeftigte-im-bereich-der-erneuerbaren-energien-nach-branchen/ ,access 11/18/2015

[ref-GER3] Statista GmbH: http://de.statista.com/statistik/daten/studie/153104/umfrage/umsatz-mit-erneuerbaren-energien-in-deutschland/

[ref-GER4] German Energy Agency (dena): http://www.renewables-made-in-germany.com/fileadmin/EMP_2014/renewables_Made_in_Germany_2015_EN.pdf, access 11/18/2015

[ref-GER5] The research initiative of the federal government: http://forschung-stromnetze.info/en/the-research-initiative/, accessed 11/20/2015

[ref-GER6] Federal Ministry for Economic Affairs and Energy, *Research priorities*: http://www.bmwi.de/EN/Topics/Energy/Energy-research-and-innovation/research-priorities.html, accessed 11/23/2015

[ref-GER7] Federal Ministry for Economic Affairs and Energy, *Research for an environmentally sound, reliable and affordable energy supply - 6th Energy Research Programme of the Federal Government*, November 2011, https://www.bmwi.de/Redaktion/EN/Publikationen/research-for-an-environmentally-sound-reliable-and-affordable-energy-supply.pdf?__blob=publicationFile&v=3

[ref-GER8] Federal Ministry for Economic Affairs and Energy, *6th Energy Research Programme of the Federal Government*: https://www.bmwi.de/Redaktion/EN/Artikel/Energy/research-for-an-ecological-reliable-and-affordable-power-supply.html, accessed 11/27/2017

[ref-GER9] Federal Ministry for Economic Affairs and Energy, *Förderprogramm "Schaufenster intelligente Energie - Digitale Agenda für die Energiewende" (SINTEG)*, http://www.bmwi.de/DE/Themen/Energie/Netze-und-Netzausbau/sinteg.html, access 12/02/2015

[ref-GER10] Federal Ministry for Economic Affairs and Energy, Funding programme "Smart Energy Showcases - Digital Agenda for the Energy Transition" (SINTEG), http://www.bmwi.de/Redaktion/EN/Artikel/Energy/sinteg-funding-programme.html, access 11/27/2017

[ref-GER-11] Federal Ministry of Education and Research, “Kopernikusprojekte für die Energiewende”, https://www.bmbf.de/de/kopernikus-projekte-fuer-die-energiewende-2621.html, access 11/27/2017 (only available in German)

[ref-GER-12] Federal Ministry of Education and Research, https://www.kopernikus-projekte.de/, access 11/27/2017 (only available in German)

[ref-GER13] Federal Ministry for Economic Affairs and Energy, Schlaglichter der Wirtschaftspolitik - Monatsbericht August 2013: http://www.bmwi.de/DE/Mediathek/monatsbericht,did=586938.html, access 11/23/2015

[ref-GER14] Federal Ministry for Economic Affairs and Energy, Innovation Through Research Renewable Energies and Energy Efficiency: Projects and Results of Research Funding in 2014, April 2015, https://www.bmwi.de/Redaktion/EN/Publikationen/innovation-durch-forschung-jahresbericht-forschungsfoerderung-ee-2014.pdf?__blob=publicationFile&v=2

[ref-GER15] Federal Ministry for Economic Affairs and Energy, Bundesbericht Energieforschung 2014 2015 – Forschungsförderung für die Energiewende, Bundesbericht, April 2015.

[ref-GER16] Federal Ministry for Econimc Affairs and Energy, Bundesbericht Energieforschung 2016 – Forschungsförderung für die Energiewende, Bundesbericht, April 2016. http://www.bmwi.de/Redaktion/DE/Publikationen/Energie/bundesbericht-energieforschung-2016.pdf?__blob=publicationFile&v=14

8 Greece

8.1 Landscape of Smart Grids R&D in Greece

By the end of 2013 the total installed capacity of RES in Greece was 7.670,32 MW (including Large Hydro). This value incorporates the following technologies: Wind Generators 1.808,65 MW, Biomass 45,81MW, Small Hydroelectric plants 220,14MW, Photo Voltaic Power Plants (except residential ones) 2.205,98 MW, Residential Photo Voltaic Systems 371,74MW and finally, Large Hydroelectric Plants 3.018,00 MW of which 700 MW are reversible (pumped storage). Compared with the figures of the previous year the increase in the total installed capacity in 2013 in Greece was 1.108,34 MW in total, which is analyzed in the following figures per technology: Wind Generation (WG) 56,64 MW, Biomass 1,06 MW, Small Hydro 6,91 MW, PV Plants 968,22 MW, Residential PVs 75,21 MW whilst the installed capacity of Large Hydroelectric plants remained unchanged.

8.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

It is self-evident from the data reported in the previous chapter that in 2013 there was a boost mainly in one technology, particularly PVs which almost makes up the total RES share installed within this year. By contrast, in 2014 the newly installed PV systems capacity sharply dropped and it reached only 17MW due mainly to the reaching of the country's goals and technical constraints in terms of installed capacity of PV plants and also because of financial considerations with regard to reforms in the funding schemes. This trend continued also for the next two years leading so far to the worst year (2016) in terms of PV investments and installations since 2007. Even still, the already installed PV systems led to a 7,05% coverage of electricity demand by PVs only in 2016. The corresponding energy yield for other technologies for the same year were: 9,24% from WGs, 1,30% from Small Hydro and 0,45% from Biomass resources.

Concerning employment and job opportunities related to the Smart Grids sector, the most noteworthy statistics regard the PV sector. PVs was until 2013 the fastest growing technology showing that only this sector directly employed people reached a number as high as 26.600. This rapid growth in this year resulted in 5.000 indirect job positions too. By contrast, the direct job positions in 2016 reduced in about 1.000.

8.3 Industry (main industry actors, where in the value chain)

A large number of companies have been active in the sector of RES and Smart Grids over the last years in Greece. These companies are either associated according to their background and area of interest (e.g. manufacturers, energy producers) or participate independently in the energy market. For instance, the Hellenic Association of Photovoltaic Companies includes 18 members mostly from industry and PV systems manufacturers and installers. In addition, the Hellenic Association of Energy Producers from PVs includes about 470 members. Apart from these companies there is a host of small enterprises currently active in the PV sector, the number of which is totally estimated to 1,700. In the wind generation sector the relevant association includes about 70 companies that produce and sell energy from wind.

8.4 Public research stakeholders

One of the most important and recent activities in the Smart Grids sector in Greece regards the constitution a technology platform, named as Hellenic Technology Platform for Smart Grids. This initiative was launched in December 2014 and it initially involves the participation of public research organizations such as: Centre for Renewable Energy Sources and Saving (CRES), Hellenic Distribution Network Operator-HEDNO, University of Patras, Aristotle University of Thessaloniki and National Technical University of Athens. The main focus of the platform is the facilitation of the smooth transition of the Greek power system from its current form to a smart model, which will be encompassing higher RES penetration. Among the top priorities of the platform are topics like island power systems and microgrids, fostering Demand Response and utilization of Storage to the grid etc.

More precisely, at national level the platform aims to:

- Establish a forum for the promotion and implementation of smart grid technologies in Greece
- Bring together utilities, industries, universities, research centers and all stakeholders related to Smart Grids in Greece
- Facilitate partnership and networking opportunities related to Smart Grids at local and international level
- Implement pilots, benchmarks and demonstration sites

Through the direct link with the activities of the corresponding European platform, namely the European Technology and Innovation Platform on Smart Grids for the Energy Transition (ETIP-SNET), the national platform aims to establish connections with European stakeholders. Also, one of the targets of the platform's activities involves participation in regional groups and, most importantly, dissemination of good practices to third countries.

From a technological point of view, main focus of the activities of the platform is on specific ongoing projects, among which we can distinguish the national-level pilot projects of installation of Smart Meters to LV and AMI to MV customers by HEDNO (it is foreseen that about 200.000 residential and commercial meters will be installed in the next two years). At European level co-funded R&D projects involve small scale pilots and microgrids implementations in autonomous islands, 100% RES, incorporating smart load and storage control. Other important co-funded projects are: IGREENGrid – Integrating Renewables in the European Electricity Grid, DREAM - Distributed Renewable resources Exploitation in electric grids through Advanced heterarchical Management, INCREASE - Increasing the penetration of renewable energy sources in the distribution grid by developing control strategies and using ancillary services and many others.

8.5 National R&D strategy

The triple targets of the 20-20-20 package are considered by the Greek Government as both obligations and opportunities. It is envisioned that they will play a key role in ensuring energy security, reducing national GHG emissions and boosting the competitiveness of the economy and attracting investment capital and technical knowhow. It is also estimated that they will assist in the economic improvement of conditions in rural areas and in boosting eco-industry that utilizes comparative advantages of local agricultural production and food industry. The target of a 20% share of renewable energy in the gross final energy consumption in 2020 will be achieved through the combination of measures for energy efficiency as well as for the enhanced penetration of RES

technologies in electricity production, heat supply and transport. A major role in this respect will be played by the streamlining of the existing framework of licensing regulations and the rationalization of the terms and conditions of land management. The contribution of RES to the national energy balance in 2008 was approximately 7.8% of gross final energy consumption and around 16.3%, of primary energy production. Greece has considerable wind and solar energy potential, which has already attracted investment interest, as well as a promising biomass and geothermal potential, which, however, still remains untapped. Most of the existing hydro potential is largely exploited but a further addition of some large 8 hydro plants including one of 500 MW pumped storage capacity and of a number of smaller (i.e. of less than 15MW capacity) ones are currently under consideration.

8.6 National priorities (examples of programmes, centers, large projects and their thematic focus)

The first priorities at national level involve the proliferation of smart metering infrastructure, facilitation of smart grid technologies such as microgrids with emphasis on the electrification of islands and use of island systems as test beds and demonstration sites for novel technologies. Thematic focus is given by the following plans:

- Study for the Development of the Transmission System (2010-2014)
- 1st Report on Long Term Energy Planning in Greece (2008-2020)
- National Renewable Energy Action Plan in the Scope of Directive 2009/28/EC (June 2010)

Ongoing programs on these thematic areas are the following:

- R&D and Demo project AI STRATIS-GREEN ISLAND; 2013-2015 and 2017-2022 with total budget at EUR 8,5 million
- R&D project TARES+ 2016-2017 with total budget at 2.78M€
- ‘Smart Grids‘: Technical study to maximize the penetration of renewables, to power quality, microgrids and distributed generation. The project is in collaboration between NTUA, Public Power Corporation and Regulatory Authority of Energy and regards the islands: Lesbos, Lemnos, Andros, Santorini and Kythnos. The study is financed with 800.000 € by the EU “ELENA” programme (European Local Energy Assistance) through the Intelligent Energy.

8.7 Funding bodies and programs

The main state body which is responsible for organizing and funding R&D projects at national level is the General Secretariat for Research and Technology. GSRT is subject to the Ministry of Education, Research and Religious Affairs and its strategic goals include among others scientific research and technological development, enhancement and exploitation of highly specialized human potential in the area of the higher education, research and innovation, innovative Public-Private Partnerships (PPPs), linked with universities and research centers, regional instruments for implementing smart specialization strategies, creation of new research infrastructures and exploitation of existing ones, and internationalization of the research and innovation system of the country.

Over the last 10 years, projects that concerned energy sector have been funded in the frame of the National Strategic Reference Framework 2007–2013 (NSFR 2007-2013) and its successor Partnership Agreement for the Development Framework 2014-2020 (PA 2014-2020). The former programme constituted the reference document for the programming of European Union Funds at

national level for the years 2007–2013. It was elaborated within the framework of the new strategic approach to the Cohesion Policy of the European Union, according to which NSRF ensured that the assistance from the Funds is consistent with the Community strategic guidelines on cohesion and identifies the link between Community priorities, on the one hand, and the national reform programme, on the other. NSRF 2007-2013 has been the main funding scheme for national projects regarding Energy Saving, Rational Use of Energy and Renewable Energy Sources in urban and rural areas. The PA 2014-2020 program constitutes the main strategic plan for growth in Greece with the contribution of significant resources originating from the European Structural and Investment Funds (ESIF) of the European Union. The PA, through its implementation, seeks to tackle the structural weaknesses in Greece that contributed to the economic crisis, as well as other economic and social problems caused by it. Moreover, the PA 2014-2020 is called upon to help attain the national targets within the Europe 2020 Strategy.

8.8 Description of national SET Plan Structure for Smart Grids Research

Responsibility:
The Centre for Renewable Energy Sources and Saving (CRES) is responsible to support the Ministry of Environment and Energy for the Greek coordination of SET-plan activities. CRES has also Sherpa representatives in the SET-plan Steering Group. CRES is the Greek national entity for the promotion of renewable energy sources, rational use of energy and energy conservation. It is a public entity, supervised by the Ministry of Environment and Energy and has financial and administrative independence.

Coordination:
Apart from being the national representative in the SET-plan, CRES is also directly involved in the activities of the ELECTRA Integrated Research Program and the European Energy Research Alliance (EERA) Joint Program for Smart Grids. CRES is also supporting the Ministry of Environment and Energy for the Greek coordination of SET-plan activities and CRES, through the Department of PVs and DG, is also directly involved in the ELECTRA and EERA activities, thereby providing a coherent link between the activities of the Group and our project. For example, in Table 1 below two major national R&D and demonstration projects which are relevant to the ELECTRA IRP activities are listed. These projects involve the reinforcement and implementation of control strategies in island power systems that would allow for a higher RES penetration. Both these projects aim at a high RES penetration, which, especially in the case of the Green Island project the target RES penetration reaches 100%. It is self-evident that the specific projects have some particularities and pose implementation challenges in terms of operation and system stability. Therefore, the interaction with ELECTRA for the remaining duration of the latter projects as well as the knowledge transfer based on the ELECTRA results will be of vital importance for the projects implementation.

Table 8-1: Supported Smart Grids R&D and Innovation projects in Greece

R&D project	Company	Total budget (Million EUR)
R&D and Demo project AI STRATIS-GREEN ISLAND*	CRES	8.5
R&D project TARES+ 2016-2017 *	GIZ GmbH	2.78
R&D 'Smart Grids': Technical study(European Local Energy Assistance) *	NTUA	0.8
*see ANNEX I for details		

9 Italy

9.1 Landscape of Smart Grids R&D in Italy

Italian 2016 electricity production has ranged around 310 billion kWh. The balance of electricity 2015-2016 is shown in figure 9.1: national production, which increased by 1.2%, covered 89% of the national request (compared to 86% in 2015). Imports decisively decreased in comparison to the previous year, showing a reduction of 15.1%. In contrast, exports increased by 37.7%, especially those towards Greece and Malta, and reached 6,155 GWh [ref_IT1].

Table 9-1: Balance of Electricity in Italy in 2015 and 2016 [Gwh] (Elaboration ARERA on TERNA data)

	2015	2016(*)	Variation %
Net production	272,428	275,649	+1.2
Received from foreign suppliers	50,849	43,181	-15.1
Sold to foreign customers	4,471	6,155	+37.7
Allocated to pumping	1,909	2,424	+27.0
Availability for consumption	316,897	310,251	-2.1

(*) Provisional data

The Italian end customers are about 36 Millions (of whom 0.6 Million are prosumers). The majority are household customers (28 Millions) - characterized by a typical energy consumption of 2,700 kWh/y and a contractual power of 3.3 kW - while the Business customers are about 8 Millions (of which: 0.1 Million connected to the MV network).

The "clean generation" (Hydropower + Thermal from Biomass + RES) has reached 37% of national electricity production in 2016 (see Figure 9.1).

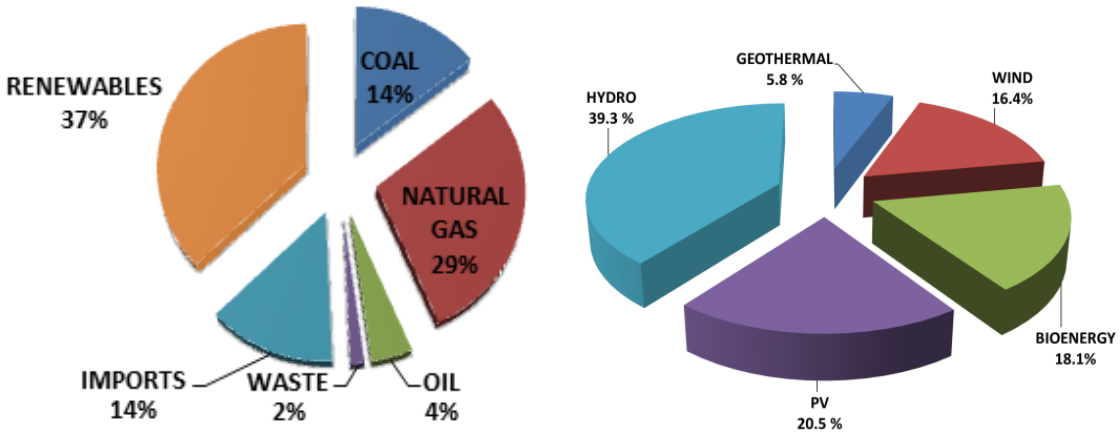


Figure 9-1: Italian electricity energy generation Mix and electricity generation from Renewables 2016 (Elaboration from TERNA Data)

In terms of installed power, Italy, is the fourth leading country in the world in terms of total PV capacity; about 46% of the installed capacity is from Renewable energy sources (out of a total installed capacity of 114 GW, about 52 GW are from RES) with 22 GW of Hydro, 19.5 GW of Solar, 9.5 GW of Wind and 0.9 GW of Geothermal).

Wind energy generation is composed by on-shore large wind farms (about 1850 plants) connected mainly to the sub-transmission (150 kV) network, while the PV plants (650,000 units) are mostly of

medium to small size (from a few kW to MW size) and are connected to the medium or low voltage distribution networks.

The National Energy Strategy 2017 recognizes that the present level of integration of RES in the electricity system has already reached the national targets for 2020. The Strategy focuses on energy efficiency in the building and transport sectors as well as on the widespread use of efficient electro-technologies. Renewables will continue to grow, with special reference to the technologies having reached market parity, without incentives.

The integration of Renewables in Italy showed up to recently a very rapid growth thanks to incentive schemes.

The following table shows the funding mechanisms and their development over time:

Table 9-2: Integration of renewables: Italian incentive schemes developed over time

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CV														
CE 1														
CE 2														
CE 3														
CE 4														
CE 5														
TO														
AD														
REG														
AST														

- **CV (Certificati Verdi - Green Certificates):** the mechanism is based on the obligation of conventional type electricity generators/importers to fulfil a minimum quota of energy produced from RES. If this cannot be fulfilled with actual plants, CV can be purchased on a trading platform.
- **CE (Conto Energia – PV Photovoltaics schemes):** different schemes have been set up since 2005 to motivate the development of a PV bulk and distributed generation portfolio. The incentive scheme is based on a feed-in premium mechanism, in which a premium is awarded to the energy produced, in addition to the revenue from the energy injected into the grid.
- **TO (Tariffa Omnicomprensiva - All inclusive feed-in tariff):** is applied to all small RES plants (< 200kW WIND or < 1MW OTHER). Cannot be applied to PV. The energy injected into the grid is purchased at "incentive prices" inclusive of energy granted incentive and value
- **AD (Accesso Diretto – Direct access)**: dedicated to micro RES plants (< 60kW wind, 50kW hydro, 200kW biomass, 100kW biogas etc.). The incentive scheme is similar to the TO, except for the quantitative level of the incentive.
- **REG (Registro piccolo impianti – Qualified list of plants):** dedicated to mid-size RES (60kW-5MW wind, 100kW-5MW biogas, 200kW-5MW biomass, 50kW-20MW hydro etc.). Incentives are allowed until the allowed quota of installed power is reached, depending on technologies. The incentive scheme is similar to the TO, except for the quantitative level of the incentive for plants < 1MW; a negative of the incentive modulation based on local hourly electricity price is applied on plants with higher ratings.
- **AST (Aste – Auctions):** dedicated to plants with higher ratings (> 5MW wind, biomass, > 10MW hydro, > 20MW geothermal). Only qualified plants can access this scheme. Yearly (or six monthly) auctions bases are fixed, based on technologies. Plants are ranked based on the discount offered on the auction base. Admitted plants are incentivized based on the resulting price (auction base-discount offered).

The integration of renewables in the electricity generation arena is visually illustrated in Figure 9.2, which shows the important relative contribution of hydro power, the slow increase in geothermal generation, the progressive deployment of bioenergy and wind and the very steep ramp of the solar PV during the first three years of the present decade.

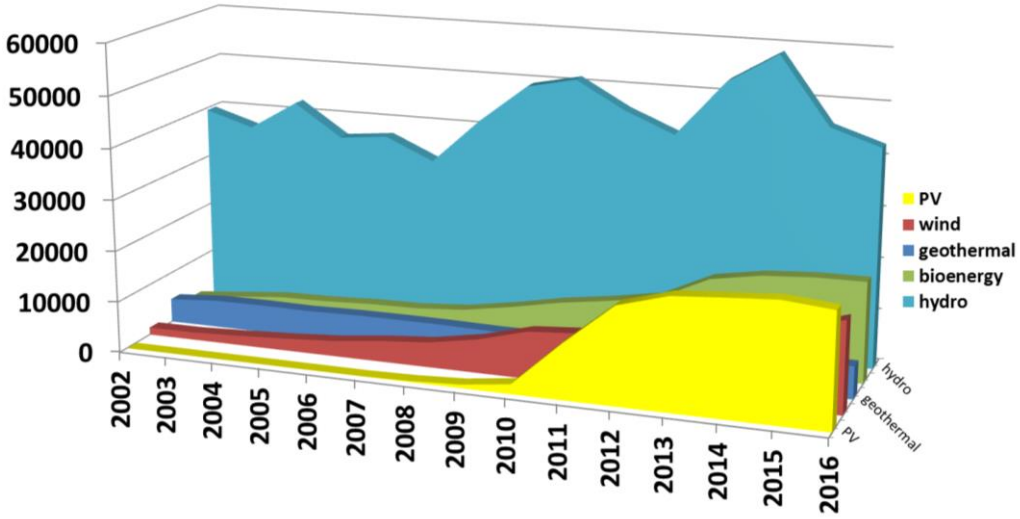


Figure 9-2: Evolution of the contribution from renewable generation [MWh]
(source: elaboration from TERNA data)

The National Energy Policy is coordinated by the Ministry of Economic Development – (Ministero dello Sviluppo Economico - MISE) that supports industrial R&D through financial intervention. The Ministry of Environment and Protection of Land and Sea (Ministero dell'Ambiente e della Tutela del Territorio e del Mare - MATTM) is responsible for co-ordinating Policy on Climate Change.

Multiple government organizations are involved in Italy's Renewable Electricity policies: MISE issues the decrees that define support policies, the Italian Energy Service Provider (Gestore dei Servizi Energetici - GSE) is responsible for managing the implementation of renewable electricity incentive programs and the Energy Market Administrator (Gestore dei Mercati Energetici - GME) manages trading of green certificates.

The Italian Energy Regulator is ARERA, the Italian Regulatory Authority for Energy, Networks and the Environment (Autorità di Regolazione per Energia Reti e Ambiente) - www.arera.it).
Besides the previous competence sectors of the Regulator (Electricity, Gas and Water), the Italian Law No. 205 of 27 December 2017 allocated the Authority regulatory and control functions over the waste cycle, including sorted, urban and related waste. ARERA, regulates the areas of its competence through rulings (resolutions), establishes and updates the base electricity tariffs, the related parameters and the reference elements, proposes funding schemes for the renewal and the variation of licenses, supervises the compliance to competition rules and acts to protect the final user. With special reference to energy and Smart Grids area, the Authority encourages the rational use of energy, especially with regard to the dissemination of energy efficiency solutions and to the adoption of measures for sustainable development. Moreover, it monitors, supervises and controls the quality of supply , safety, access to networks, tariffs, incentives for renewable and similar sources.Another important Authority in the Smart Grid sector is the Italian Communications Regulatory Authority AGCOM (Autorità per le Garanzie nelle Comunicazioni), which has the dual responsibility of ensuring the correct competition among the telecom market operators protecting pluralism and fundamental freedoms of citizens in the field of telecommunications, press, the mass media and postal services (www.agcom.it). ARERA and AGCOM are starting to work together in order to define rules to support the development of Smart Grids in the Country.

In recent years, electric network operators and technology and services providers have invested in Smart Grids programs both to support an efficient transition to a low carbon economy and to smarten the existing networks.

9.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

Italy is among the most advanced countries in the implementation of Smart Grids, systems and energy efficiency/energy storage. The main drivers for this development are:

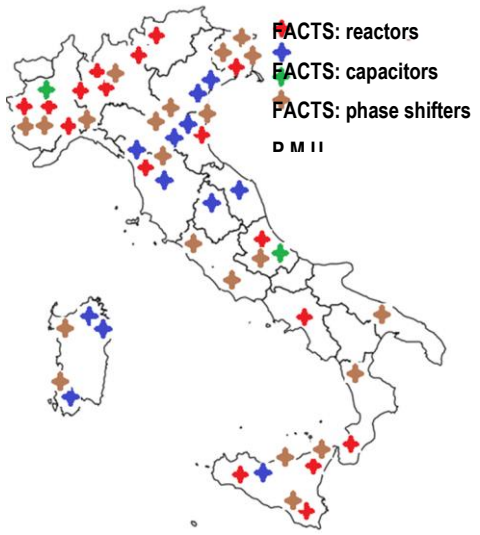
- the massive connection of RES ongoing since several years now;
- the massive roll-out of best practice solutions developed by e-distribuzione S.p.A. – the main Italian DSO- followed by the mandatory installation programme of smart meters set by ARERA in 2006.

Since 2000, e-Distribuzione introduced a set of innovative smart grid tools in its industrial management procedures (>2.5 billion euros investments) ranging from the Smart Metering, the Remote Control and Automation of the MV distribution network, and the Work Force and the Asset Management. In particular, under the TELEGESTORE project, the Automated Meter Management (AMM) System for low-voltage (LV) concentrators and remote meter management was deployed. The implementation of the project led to the installation of more than 33 million smart meters - able to transmit electricity consumption data, receive updates of the contractual parameters and remotely manage the supply connectivity. With over 99% of electronic meters already installed, Italy is well ahead of the timetable fixed by the European Commission, of at least 80% by 2020. Under the REMOTE CONTROL and AUTOMATION project - one of the most relevant worldwide by dimension - 2,200 HV/MV Primary Substations and over 130,000 MV/LV Secondary Substations out of about 400,000 integrate conventional electromechanical solutions with ICT ones in the MV distribution network operation [ref_IT2].

Some Italian key Smart Grids facts and figures are highlighted in the following Table.

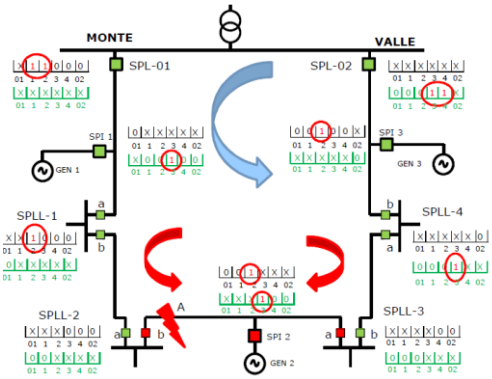
Table 9-3: Key Smart Grids facts and figures in Italy 2016

TRANSMISSION NETWORK SMART GRIDS FEATURES



- Plant Control and Remote Operation Systems (SCTI): an integrated platform for remote monitoring and operation of transmission plants;
- Distributed grid Management based on space technologies (SPACE4ENERGY): manage grid configuration and protection, power flow planning and forecasting of production from RES;
- Development and use of advanced digital tools for Dynamic Network Simulation (SICRE), Operation network simulation (CRESO), Dynamic security assessment (DSA)
- Advanced equipment asset management (MBI): trends equipment conditions and operation, based on on-line monitoring of transformers, CTs, VTs, circuit breakers.
- Experiments of dynamic line loading, including the use of composite conductors
- 4 HVDC lines in operation
- STORAGE LAB: test of technological mix capable of optimizing the cost/benefit ratio of storage systems

DISTRIBUTION NETWORK SMART GRIDS FEATURES



- 100% HV/MV substations (>2,200) remotely controlled
- 30% MV/LV Secondary Substations (>130,000 MV/LV SS) and several thousands pole-top MV switches are remotely controlled; several installations of remotely controlled of LV breakers. Standardised solutions adopted
- Improved neutral grounding system (Petersen Coil)
- Automatic fault clearing procedures implemented on 70% of MV lines; Remote management of MV fault detectors
- Web-based functions for network automation: on-line newtork schemes, real-time access to interruptions data, network consistency and management data, GIS and real time supply situation and access to AMI data
- Planning tools for system expansion taking into account DG, RES forecast (MAGO), EVs, storage (7 trial applications: up to 2 MVA, 2 MWh), demand response
- Trial applications of advanced voltage control algorithms to manage high penetration of DG through an Advanced Distribution Management central System

ELECTRIC VEHICLE CHARGING STATIONS

- >3,000 EV private and public charging stations installed in 60 provinces (out of these 900 are installed by ENEL)
- Normal power (Quick/Slow) charging (3 kW and 22 kW AC) and fast charging (43 kW AC) have been developed
- High power (Fast) charging (AC 43 kW and DC 50 kW) to be installed in short term (starting from Sept 2017) in highways and gasoline filling station);
- 2,500 EVs introduced in 2012 (mostly light-duty quadricycles)
- Agreements with regions and municipalities to foster electric mobility (infrastructure);
- Focus on interoperability between energy operators

SMART METERS

- Number of 1G smart meters installed: >32 million
- PLC communication between meter and concentrator (MV/LV substation), 2G/3G towards AMM (Automated Meter Management) system control center. Open communication protocol: Meters and More™
- Enabled functionalities: remote reading and load profiles, remote customer and contract management
- Additional devices to enable active demand and energy management, by enhanced bidirectional communications
- In progress: installation of the new 2G meters enabling real time consumptions moniotring and new energy services for final customers

The systems and initiatives implemented are in continuous evolution and new features, technologies and flexibility are tested and introduced towards a larger Smart Grids development.

Italy is progressing towards the "**2nd generation" Smart Meter**. With a view of replacing the first generation meters that will have completed their design life time, ARERA has defined the functional specifications and the expected performance levels of the so-called "2G" smart metering system. In particular, the "2G" meters are equipped with two communication channels, the first dedicated to signals towards the electricity system and the second towards the users' devices, using standard protocols to ensure interoperability. The 2G smart metering systems allow remote reading and management, contract reprogramming, rating adjustments etc. The possibility of an incremental evolution of meters, with special reference to communication has been envisaged considering both optic fiber and wireless channels. In this context, ARERA is about to start a process for assessing the availability of standardized technological solutions, allowing the definition of these incremental functions, with the collaboration of the Italian Authority for Communication Guarantees (AGCOM). [ref_IT1].

Moreover, on the basis of the results gathered in pilot demonstration projects campaign (2010-2014), ARERA has adopted a new approach towards the regulation for the development of smart power systems i.e. the "*output-based*" incentives - gradually phasing out the mechanisms in force until 2015 based on the remuneration of investments ("*input-based"* approach)-for the deployment of large scale Smart Grids pilots plants [ref_IT1].

9.3 Industry (main industry actors, where in the value chain)

Italian Power producers are mostly private companies (no operator can own more than 50% of the total installed power) and they sell to wholesale operators or directly to the clients.

Importers are also mostly private companies; they have an interconnection capacity and arbitrate the power flows between Italy and the neighbouring countries.

The Italian transmission system is a national monopoly. TERNA S.p.A: (www.terna.it) is the national Transmission System Operator, operating under concession and regulated by ARERA. TERNA owns the entire high-voltage (HV) network and is responsible of planning, operating and maintaining the transmission system. TERNA's major stakeholder is a public institution.

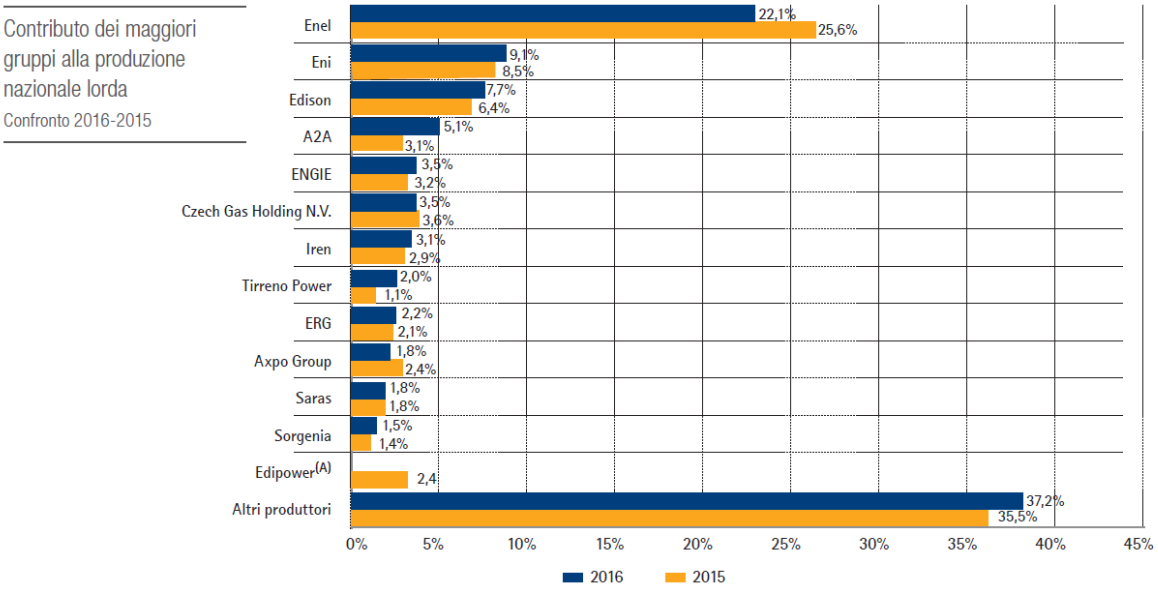
The Italian transmission network is operated with 3 voltage levels, namely: 380 kV, 220 kV, 132-150 kV. With a total length of 72.800 km of HV lines, the Italian transmission network is the largest HV network in Europe and Italy is interconnected to the wider European transmission system by means of 25 HV interconnectors: AC overhead lines to France, Switzerland, Austria, Slovenia, DC submarine cables to France/Corsica, Greece and Montenegro (the latter under construction), and AC submarine cable to Malta.

To respond to the increased risks connected with renewable penetration over the past years and to evolve towards smart grid paradigm, TERNA has constituted a subsidiary company, Terna Storage, that acts as an innovation pole operating in Italy and is engaged in the development and implementation of storage system projects for the transmission grid. In particular, programs have been developed, involving Italian and foreign universities as well research centres, consisting of two flagship projects aimed to address the installation and management of different types of storage systems: "Energy intensive" - launched with the 2011 Development Plan which envisages the construction of 3 storage systems in Southern Italy for a total 34.8 MW capacity - and "Power intensive" - approved by the Italian Ministry of Economic Development (MISE) within the 2012

Defence Plan which will increase the security of electricity systems in Sicily and Sardinia with the installation of storage systems for a total 40 MW capacity.

Concerning the Distribution - including medium voltage power lines (10 to 20 kV) and low-voltage lines (less than 1000 V, normally 400 V) and all the related components (e.g. substations) - Italian configuration is characterized by many local monopolies with about 130 DSOs, more than 100 of whom are small/micro DSO. Among the DSOs the biggest one is e-Distribuzione (supplying geographical areas covering 85% of the customers), followed by ACEA Distribuzione in Rome (4% of the customers) and A2A in Milan-Brescia (3% of the customers); of the others DSOs, only 7 DSOs have more than 100,000 customers.[ref_IT1].

The contribution of major suppliers to gross national production is shown in the following figure:



(A) Edipower was entirely acquired by A2A in 2016

Figure 9-3: Major suppliers contribution to gross national production
(Source: ARERA Annual Report - 31 march 2017)

The energy Retailers (about 300) are mostly private companies. They buy energy from generators and sell it to final users.

Italy has an Operator for the protected market customers: Acquirente Unico (AU), a publicly owned company which acts as the intermediate between the market and the household customers not willing to access the free market. It provides to buy energy on the wholesale market at conditions defined by the Regulator and to deliver it through the local distribution companies. Starting from July 2019, the protected market will be dismissed and all users shall interact on the free competitive market.

The Italian Electricity Market is managed by GME (Gestore del Mercato Energetico) (www.gme.it) which manages the electricity exchange market, dispatches power plants and sets their remuneration, manages energy efficiency certificates and emission trading shares.

The Energy Service Operator is Gestore dei Servizi Energetici (GSE) (www.gse.it), which promotes the development of renewable energy sources and energy efficiency by granting economic incentives and supporting the policy makers.

Concerning the technology providers and manufactures the Italian panorama is characterized by the presence of many SMEs, a large number of micro and small enterprises and large multinational companies. Some large international companies operating in the Smart Grid sector are ABB, ALSTOM, SIEMENS and TELECOM.

ANIE Energia (www.anienergia.anie.it) – the Association of energy related manufacturing companies - with 211 member companies, is the most important Association for the Smart Grid sector. It represents industries that manufacture, distribute and install equipment, components and systems for the generation, transmission, distribution and storage of electricity for its use for industrial and civil applications. A dedicated Smart Grids Area in ANIE is focused on promoting the competences and experiences of the companies, gained also in the participation to pilot projects, both at national and international level. [ref_IT3].

Representative Association of companies of the Smart grid sector is also "ANIE Automazione" www.anieautomazione.anie.it) – the Automation and Measurement Association, which - with its 95 member companies- represents the Italian reference for companies providing technologies for factory automation, process and electric networks.

The Italian Smart Grids Industry has a voice in the Industrial Initiative ***smartgridsitalia*** (www.smartgridsitalia.it), the developing business intelligence & Matchmaking Platform established in 2014 with focus on interoperability. Starting from April 2015, Smartgridsitalia is also a National Technology Platform (NTP) working in cooperation with ETIP- SNET & other NTPs in the smart grid field [ref_IT4].

Other entities supporting the Smart Grids research are also Regional and National technological Clusters, which supportthe matching among research centres, universities and companies, fostering and promoting innovation and initiatives. Italy is involved, together with National Research/Industrial actors and energy stakeholders, in Energy Clusters both at National and Regional level. In particular, the Lombardy Energy Cleantech Cluster (LE2C) (www.energycluster.it) – recognized by the Lombardy Region- gathers about 100 large, small and medium companies, 9 Universities and Research Centres, 10 organizations of industrial associations as well as no-profit bodies, 6 Institutions from the Public Sector and 4 Financial Institutions (banks), for a total of 31.000 employees and a turnover of more than 23 billion Euros Operating in the smart grid sector through its "Smart Energy System" Technological area & Working Group, the Cluster is an actor with a primary role with the Lombardy Region and the European Union, supporting company's competitiveness, fostering and promoting innovation and initiatives in the smart grid sector.

9.4 Public Research Stakeholders

The Italian main actors involved in the Research in the electric field are the three funding Ministries [Ministry of Economic Development (MISE), Ministry of Education, Universities and Research (MIUR) and Ministry of the Environment and Protection of Land and Sea (MATTM)] and the research performers including many Universities – distributed on the whole National territory-, Research Centres and Institutions like CNR (National Research Council – www.cnr.it), the largest public research institution in Italy, ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development – www.enea.it) and Ricerca sul Sistema Energetico RSE S.p.A. (www.rse-web.it) and some Regions (using governmental funds) together with local Research Institutes.

In particular, RSE S.p.A. is a publicly-controlled Company (the sole shareholder is GSE S.p.A) which carries out research in the field of energy with special focus on national strategic projects funded through the Fund for Research into Electrical Systems.

Italian Regional Governments (Puglia, Campania, Sardegna, Sicilia, Emilia Romagna, Toscana, Lombardia, etc.) are also supporting Smart Grids Research, fostering the local R&D development by means of Regional Operating Plans (POR). The projects proposed in the Plans involve local industry and Research entities, with Regional Funds also connected to European Funds (e.g. ESIF - European Structural and Investment Funds).

9.5 National R&D strategy

Italy has no specific Smart Grid R&D strategy, but the national climate and energy targets presented in Italy's *National Energy Strategy* (NES) 2017, published by Ministry of Economic Development, contain many initiatives, which touch also Smart Grids [ref_IT5]. Main implementation tools of NES are Plans and Programs both at National and Regional level and Incentives for operators by the Regulator.

NES is closely coordinated with the European Strategic Energy Technology Plan (SET Plan) and addresses the developments of the energy system with a vision towards 2030 aiming at achieving the following 4 main objectives:

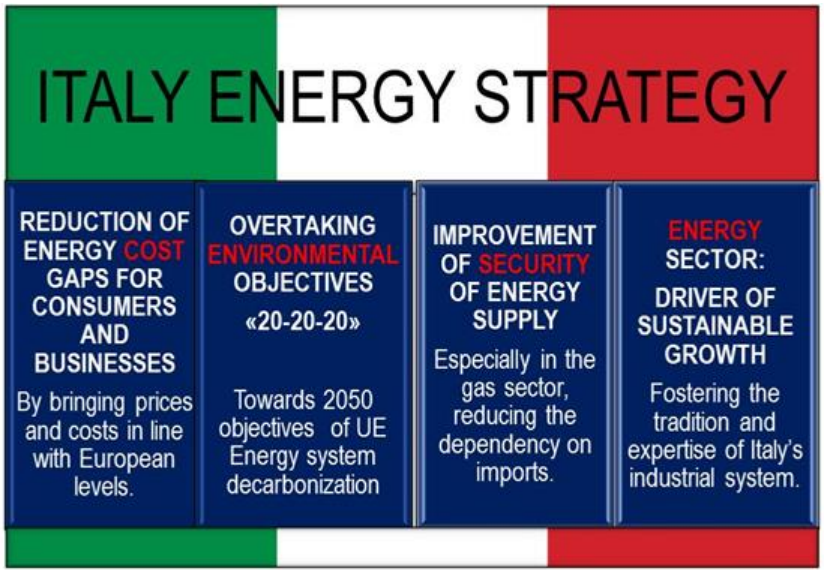


Figure 9-4: Italian National Energy Strategy (NES) Targets

Recognizing that current level of RES integration in the electricity system has already reached the National targets for 2020, the Italian NES has a focus on:

- Continuous improvement in RES integration
- Flexibility of Transmission and Distribution Networks
- Customer Empowering
- Widespread use of Efficient Electro-technologies
- Energy Efficiency in all sectors

In order to attain its goals, the Italian Energy Strategy identified a few top priorities, among which, as far as Smart Grids are concerned, we mention:

- Sustainable development of renewable energy sources and integration,
- Cost effective integration of Distributed Generation (DG) using advanced monitoring and control
- Enable the provision of grid related service exploiting Vehicle-to-grid (V2G) and smart charging functionalities
- Develop an electricity market fully integrated with the European market and the relevant electricity infrastructure
- Modernise the energy sector governance through innovation
- Foster energy efficiency

In particular the trends foreseen in renewable and energy efficiency fields are reported in the following figure.

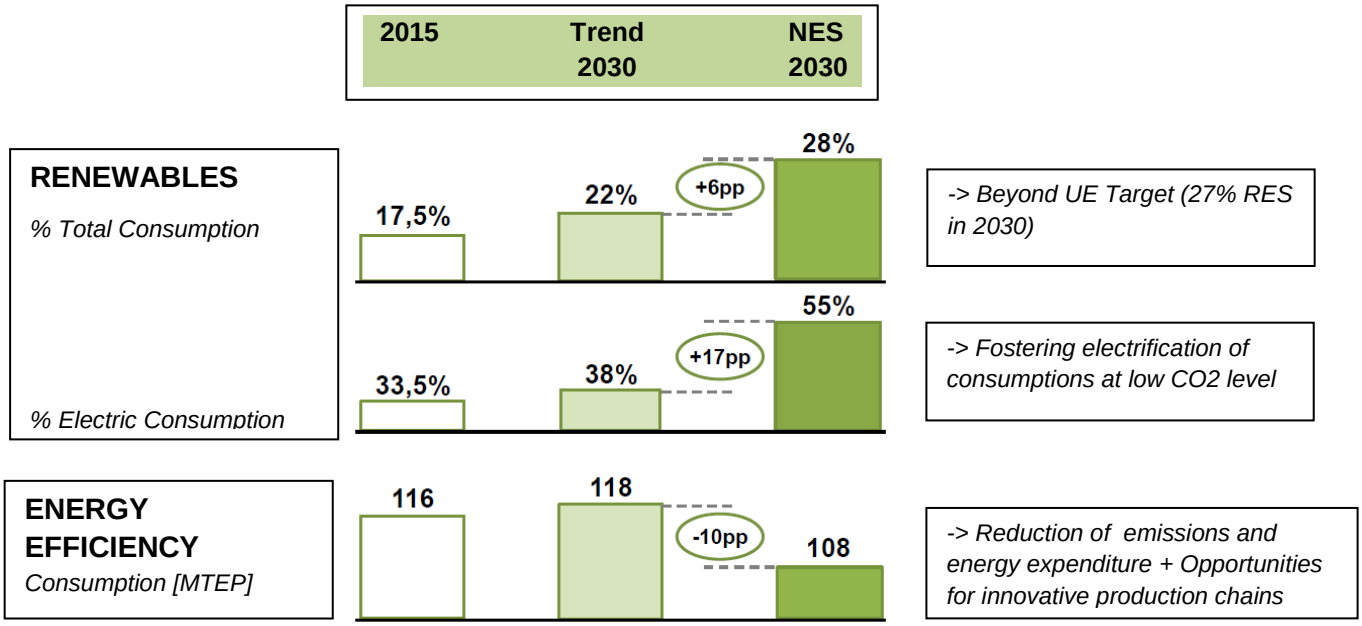


Figure 9-5:Renewables and Energy Efficiency: NES targets
(Source: SEN 2017)

It is interesting to highlight that the National Energy Strategy 2017 arose from a wide participative process, which involved all the public and private stakeholders of the sector - among the others, the most important Research actors at national level- during both its preliminary stage and the public consultation proper and a great attention is given to the theme of Research.

9.5.1 Mission Innovation

At the end of 2016 the global Initiative “MISSION INNOVATION” (See Chapter 18) has been launched and Italy has considered this initiative as a strong commitment and opportunity to accelerate public and private efforts on clean energy research and innovation- Italy has included Mission Innovation as a priority of action in the new National Energy Strategy (NES), being a tool of Governance and Regulation of Research and Innovation.

Italy has committed to double the value of the portfolio of resources for public research in the clean energy field to be brought, at national level, from 222 Million Euro (250 Million of USD) in 2013 to 444 million euros (500 million USD) in 2021.

The Ministry of Economic Development (MISE) has been appointed by the Italian Prime Minister's Office, as lead Administration of the Italian participation in Mission Innovation. Other ministries involved are the Ministry of Foreign Affairs and International Cooperation (MAECI), the Ministry of Economy and Finance (MEF), the Ministry of Education, Universities and Research (MIUR), the Ministry of Environment and Protection of Land and Sea (MATTM).

The public R&D institutions which carry out energy-related research are the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the National Research Council (CNR) and Research on Energy Systems (RSE) which are committed in the context of Programme Agreements with MISE. An important role is also played by the regional governments and the scientific community (universities, R&D labs).

Italy is involved in all the seven Innovation Challenges defined in Mission Innovation, with particular commitment in the **Innovation Challenge 1 - Smart Grids (IC#1),** where RSE – Ricerca sul Sistema Energetico, on behalf of MISE, coordinates the Innovation Challenge together with China and India.

Besides co-leading the Challenge Italy has the role of BIE (Business and Investor Engagement) reference point within IC#1.

In 2017 in the framework of MI IC#1, Italy co-organised and actively contributed to the two International deep-dive Workshops of the Challenge held in Beijing (4-6 June) and New Delhi (16-18 November) with presentations, sessions organization and coordination, involving the different national and international Smart Grids stakeholders and Institutions.

Italy actively contributed to the development of the Challenge activities and the outcomes achievement (see chapter 18), working closely with the Chinese and Indian co-leader representative Institutions and all the IC#1 members.

In particular, Italy was in charge of the management of Questionnaire Q1, (released in IC#1 to identify the most important R&D priorities in the national strategies of IC#1 member Countries), the definition of the main Q1 outcomes (top 10 R&D priorities) and the definition of Key Performance Indicators (KPIs) to monitor IC#1 activities progress. A contribution was also given to the design and creation of a Service Platform to support IC#1 activities.

Within BIE activities, Italy contributed with the definition of possible cooperation models to be implemented in IC#1 and the development of links with WEF (World Economic Forum).

Italy also organised a dissemination event, held in Rome on 28th sept 2017, where IC#1 achievements and outcomes of Beijing's 1st deep-dive Workshop were shared with the main Italian actors operating in the Energy and Smart Grids fields (DSO, TSO,& Industry), including a round table discussion and the participation of Chinese, Indian and Italian Government Representatives (MISE).

Among the R&D Cooperation Agreements signed among participating Countries in IC#1, Italy signed a *"Cooperation Agreement on Joint application for Strategic Key Program for International Scientific and Technological Innovation"* Italy-India (between RSE and the Indian Institute of Technology Roorkee) and Italy China (between RSE and the Institute of Electrical Engineering-Chinese Academy of Sciences IEE CAS).

In the framework of a Funding Opportunity Announcement launched by India, Italy is also involved in a joint RD&D proposal on "*Demonstration of MW scale Solar energy Integration in weak grid using Distributed Energy Storage architecture (D-SIDES)".*

Italy is also actively participating in all the 6 R&D Tasks identified within IC#1 which will be launched in 2018 and has committed to be leading/co-leading in the Tasks "*Electricity Highways*" and "*New Grids Architectures*", where a two year Program of Work (POW) has been already defined, collaborating with the different countries which expressed their availability to contribute to the activities of the Tasks.

9.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

The national priorities in smart grid research are: Renewable integration; Intelligent planning and operation of network; Component technologies innovation also with attention to ICT issues; energy Storage systems and integration.

A total of 139 Smart Grids Projects have been implemented in Italy (source JRC Data Base *"Smart Grids projects outlook 2017"*) since 2008, more than 35 of which are still ongoing [ref_IT6]. In particular, Italy participates to a total of 64 R&D (Research & Development) projects and 75 D&D (Demonstration & Deployment) projects.

See for details Table 9.4 "*Supported Smart Grids R&D and Innovation projects in Italy"*, where the most recent projects (having a planned conclusion in/beyond 2017) have been reported. We must notice that as far as Smart Grids demonstration and deployment projects are concerned key obstacles and challenges still appear to be at the social and regulatory levels (rather than technical constraints) [ref_IT6]. Concerning this point, the Italian Regulator (ARERA) is launching new incentive policies starting from the experiences and lessons learned from pilot projects awarded in the last few years (as mentioned in the following chapters).

Research & Development programs supported by RDS "Research for the Energy System"

Research & Development programmes dealing with Smart Grids are also supported by RdS (Ricerca di Sistema - Research Fund for the Italian Electrical System). The RdS program is the research and development program aimed at the technical and technological innovation of general interest for the electricity system in view of an enhancement of competitiveness, security and environmental compatibility, ensuring for the country suitable conditions for a sustainable development. The financing of this activity is achieved through a levy on the electricity bill of each consumer (with the present rules, the levy dedicated to the RdS scheme for an average household consumer is around 0.50 €/year).

Research programmes dealing with Smart Grids are worth 7-8 M€/year and consider: integration of distributed generation, energy storage, active distribution network control, automation and related communication needs and technologies, power electronics, user network integration and system aspects of demand response, DC transmission and distribution, measuring and metering, modelling.

The research activities on Smart Grids financed by RdS are essentially carried out by RSE S.p.A under a Contract Agreement between RSE S.p.A. and the Ministry of Economic Development. All results, reports, papers produced in the framework of RdS are public and can be consulted and downloaded from www.rse-web.it. Most of the activities under RdS have close interactions with the issues mentioned in Italy's National Energy Strategy. In fact, three of the NES priorities are closely linked with the research of the electrical system: energy efficiency, sustainable development of energy from renewable sources and electricity market.

Among others, the RSE Smart Grids project are aiming at:

- The development of models and algorithms for management and control of distributed energy resources and their experimentation in MV active networks and in the RSE DG (Distributed Generation) Test Facility;
- The study and application of communication technologies for active networks;
- The development of electronic converters and the testing of protection systems;
- The study and experimentation with DC active networks, including the analysis of failure problems

Demonstration projects awarded by the Energy Regulator (ARERA):

In view of a better understanding of the possible future regulatory mechanisms for motivating the distribution system operators to adapt their network to the fast changing conditions, the Italian Regulator (ARERA) has adopted in the past years a series of measures for initiating pilot projects on the distribution/transmission networks in three different areas:

- **ARERA 39/10** - Increasing the hosting capacity for DG of active distribution networks: Pilot projects aimed at demonstrating the effectiveness of network Smart Grids measures to increase the hosting capability of distribution networks in presence of DG at a level that produces a reverse power flow from the distribution network back to the transmission network, at least for a portion of the year. Pilot projects have been financed by means of a tariff-based incentive (+2% increase of the WACC - weighted average cost of capital for 12 years with respect to ordinary remuneration).

In particular the following 7 projects have been developed within the ARERA 39/10 by the main Italian DSOs:

- Isernia Smart Grid Project (e-distribuzione)
- ACEA Smart Grid Project (ACEA)
- Lambrate and Gavardo Smart Grid (ARETI)
- Villeneuve Smart Grid (DEVAL)
- S. Severino Marche Smart Grid (A.S.S.E.M.)
- Terni Smart Grid (ASM)

The trials have been completed by the end of 2014. The monitoring of the operation of active networks allowed to assess the actual impact of the technical solutions adopted for later implementation on a larger scale. Analysis of the projects results has been made by ARERA (act DCO 255/15), which has defined new incentives that will foster the deployment of new large projects to be implemented in the Italian electric network.

In particular projects are developed under the following ARERA resolutions:

- **ARERA act 646/2015/R/eel** "*Integrated text of the output-based regulation of electricity distribution and measurement services for period 2016-2023*": Smart Grid solutions with favourable benefit-cost ratio (according to 2551/15), related to "observability" (TSO-DSO data exchange) and "Voltage control" on MV networks are included in an incentivized remuneration.
- **ARERA act 300/2017/R/eel**: ongoing pilot projects on the evolution of the Ancillary Service Market. In particular, pilots have the focus to test how demand side, storage systems and RES based/small production units could participate to the ancillary service market (tertiary reserve and balancing; voltage support).

- **ARERA 242/11** - business models for EV public recharging infrastructure: 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). Currently, only the latter 2 models could be implemented.
- **ARERA 288/2012**: Energy storage systems (ESS) demonstration projects on transmission networks: Pilot projects aimed at demonstrating in real cases the possibility to reduce the curtailments on RESs production due to grid congestions and to improve the system security in certain areas.

Energy Storage projects

Energy storage is seen as a strategic tool for managing RES variability. The spread of intermittent generation sources throughout the entire electricity network requires not only an increased coupling of RES local production with centralized generation, but also a further development and implementation of new large-scale and decentralized storage technologies. The roll out of Smart Grids will hence also depend on cost effective energy storage, particularly in the early stages while other distribution and demand-side management solutions are being developed, adopted and implemented.

Demonstration projects of advanced storage application for the distribution grid are ongoing or already deployed, among which we can mention:

- **POI 2007-2013**: 3 installations in HV/MV substations of Southern Italian Regions (Sicily, Puglia, Calabria), 2 MVA / 1 MWh (2 installations) + 2 MVA / 2 MWh (1 installations), Lithium Ion. The aim of these demonstrations was to perform a “compensation” service for unbalances at the TSO/DSO border, exchanging a predictable energy flow profile.
- **GRID4U project,** 1 MVA / 1 MWh, Lithium Ion and **ISERNIA project,** 1 MVA / 500 KWh, Lithium Ion, in which the system was installed on the MV side of a primary substation with the aim of increasing the non-predictable RES generation hosting capacity in MV grid, reducing congestion and acting in synergy with the controllable loads, like EV charging stations.
- **Puglia Active Network** (on-going) The project, funded under the NER 300 Program of the European Union, will facilitate the integration of more than 3 GW of distributed renewable generation (DRES), impacting 80% of the MV network located in Puglia, a southern region of Italy. Novel functionalities such as self-healing control grid methodologies to reduce the number and the cumulative duration of long and short interruptions, nearly real-time monitoring of generation and grid conditions (including feeders voltage, reactive and active power flows) and predictive maintenance, will involve more than 100 primary substations and more than 8,000 secondary substations of the e-Distribuzione network. In addition, e-Distribuzione will contribute to the deployment of a backbone of charging stations for electric vehicles in strategic, mostly touristic, areas.

National Program in the Fields of Smart Grids and Renewable Energy

In addition to the actions from the Ministry of Economic Development aimed at implementing the NES, the Ministry of Education, Universities and Research (MIUR) has set out the National Research Plan for 2015 - 2020, to define contents and governance of applied research. The programmes include twelve “specialisation areas”, among which the following Smart Grids related are reported:

- Energy
- Technologies for life environments
- Sustainable mobility
- Smart, Secure and Inclusive Communities

Under the Decree 20 March 2017 "National Operational Program - Enterprises and Competitiveness" (PON - I&C) 2014-2020 *"Electricity Infrastructure for the Implementation of Smart Grids in the Less-developed Regions"* Smart Grids Projects in the Distribution Network (MV/LV) will be developed, focused on energy increase from distributed generation based on renewable sources.

9.7 Funding bodies and programmes

The Italian funding bodies for R&D do not specifically address Smart Grids R&D. Smart Grids projects can compete towards specific topics (e.g. renewable, communication technologies, energy efficiency, intelligent networks, etc.) within different funding programmes. Main national funding programs are managed by Ministry of Economic Development (MISE), Ministry of Education, Universities (MIUR) and Research and Ministry of the Environment and Protection of Land and Sea of Italy (MATTM) and ARERA (Italian Regulatory Authority for Energy, Networks and the Environment). Examples of Italian smart grid projects funded by ARERA were mentioned in the previous section. General guidelines are established by pluriannual plans and related annual calls.

As mentioned in the previous section, the **RDS Program – Research for the Energy System** - the three year national R&D programme aimed at the technical and technological innovation of general interest for the electricity system- is the main R&D funding program a national level.

As for deployment, the Interregional programme for RES and energy saving "Programma Operativo Interregionale Energie Rinnovabili e Risparmio Energetico 2007-2013 (**POI ENERGIA**)", fostered by MISE, with a total funding of around 1 billion Euros (coming also from public administrations and companies of Italian convergence objective regions: Calabria, Campania, Apulia, and Sicily), financed 1.887 projects concerning energy efficiency and RES energy production, grid reinforcing, development and deployment of Smart Grids technologies.

More recently, a decree signed by MISE at the end of 2016 (**Piano Operativo Nazionale – PON**) supports investments for electrical infrastructures in the Italian convergence objective regions. In particular, the decree actions support:

- Interventions for the implementation of Smart Grids for energy distribution
- Interventions on transmission grids that are strictly complementary to the interventions on distribution networks.

In order to incentivise such kind of projects the decree allocates around 321 M€, The interventions foreseen will be implemented through forthcoming calls for proposal, acts and measures.

European funded projects

Italy has always been deeply involved in European Programs. The collaboration links in European multinational projects (weighted by project budget) is shown in the chart of the following figure In this chart, the circumference of the circle is the total smart grid budget (268 million € invested by

Italy) and chords illustrate the relationship between the countries (million € invested by Italy with other European Countries).

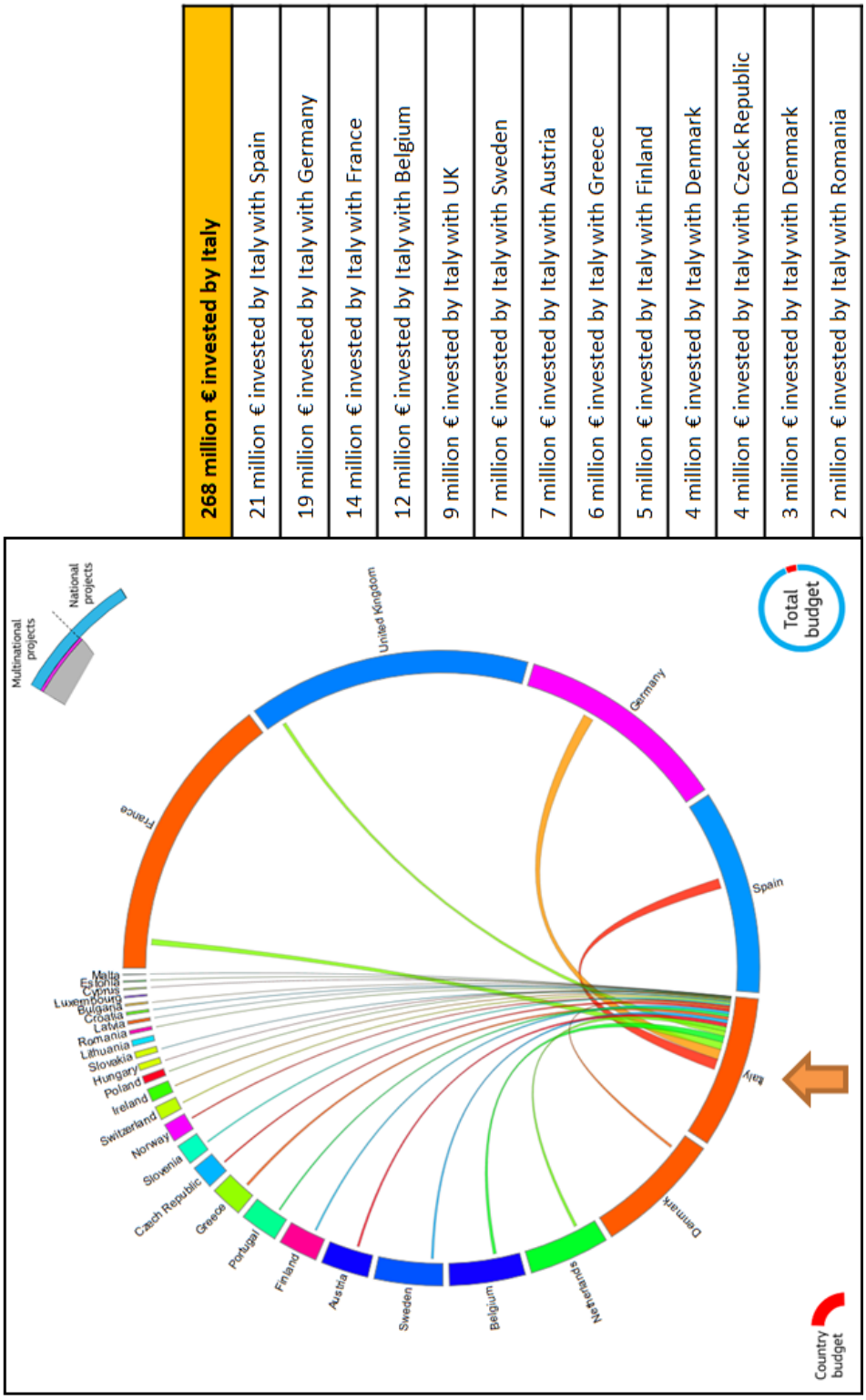


Figure 9-6: European smart grid projects: relationship chord chart
(Source: JRC)

Horizon 2020

From an half-path picture of the H2020 Work Program (February 2017- [ref_IT8]), Italy is among the top countries to obtain the largest financial contribution from the Program. In particular, Italy gets overall an average of 8.0% of the total budget of Horizon 2020, which varies according to the

issues addressed. In terms of total number of applications, Italy is the sixth in the applications of EU Members since the start of H2020 [ref_IT9]. With special reference to the H2020 area "*Secure, Clean and efficient energy*" (SC3), where most of the Smart Grids issues are included, Italy has a success rates of 14% for Participation (coordinator + partner) and of 13,2 % for financial contribution, as shown in the following table:

Table 9-4: Italian success rates in H2020 Theme "*Secure, Clean and efficient energy" (SC3*)
(source [ref_IT8])

Italian proposals in H2020 SC3	Participation (n)	Financial Contribution (€)
Retained	**342**	**135.688.123,00**
Reserve	279	126.825.894,00
Below available budget	137	47.485.929,00
Rejected	1.680	717.949.684,00
Total Eligible presented /required	2.438	1.027.949.630,00
Success rate	**14,0 %**	**13,2 %**

In particular, with reference to the Smart Grids sector, Italy is involved in projects devoted to the themes: active distribution networks, AC and DC high energy corridors, new grid architectures, road-mapping of future research/innovation needs for the energy system, integration of DER and energy storage into energy networks.

Among recent Projects in the Smart Grids field the followings can mentioned:

IntEnSys4EU - *Integrated Energy System- a pathway for Europe*, which aims at extending the existing Research and Innovation roadmaps through permanent and direct interactions with the impacted energy system stakeholders and all the Member States in view of validating the portfolio of innovative solutions via appropriate funding mechanisms (https://www.etip-snet.eu/).

SmartNet - *Smart TSO-DSO interaction schemes, market architectures and ICT Solutions for the integration of ancillary services from demand side management and distributed generation*, which aims at providing optimised instruments and modalities to improve the coordination between TSOs and DSOs and the exchange of information for monitoring and for the acquisition of ancillary services from subjects located in the distribution segment (flexible load and distributed generation). (http://smartnet-project.eu/)

ERIGrid - *European Research Infrastructure supporting Smart Grid Systems Technology Development Validation and Roll Out*- Intelligent power networks development to integrate distributed energy sources and generators into energy systems. 18 of Europe's top research institutions are involved to pool together their know-how and improve research infrastructures within the smart grid sector (https://erigrid.eu/the-project/)-

EU-SysFlex - *Pan-European system with an efficient coordinated use of flexibility for the integration of a large share of RES*- (large EU project with 34 partners from 14 different European countries)- which aims at ensuring an efficient and sufficient level of system services provided to facilitate world leading level of RES while maintaining the expected level of resilience (http://ww.eu-sysflex.com)-

OSMOSE - *Optimal System with a Mix Of flexibility Solutions for Europe* (large EU project with 33 partners from 9 different European countries; 6 TSOs, research partners, industry and market players) which addresses the identification and development of flexibilities required to enable the Energy Transition to high share of renewables. OSMOSE proposes four TSO-led large demonstrators (coordinated by RTE, REE, TERNA and ELES) aiming at increasing the techno-

economic potential of a wide range of flexibility solutions and covering several very innovative approaches and applications.

National Operational Program Metropolitan Cities 2014 - 2020 (PON METRO) awarded by the Ministry of Economic Development (MISE)

Under the responsibility of the Ministry of Economic Development - in support of the recent institutional reforms and the new central role given to urban and metropolitan cities- Italy has defined the National Operational Program Metropolitan Cities 2014 - 2020 (PON METRO)

The program enables the metropolitan cities to promote integrated and polycentric interventions able to redevelop Italian urban settlements so that they become places where life and work is innovative, attractive inclusive and sustainable.

The program, adopted by the European Commission, has a budget of over 892 million euros, of which 588 million of Community resources: 446 from the Fund for Regional Development (ERDF) and 142 the European Social Fund (ESF) and, in addition, 304 million from National co-financing.

14 Metropolitan cities are involved in the program: Turin, Genoa, Milan, Bologna, Venice, Florence, Rome, Bari, Naples, Reggio Calabria, Cagliari, Catania, Messina and Palermo. [ref_IT7].

9.8 Description of national SET Plan Structure for Smart Grids

Italy's technological innovation activities are closely co-ordinated with the European Union Strategic Energy Technology Plan (SET Plan) in the perspective of the full implementation of the Energy Union at European level. In coming years in fact, EU R&D resources will increasingly be allocated to the priority projects identified under the SET Plan, as already happened for the Horizon 2020 Programme for Research and Innovation.

The main priorities of the Italian Energy Strategy are aligned with the main SET-plan priorities:

- **Foster Energy Efficiency:** save an additional 20 MTOE of primary energy by 2020 (rising the national target to more than 25% – i.e. well above the European benchmark).
- **Promote a competitive gas market,** integrated with European markets, with aligned prices and with the possibility of becoming the main southern European hub.
- **Sustainably develop renewables,** exceeding the European targets for 2020, keeping energy bills under control, aligning incentives, selecting technologies.
- **Develop an electricity market** fully integrated with the European market, gradually removing all distortions and absorbing current surplus production capacity, develop the electricity grid, reduce congestions and bottlenecks, limit market inefficiencies and distortions, rationalizing the system charges present in electricity bills, review the special conditions granted to specific categories of users.
- **Restructure the refining industry and the fuel distribution network**, in order to achieve a more sustainable system with European levels of competitiveness and service quality.
- **Sustainably raise national hydrocarbons production,** which will bring major economic and employment benefits, while observing the highest international standards in terms of safety and environmental protection.
- **Modernise the system of governance of the sector**, with the aim of making decision-making processes more effective and more efficient.

In the framework of the European Energy Research Alliance (EERA), Italy coordinates the **EERA JP SG** (EERA Joint Program on Smart Grids), which includes 40 Research Organization representing 17 European Countries. As coordinator of the JP SG, Italy also coordinates the two main governing bodies of the JP: the Steering Committee (SC) and the Management Board (MB).

Italy is also supporting the implementation of the EU Strategic Energy Technology Plan (SET - Plan) through the participation in **ETIP-SNET**, where Italy is member of the Governing Board.

Moreover, besides an active participation in several **Temporary Working Groups** (TWG) **of the SET Plan**, Italy coordinates - together with the Austrian Ministry of Innovation and Transport - the work of **TWG4** entitled "*Increase the resilience and security of the energy system*". The TWG gathers the representatives of ministries and public funding agencies of 15 countries with the aim to identify initiatives of common interest in the development of the European energy system and to engage in a real and effective collaboration through their respective public funding sources around three main subjects, namely: the development of an optimised European power grid, the development of integrated local and regional energy systems and their enabling crosscutting activities (e.g. digitalisation, market and regulation).

International cooperation

In addition to the EU dimension, Italy is committed to developing international cooperation on a multilateral level. In this framework, with reference to the Smart Grids Sector, Italy is active in the International Energy Agency (IEA) Technology Collaboration Programme (TCP) **ISGAN (*International Smart Grids Action Network*)**, the Clean Energy Ministerial (CEM) initiative on Smart Grids, which aims to improve the understanding of smart grid technologies, practices and systems and to promote adoption of related enabling government policies. In ISGAN, where 25 participating Countries have agreed to collaborate on advancing clean energy technologies, Italy holds the Vice-Chairmanship, provides the Italian delegate and alternate member within the Executive Committee (ExCo), the Annex 2 "*Smart Grid Case Studies"*, Annex 3 "*Cost-benefits analysis and toolkits*", Annex 4 "*Synthesis of Insights for Decision Makers*", Annex 5 "*Smart grids International research facilities network*", annex 6 "*Power system analysis*", annex 8 "*Smart Grids academy".*

Moreover, in the framework of the **IEA Energy Technology Network**, Italy has researchers representatives within the **Committee on Energy Research and Technology (CERT**), which is the body supervising the activities of all 38 TCPs of the IEA, thus contributing to shape the activities of more than 6000 researchers representing nearly 300 public and private organisations located in 53 countries. In particular, Italy has the vice-Chairmanship of the **End Use Working Party (EUWP)**, whose main objectives are to guide the work of the IEA TCPs more focuses on end uses of energy, (namely ISGAN, HTS and DSM) and to identify gaps in technologies and energy end-use systems. The EUWP builds relationships and engages with industry and partner countries through the work of the end-use IEA TCPs.

Italy is also involved and committed in Global Initiatives, like the new **global initiative MISSION INNOVATION**, which is also a part of the new National Energy Strategy (NES) [see point "National R&D strategies" and Chapter 18].

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[ref_IT7]: Programma Operativo Nazionale Città Metropolitane 2014 – 2020 (PON METRO)
[ref_IT8]: APRE Overview Analysis report on H2020 (July 2017)
[ref_IT9]: EU HORIZON 2020 IN FULL SWING — Three Years On - Key facts and figures 2014-2016

Most important sites mentioned in the text are reported in the following:

www.arera.it; www.agcom.it ; www.terna.it; www.gme.it ; www.gse.it; www.anienergia.anie.it; www.anieautomazione.anie.it; www.smartgridsitalia.it; www.energycluster.it; www.cnr.it; www.enea.it; www.rse-web.it.

Table 9-5: Supported Smart Grids R&D and Innovation projects in Italy (source: JRC Data Base: "Smart Grids Project Outlook 2017)

R&D project	Company	Total budget (Million EUR)
RdS Research Fund for the Italian Electrical System	RSE	7/8 per year
GRID+Storage "*Support to R&D strategy in the area of SET Plan activities in smart grids and energy storage"* (EU Tender – 2014-2017)	RSE and European members (VITO, EDSO, ENTSOE, EASE, TECHNOFI)	1,49
INCITE "*Innovative controls for renewable sources Integration into smart energy systems"* (EU H2020-2015-2019)	ALMA MATER STUDIORUM-UNIVERSITA DI BOLOGNA	3,53 3,53*
IndustRE "*Innovative Business Models for Market Uptake of Renewable Electricity unlocking the potential for flexibility in the Industrial Electricity Use"* (EU H2020- 2015-2017)	-SCM Group -SER Società Energie Rinnovabili-	1,9 1,9*
NOBEL GRID "*New Cost Efficient Business Models for Flexible Smart Grids"* (EU H2020-2015-2018)	-ASM Terni S.p.A. - Engineering Ingegneria Informatica SPA	13,86 11,72*
SCISSOR "*Security In trusted SCADA and smart-grids*" (EU H2020-2015-2017)	-Consorzio Nazionale Interuniversitario per le Telecomunicazioni; -RADIO6ENSE, SEA Favignana	3,99 3,5*

SINFONIA "*Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions"* (EU FP7-2014-2019)	-Agenzia Casaclima -Bolzano Municipality-Ipes, -SEA *Società' Elettrica Altoatesina*	43,15 27,45*
SmartNet "*Smart TSO-DSO interaction schemes, market architectures and ICT Solutions for the integration of ancillary services from demand side management and distributed generation*" (EU H2020 -2016-2018)	22 partners from 9 different European Countries (Research Centres and Industries) among which: RSEEuropean University Institute SIEMENS IT, SELTA,EDYNA, TERNA.	12,66 12,66*
ERANet SmartGridPlus *"ERA-Net Smart Grids Plus: support deep knowledge sharing between regional and European Smart Grids initiatives"* (H2020-2015-2020)	Lombardy Region	44,56 13,51*
METER *METrology for 'Energy and Networks* PON (National Operational Program) Funded project	ENEA with Italian Universities, Industries and Consortia.	6,43
MICCA *D.C. and A.C. Hybrid Microgrids* PON (National Operational Program) Funded project	Università di Napoli, ENEA, CNR, Gruppo Getra and Consortia.	6,39
Demonstration & Deployment Project	**Company**	**Total budget (Million EUR)**
BEST PATHS "*Beyond state-of-the-art technologies for power AC corridors and multi-terminal HVDC systems"* (EU Project FP7 -2014- 2018)	More than 40 Partners among which IT: TERNA, RSE , De Angeli, TOSHIBA IT, Columbus Superconductors	62,8 35,5*
VSC-HVDC pilot plant project (Voltage Source Converter - High Voltage Direct Current) (2016-2021)	ENEA and other international partners (Toshiba and NEDO)	
FLEXICIENCY "*Energy services demonstrations of demand response, FLEXibility and energy effICIENCY based on metering data*" (2015-2019)	e-distribuzione, ENEL ENERGIA, Siemens Italia and other partners	19 13,9*
Flexmeter "*Flexible smart metering for multiple energy vectors with active prosumer* " (H2020- 2015-2018)	IREN Energia, Politecnico Torino, STMicroelecronics, Telecom Italia, University of Bologna	3,87 3,2*
NETEFFICIENT "*Energy and economic efficiency for today's smart communities through integrated multi storage technologies*" (EU Project -2015-20109)	University of Cagliari; CRS4 *Centro di ricerca, sviluppo e studi superiori in Sardegna*	11
SmarterEMC2 "*Smarter Grid: Empowering SG Market*	Thales Italia	3,75 3,08*

Actors through Information and Communication Technologies" (H2020-2015-2017)		
TILOS "*Technology Innovation for the Local Scale, Optimum Integration of Battery Energy Storage"* (H2020-2015-2019)	FZSONICK, FIAMM Energy Storage Solutions	13,7 11*
Puglia Active Network Co-funded project under NER 300 UE - 2014-2024	e-distribuzione and smart grid/energy technology providers	170 85*
TERNA PROJECT Sardinia Energy Laboratory	TERNA and Italian and foreign technology providers	93 (investment size)
Energy Intensive Storage for congestion and security management on HV grid	TERNA. RSE, CESI, CNR, ENEA and foreign technology	160 (investment size)

(*) EU contribution
Project Budget References:
- European Commission CORDIS data;
- ENEA and TERNA web site

10 LATVIA

10.1 Landscape of Smart Grids R&D in Latvia

Within the framework of implementation of the action plan for the EU planning period 2014-2020, the Ministry of Economics (responsible for Energy Sectorial Policy) support the measures in the framework of the Strategy for Smart Specialization (RIS3- from 2014). Therefore, two priorities related to the Smart Grids development (out of seven) need to be mentioned, namely: Smart Energy and ICT.

Table 10-1: Potential specialization niches of the Latvian industries within the framework of the Smart Specialization related to Energy Sector

Priority of Development	Related Area of Smart Specialization	Potential specialization niches related to Energy Sector
Smart energy	A well-developed knowledge base (fundamental science and science infrastructure) and human capital in the fields where Latvia has comparative advantages and which are significant in the national economy transformation procedure: in the fields of knowledge related to the smart specialization (1) knowledge-intensive bio- economics, (2) bio-medicine, medical technologies, bio-pharmacy and bio-technology, (3) smart materials, technologies and engineering systems, (4) smart energy (5) in key technologies identified by ICT, as well as (nanotechnologies, micro- and nano- electronics, photonics, advanced materials and production systems, bio-technologies).	Energy efficiency; the EU climate and power industry network for 2030.
Information and Communication Technologies		Innovative knowledge management, methods and tools for system modelling and development of software; innovative use of ICT hardware and software; cyber-physics systems, language technologies and semantic network; large-scale data and knowledge infrastructure; information safety and quantum computers; computer system testing methods.

The RIS3 was developed with aim to concentrate public R&D investment in programs that create future domestic capability and interregional comparative advantage. This conceptually new and complex strategy provides a balanced and complementary support tool kit to strengthen innovation capacity of Latvian economy. By measures of Innovation Union Scoreboard, currently Latvia is a modest innovator. Therefore, its RIS3 is a strategy of economic transformation towards higher added value and more efficient use of resources. The strategy aims at restructuring of export by inducing change and growth in:

1. Production and export structure in traditional sectors of economy;
2. Future growth of sectors in which exist or may be products and services with high added value;
3. Sectors with significant horizontal impact and contribution in transformation of national economy.

To concentrate public R&D investment in programs that create future domestic capability the strategy has defined three core criteria for allocation of public resources:

- Growth of S&T human capital (knowledge and networks), expressed as increased competence of individuals engaged in projects;
- Scientific excellence, characterized by the level of usefulness of new knowledge for future or present economic and societal challenges;
- Net economic value or today's financial and social benefits that project will create.

In 2015 descriptions of ecosystems of each specialization area were developed to introduce policy makers, R&D sector, entrepreneurs and general public with main actors who create and use knowledge and by doing so generate the added value. Descriptions of ecosystems provide a context in which knowledge is created including the scale of each knowledge area, core challenges, public funds and regulations.

In 2016, to ensure the monitoring of the impact of public investment in R&D in the RIS3 context, a three-level monitoring system was launched. By 2020, about one billion EUR will be invested in programs related to RIS3 goals to strengthen competitiveness of R&D sector, enhance entrepreneurship and increase innovation capacity of Latvian economy.

10.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

The current Latvian energy and climate-related policies are defined in the "National Development Plan 2014-2020", covering up to 2020. The main energy targets for the 2020 period has been defined by the Ministry of Economics in the Latvian Energy Long-term Strategy 2030 ("Strategy 2030"), which includes energy-related targets and planned policy measures.

The R&I strategy is defined in the Guidelines for National Industrial Policy (2014-20), the Guidelines for Science, Technology Development and Innovation (2014-20) and in particular the Smart Specialization Strategy, including "Smart Energy" as a Specialization field (RIS3, 2014-20). The Ministry of Education and Science and the Ministry of Economics share responsibility for research and business innovation policy.

Based on the energy policy development guidelines laid down in 2013 by the Energy Strategy 2030, including several measures:

Energy independency, energy efficiency and climate change: energy independence, renewable energy sources and alternatives to fossil fuels, secure energy, environment, ecosystems and biodiversity, promotion of a low-carbon economy, climate change mitigation, pollution reduction and adaptation to climate change, reduction of greenhouse gas emissions.

10.3 Industry (main industry actors, where in the value chain)

Energy balance data of Latvia from 1990 to 2015 are show in the following figure primarily of an economic nature of the country development in this time period. Until 2000, the Gross inland energy consumption and Final energy consumption main indicators of the country had fallen more than twice as many. Then, over the last fifteen years, a gradual increase in production and consumption are observed. Gross inland energy consumption 12.2% and Final energy consumption by 17.3% were increased in 2015, compared to 2000.

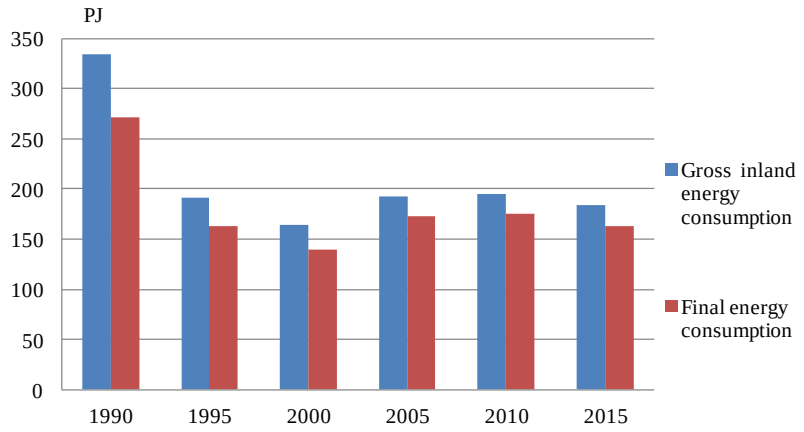

Figure 10-1: Energy Balance of Latvia: Gross inland energy consumption and Final energy consumption 1990-2015

The Final energy consumption in the different economic sectors is shown in Figure 10-2, 1990-2015: the percentage contribution was 4.1% of the Agriculture sector, 22.5% of the Industry sector, 30.9% of the Residential sector, 30.6% of the Transport sector, 11.9% the Commercial and Others sectors.

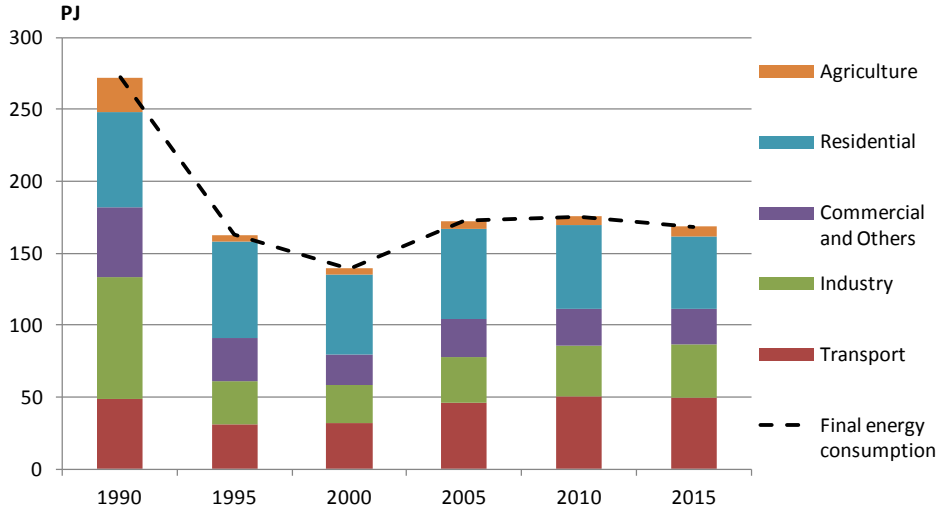

Figure 10-2: Final energy consumption with contribution of economic sectors, 1990-2015

The analysis of energy sector of Final energy consumption structure reveals that more than 60% is relevant to the Transport sector and the Residential sectors. Although such a percentage of energy consumption by these sectors has been maintained for many years it must be pointed out the Residential sector has average annual decline of 2.1%, while the Transport sectors has increase by 1.2 % approximately.

Energy system overview of Latvia. The total energy production in Latvia are generated by hydropower plants and combined heat and power plants, where renewable energy sources (water, wood and wind) and fossil fuels (natural gas and diesel) as the primary fuels. The main electricity and heat producers are the Daugava hydropower plants (Keguma HPP, Plavinu HPP, and Riga HPP), Aiviekste HES, Ainazi WPP, Kegums boiler house and two Riga combined heat and power plants (Riga TEC-1 and Riga TEC-2).

According information of Sustainability and annual report 2015 (Latvenergo Group) the installed capacity of Daugava HPPs is: 264.1 MW for Kegums HPP, 868.5 MW for Plavinas HPP and 402 MW for Riga HPP. Their work time schedule are designed for peak, half-peak and emergency

modes of operation, as generation of electricity depends on the water inflow in the Daugava River. In 2015 electricity generation at Daugava HPPs was 1.805 GWh or by 6.2% less compared to the previous year and by 50% compared to 2012 (Figure 10-3) The decrease in generation is due to the reconstruction, the completion of which is planned in 2022.

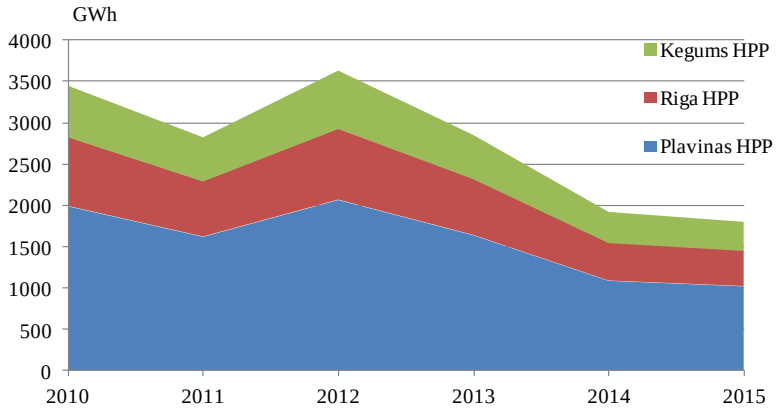

Figure 10-3: Electricity generation at Daugava HPP (2010-2015).

Both CHPPs have total installed electrical capacity is 1025 MWel and thermal energy capacity is 1617 MWth, and work in cogeneration mode. In 2015, the production of thermal energy was 2,175 GWh, it is by 6% less compared to the 2014 or by 18.6% less compared to the 2010 and the electricity generated was 2025 GWh, which is by 23% more compared to the 2014 or by 15.7% less compared to the 2010.

As can be seen from Figure 10-4, trends of generation observed at Riga CHPPs depends on thermal energy and electricity demands, determined by the duration of the heating season and the operational modes to market conditions.

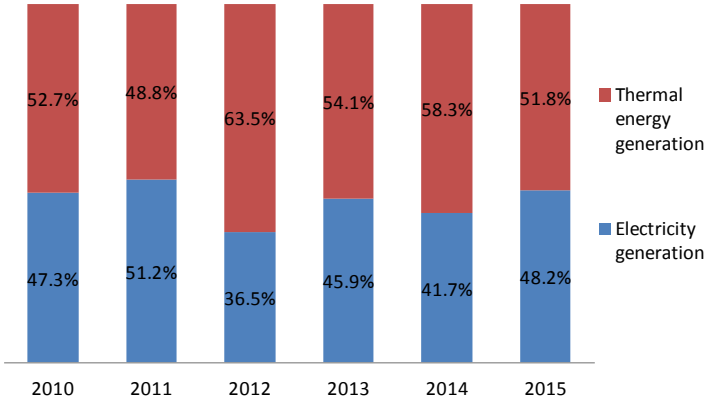

Figure 10-4: Generation at Riga CHPPs (2010-2015)

In the energy system of Latvia are also included Liepaja CHPP, Ainazi wind power plant, Aiviekste HPP, Kegums boiler house and small boiler houses and power plants.

The total electricity output at the small boiler houses and power plants was approximately 0.1% of the total generation output. Theoretically, according to the information provided by Latvenergo Group, about 146 small power plants are capable of producing about 300 GWh of electricity per year. However, it was shown that their potential is less owing to the considerable restrictions on the use of hydro resources, existing laws on the protection of the environment, weather and landscape current conditions.

10.4 Public Research Stakeholders

One of the main public stakeholders in the field of Smart Grids in Latvia is:

- Smart Grid Research Centre of the Institute of Physical Energetics - Leading Institute in the field of energy research in Latvia.

10.5 National R&D strategy

Based on energy policy development directions (Energy Strategy 2030), Energy Policy Guidelines for 2014-2020, several measures in the field of Smart Grids are included, respectively:

- In framework to support EEGI Latvian research projects fit several roadmap clusters related to DER integration, Integration of smart customers, Integration of smart metering and Smart Distribution Network.
- Latvia welcomes the efforts of the ERA Net+ program.
- Smart Grids in Smart Cities (grid and infrastructure operators, smart city projects, program managers). Riga Energy Agency is responsible for the activities in the field of Smart Cities in Riga City under SEAP.
- Integration of Electro Mobility (state of knowledge, joint mapping of existing projects). Electro Mobility is also an important issue for Riga Energy Agency.

10.6 National priorities (examples of programmes, centers, large projects and their thematic focus)

- **Smart Energy**, as national priority was selected by Prime Minister Council, launched in 2016, the board of the council is based on the Smart Grid Research Centre at the Institute of Physical Energetics. The aims is to select actual energy priorities and deliver them to the Prime Minister and Cabinet of Ministers, to establish key challenges of the R&I, regulation in the **field of Smart Energy**.

- Smart Grids Latvia platform (SGL, 2015), where the top 3 priorities are selected: **Demand Response, Market Integration, and Integration of Renewables**, based on utilities, industries, universities, research centers and all stakeholders' needs, related to Smart Grids development in Latvia. SGL is actively contributing to the ETIP-SNET Platform Regional cooperation, by organizing regular webinars and workshops, supporting Baltic – Nordic Regions Smart Grids platforms cooperation.

- National R&D priorities in the higher manner are coordinated by Latvian Council of Science - advises on science, R&D and higher education policy formulation and implementation acting as well as a research funding council. The Council consists of representatives of 14 institutions and operates through five expert commissions. The expert commissions are responsible for the assessment of scientific research projects and programmes, formulation and constant improvement of evaluation criteria for projects and institutions, and the evaluation of the general situation in each of Latvia’s relevant scientific fields, as well as on Smart Energy.

As example, can be mentioned ETIP SNET Northern Region 1st Workshop organization (December 7-8, Riga Latvia) organized by SGL, where the SGL take a leading role of the national opinion collection and prioritization of R&I topics, consolidation of the best practices and deployment perspectives from the Baltic and Nordic Regions.

10.7 Funding bodies and programs

The Ministry of Finance (MoF) is in charge of the planning of Basic Research Funding (institutional funding) while the Ministry of Education and Science (MoES) is in charge of the operational management. The beneficiaries are State established, registered research institutions, research institutes and higher education institutions.
The Government Research Programmes (targeting high-impact, industry-relevant research in priority areas of national development) and the Fundamental and Applied Research Grants (targeting scientific and technological advances, solutions in specific research areas) select projects on a competitive basis, through open calls for proposals, and involve four different stakeholders:

- Central planning is carried out by the MoF
- Selection and supervision is done by the MoES
- Expertise is provided by the Latvia Council of Science (LCS)
- Management is carried out by the Study and Research Administration (SRA – Subordinated to the MoES).

The beneficiaries are State established, registered research institutions, research institutes and higher education institutions (as well as scientists and scientist groups for the Research Grants).The Ministry of Finance and the Ministry of Economics are also involved in the planning and supervision of Structural Funds, while the funds available are managed by the Administration by the Central Finance and Contracting Agency (CFCA - subordinated to the MoF) and the State Education Development Agency (SEDA – Department of the MoES).

The Latvian Academy of Sciences (LAS) promotes international scientific collaborations and supports the internationalization of Latvian science. LAS has been coordinating and implementing EUREKA and COST programmes, the Joint Baltic Sea research programme BONUS, Joint Technology Initiatives and the functions of national funding agency for ERA-NET and ERA-NET Plus projects.
The Research and Innovation Council (RIC) is an advisory body created in 2013. RIC is chaired by the Prime Minister and gathers Ministers, representatives of higher education institutions (HEIs), representatives of the regions, Chamber of Commerce, Confederation of Employers, Baltic Innovative Research and Technology Infrastructure (BIRTI - an NGO the Academy of Science and the Cross-Sector Coordination Centre. Its task is to advise the Cabinet of Ministers on important matters concerning research and technology investments and the evaluation of policy proposals in Latvia.

10.8 Description of national SET Plan Structure for Smart Grids Research

Latvian national research and innovation strategy on Smart Grids is implemented through the Energy Strategy 2030 which has the aim to ensure a positive impact of the energy sector on the national economy of Latvia, while striving for a safe, secure energy supply and sustainable energy:

- Stable energy supply and developed infrastructure provided to energy users;
- Reduced dependency on imported energy resources, new and efficient technologies for the use of renewable resources are encouraged, measures to improve energy efficiency are implemented.

With support from Ministry of Economy and Latvian Association of Power Engineers and Constructors is launched Smart grid Platform Latvia (based on the Smart Grid Research Centre at the Institute of Physical Energetics). Smart Grids Latvia (SGL) aims to conduct research on Smart Grids, to promote technology transfer, to provide best practices in smart grid education, to develop and adapt technological solutions for the Latvian Power System, were top 3 priorities are selected: Demand Response, Market Integration and Integration of Renewables. The SGL will bring together utilities, industries, universities, research centres and all stakeholders related to Smart Grids development in Latvia.

Table 10-2: Supported Smart Grids R&D and Innovation projects in Latvia

R&D project	Company	Total budget
H2020, ERA-NET Smart Grid Plus project CLOUDGRID -Transnational CLOUD for Interconnection of Demonstration Facilities for Smart GRID Lab Research & Development (2017-2019), project partner Institute of Physical Energetics. http://www.eranet-cloudgrid.eu/	IPE (project partner)	Total Project Budget: € 2,300,000. (Funding: € 1,900,000.-)
FP7 IRP –ELECTRA European Liaison on Electricity Committed Towards long-term Research Activities for Smart Grids (2013-2018), project partner Institute of Physical Energetics. http://www.electrairp.eu/	IPE (project partner)	Total Project Budget: €13120736.00
The SmartGen Project (ERA NET - 2010-2013): Efficient identification of opportunities for Distributed Generation based on Smart Grid Technology. Project coordinated by Sweco Norge AS (Norway) with the participation of the Institute of Physical Energetics (Latvia), Bacher Energy Ltd (Switzerland) and Balslev A/S (Denmark).	IPE (project partner)	0.2MEUR
The Quality & Safety Project (ERA NET – 2010-2013): Power Quality and Safety Requirements for People and Electrical Equipment in Smart Grid Customer Domain. Project coordinated by the Tallinn University of Technology (Estonia) with the participation of the Riga Technical University (Latvia) and of the Graz University of Technology (Austria).	RTU (project partner)	0.2MEUR
Demonstration & deployment Project	**Company**	**Total budget**
H2020, project RealValue, (2015-2018), provide an innovative means to mitigate the challenges associated with, and maximise the value of clean energy from renewable sources. **http://www.realvalueproject.com/**	RTU (project partner)	Total cost: €15,413,331 EU contribution: €11,987,430

References

[ref_LV1] https://rio.jrc.ec.europa.eu/en/library/rio-country-report-latvia-2015

[ref_LV2] https://rio.jrc.ec.europa.eu/sites/default/files/PSF_Latvia_interests_precizeta.pdf

11 Norway

11.1 Landscape of Smart Grids R&D in Norway

In Norway historically inexpensive hydro power has been the main energy source for electricity generation. Thus, today 98- 99% of the total electricity generation in Norway is hydro power based. Due to this fact, it is not on the Norwegian Smart Grid agenda to convert fossils based electricity generation to renewable generation. But as Norway is committed to fulfil the so-called European Renewables Directive [ref-NO4], 67% of the total energy use in Norway should be based on renewable energy by 2020 which requires an increase in renewable electricity generation which should be used to substitute the use of fossils based energy in industry (on-shore and off-shore) and in transport. Incentive schemes in terms of a common green certificate market with Sweden thus motivates for more renewable electricity generation which in part will be based on intermittent energy sources like wind, PV and small hydro power plants without any reservoir capacity.

11.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

The Norwegian power system and electricity use has several characteristics different from most countries giving specific challenges and opportunities within the Smart Grid context:

- Large part of electricity in the domestic sector used for space and water heating offers much flexibility for demand response and demand side management schemes.
- Large availability of hydropower plants with reservoirs which are fast and easy to control. These offers low-cost balancing services. (Most new production is small scale distributed generation without storage.)
- Quickly growing share of purely battery based electric vehicles reaching 130 thousands or 4 % of all personal vehicles in 2017 [ref_NO13], due to very good incentives (tax exempt, free parking, free use of toll roads and bus lanes etc.) 0
- Significant part of the LV distribution system is of type 230 Volt IT system (230 V line voltage) different from the 400 Volt line voltage systems in most of Europe.
- Weak grids with approx. 40% of the supply terminals weaker than the standardized EMC reference impedance give more severe voltage quality problems when connecting EVs, PVs etc. than many countries 0
- Well-developed broadband communication to homes and increased use of fibre-to-home communication provided by power utilities.
- Well-developed electricity markets. There are multinational markets with significant volumes for day-ahead, intra-day and balancing with participation of producers and consumers.

In total, Norway's power system and markets are well positioned for a future smarter and more renewable power and energy system, but some barriers such as weak grids in parts of the LV system needs to find their cost efficient and smart solutions.

11.3 Industry (main industry actors, where in the value chain)

The Norwegian Smart Grid Centre has currently 47 directly involved members from universities, research bodies, supply industry, transmission and distribution companies as well as infra-structure

providers within telecommunication. Some of these members are large companies operating worldwide while others are smaller niche companies dealing with more specialized issues in the Norwegian system. As ICT security, reliability and privacy of data are essential also service providers within these disciplines are well represented.

11.4 Public research stakeholders

The main public research actors in the area of Smart Grids are:

- Norwegian University of Science and Technology (NTNU) and in particular the Department of Electric Power Engineering (associated member in EERA JP SG).
- Norwegian Centre of Expertise (NCE) Smart Energy Markets 0 is a business cluster and a world-class competence centre working for sustainable development through green innovation in the trading of energy, raw materials and carbon offsets.
- University of Agder, Department Energy Systems is involved in research on Smart Grid and Grid Integration of Renewable Energy Systems 0

11.5 National R&D strategy

Energi21 is the Norwegian Ministry of Petroleum and Energy's permanent strategic body for research, development and demonstration in the energy sector. The main purpose of the Energi21 strategy reports is to provide the Ministry of Petroleum and Energy with recommendations on future strategic priority areas for efforts to develop new climate-friendly, environment-friendly solutions in the energy sphere.

The Energi21 strategy documents are drawn up in cooperation with trade and industry, academia and the relevant authorities. The guiding principles for national and international strategies in the energy sphere revolve around the need to address climate challenges and safeguard both security of energy supply and competitiveness. These factors, together with assessment of the potential to meet targets and of Norway's national competitive advantages, form the basis for the recommended strategic priority areas and proposed measures.

11.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

The Norwegian Smart Grid Centre

The Norwegian Smart Grid Centre was established in 2010 on the basis of a recommendation of the Ministry of Petroleum and Energy in its national strategy process for defining future Energy R&D in Norway (Energi21 process). NTNU and SINTEF answered to this challenge and became the locus of coordinating national research, demonstration, laboratory, education, standardisation and information activities to optimise the use of resources and avoid uncoordinated parallel activities 0.

Demo Norway

Full scale demonstration projects connected to real power systems are necessary to properly develop, test and verify Smart Grids solutions. Immature and high-risk solutions are best studied and tested in laboratories while the more mature cases and cases which include the behaviour or human response of customers need to be tested in demonstration projects that are linked to real

power systems with real customers. One of the goals of the Norwegian Smart Grid Centre is to establish national demos and laboratories for the purpose of developing, testing and verifying Smart Grid technology and services. Demo Norway is the result of coordinated development of complementary demos at individual sites ("Living Labs") with modern off-grid laboratory facilities at the research institutions NTNU/SINTEF.

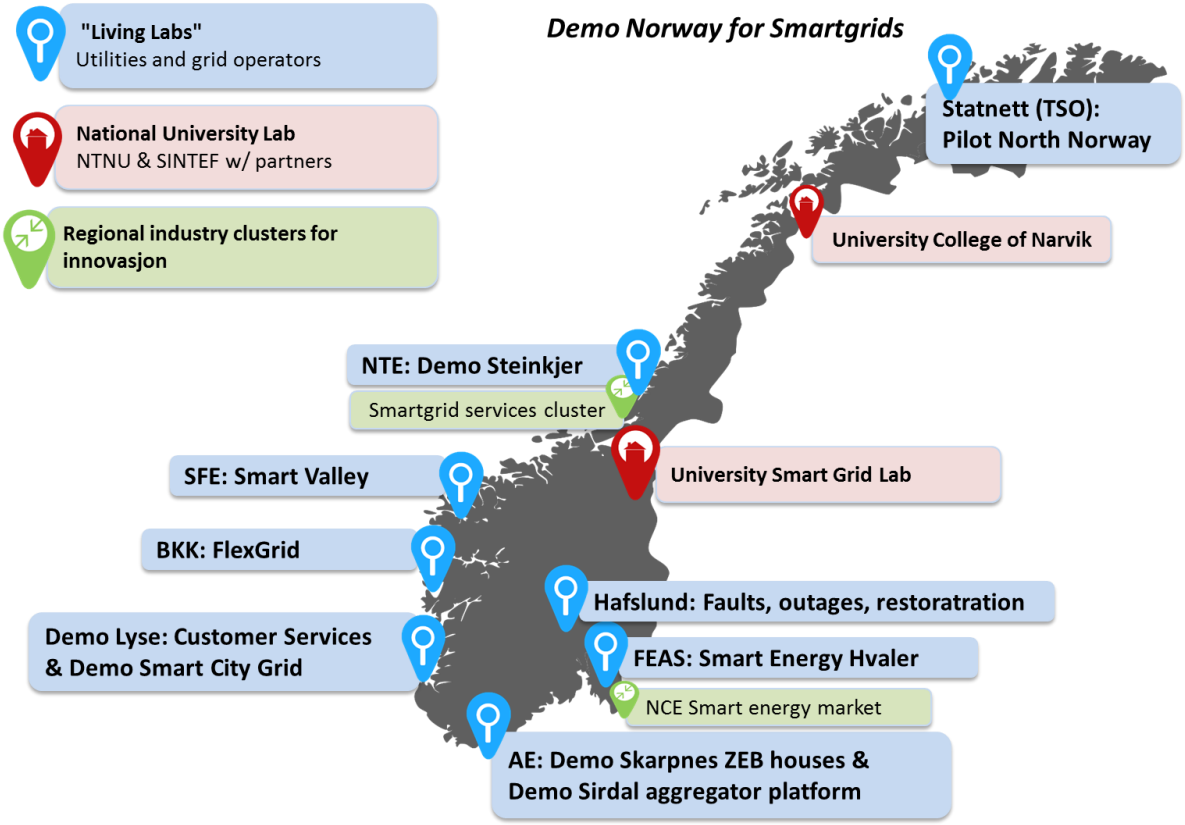

Figure 11-1: Overview of the demonstrations facilities of the Demo Norge distributed across Norway in 2015

National Smart Grid Laboratory

In the area of Smart Grids, several research laboratories have been operating in Norway in a rather uncoordinated manner for several years. Each of them could offer a limited range of services and testing capabilities with limited access. The concept of a National Smart Grid Laboratory did not exist until the Norwegian Research Council decided to open a dedicated call for applying for funding to build National Infrastructures in the year 2012. As a result of that, a brand new Smart Grid National Laboratory was granted by the Norwegian Research Council to a consortium composed by NTNU, SINTEF, Narvik University College (NUC), and NCE SMART 0 under the leadership of NTNU. The Smart Grid National Laboratory project started in March 2014 and will run for the next 5 years. This laboratory is built around an existing facility comprised of the renewable energy laboratory, the energy storage laboratory, the converter and control activities connected to the power electronics laboratory, the electrical installation laboratory and the PV solar panels at the NTNU campus.

The Smart Grid Lighthouse

The Smart Grid Lighthouse is an initiative by the Norwegian University of Science and Technology (NTNU) aimed at highlighting and coordinating the research and education activities related to Smart Grid within the University. The Lighthouse integrates multidisciplinary activities covering the

areas of electrical engineering, control systems, computer science, telecommunication as well as societal aspects, economics and new business models.

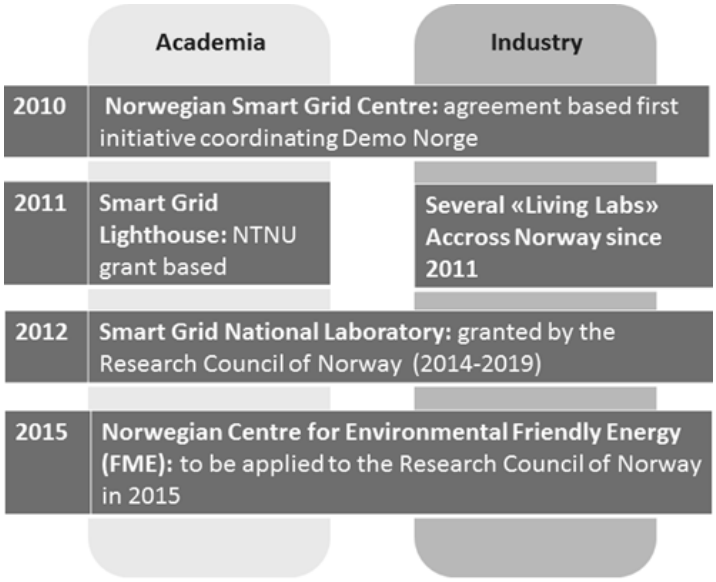

Figure 11-2: Timeline overview of major Smart Grid initiatives in Norway
(Source: 0)

Norwegian Smart Grid Centre for Environmentally Friendly Energy (FME)

Norwegian Smart Grid Centre for Environmentally Friendly Energy (FME) is in an initiative built on the foundation of the several joint Smart Grid actions taken since 2010 and described in the previous sections of this chapter [ref_NO15]. A chronological overview describing the nature of the smart grid initiatives preceding this Innovation Centre is given in Figure 11-2. A Smart Grid FME will, by its scope, perspective and nature, embrace all the preceding initiatives in Smart Grid in Norway. A Smart Grid FME will encourage enterprises and network operators to innovate by placing stronger emphasis on long-term research and by making it attractive for enterprises that work on the international arena to establish R&D activities in Norway. The FME grant specific for the Smart Grids domain was awarded to joint Consortium of SINTEF Energy Research and The Norwegian University of Science and Technology (NTNU) together with 29 industrial partners, called Centre for Intelligent Electricity Distribution. The overall budget for the Centre for Intelligent Electricity Distribution (CINELDI) is about 40 mil Euros and duration is eight years [ref_NO14].

Several partners from ELECTRA IRP /EERA JP SG are actively involved in CINELDI via participation in its Scientific Committee, including Tecnalia, VTT, USTRATH and DTU.

11.7 Funding bodies and programmes

The Research Council of Norway

The main funding body for R&D activities in Norway is the Research Council of Norway. At the moment there are two programmes, which are essential for development of Smart Grids in Norway: ENERGIX and FME Centres.

Large-scale programme for energy research (ENERGIX) was launched in 2013 and has 10 years duration 0. The ENERGIX-programme provides funding for research on renewable energy, efficient use of energy, energy systems and energy policy. The ENERGIX programme is designed to provide support for the long-term, sustainable restructuring of the energy system in order to

accommodate a greater supply of new renewable energy, improve efficiency and flexibility, and facilitate closer energy integration with Europe. The programme is a key instrument in the implementation of Norway's national RD&D strategy, Energi21, as well as for achieving other energy policy objectives.

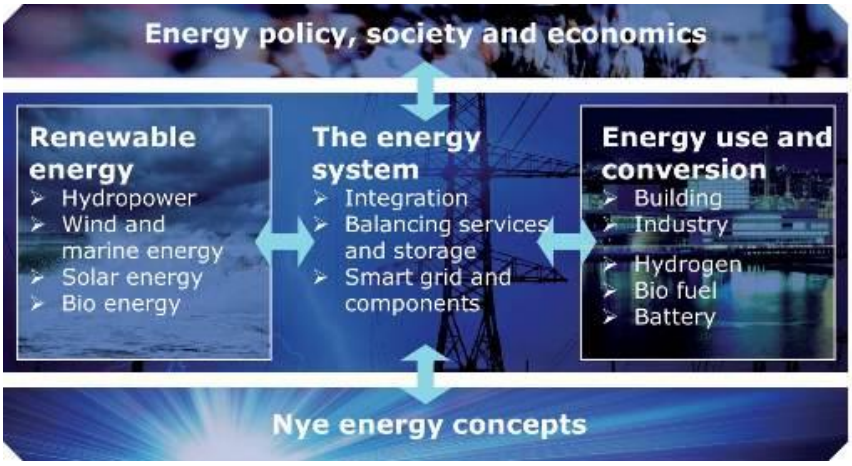

Figure 11-3: Thematic priority areas for Energy program
(Source: Research Council of Norway)

The Research Council of Norway is responsible for funding a select number of Centres for Environment friendly Energy Research (FME), which seeks to develop expertise and promote innovation through focus on long-term research in the area of environment-friendly energy. The objective of the scheme for Centres for Environment-friendly Energy Research (FME) is to establish time-limited research centres which conduct concentrated, focused and long-term research of high international calibre in order to solve specific challenges in the field. It is expected establishment of FME dedicated to Smart Grid domain.

Enova SF

Enova SF is a public enterprise, owned by the Ministry of Petroleum and Energy. Enova promotes more efficient energy consumption and increased production of "new" renewable energy. This also covers the domain of Smart Grids.

This is done via targeted programmes and support schemes in the areas in which the greatest effect in the form of saved, converted, or generated clean energy can be documented. Enova in practice works in the segment related to market introduction and investment support of new technologies 0.

Nordic Energy Research

Nordic cooperation in energy research started 1975, leading to common pot research funding since 1985 and the establishment of Nordic Energy Research as an institution under the Nordic Council of Ministers in 1999 0. The Nordic Energy Research is a platform for cooperative energy research and policy development under the Nordic Council of Ministers – the intergovernmental body between Denmark, Finland, Iceland, Norway and Sweden. The organisation supports projects, which pursue the overall Nordic strategy in carbon emissions and its dependence of fossil fuels, and at the same time create new growth industries based on green technology. The strategy for 2015-2018 is based on a series of stakeholder workshops conducted in each of the Nordic countries during the spring of 2014.

11.8 Description of national SET Plan Structure for Smart Grids Research

Norway is an active participant in several initiatives under the SET Plan and has participated in many projects funded under the EU Seventh Framework Program. The overall national strategic research priorities for the Energy domain are done by Energi21. The main function of the Energi21 initiative is to provide strategic input and recommendations to the authorities on research, development and demonstration activities targeted towards the development of new, climate-friendly, stationary energy technology. The Energi21 strategy is to be an integrated, unifying strategy for the energy sector where the stakeholders, through their active participation, give support to collective strategic objectives and measures. The Ministry of Petroleum and Energy uses the strategy when determining its allocations to research, development and demonstration in the energy sector.

The above mentioned strategic priorities are implemented via specific research programmers as the above mentioned ENERGIX and FME centres. These programs are operated by Research Council of Norway. The organisation is presented

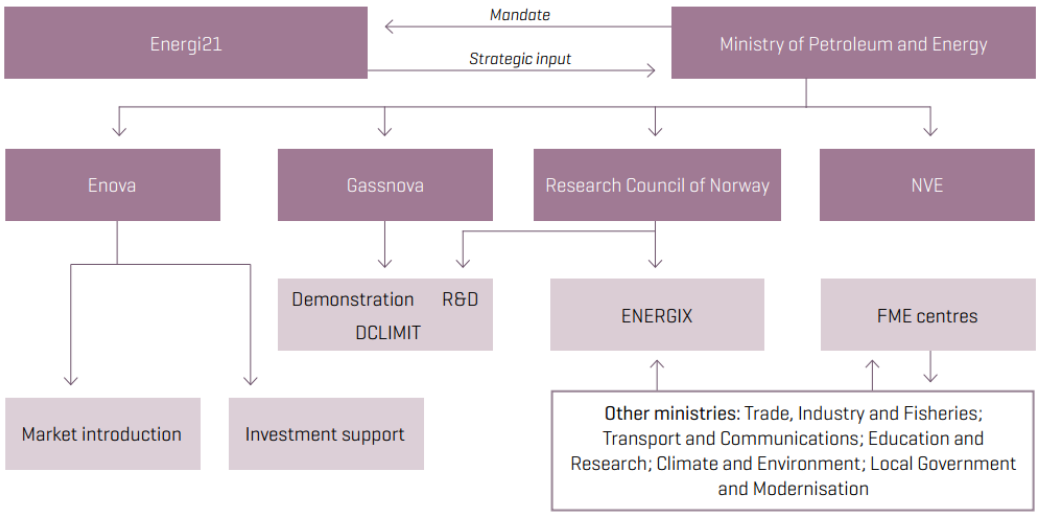

Figure 11-4: Organization of energy research under the Ministry of Petroleum and Energy. Source Energi21

In addition to this the Norwegian Smart Grid Centre has worked on overall coordination and strategy of Smart Grid Related Research financed by the industrial actors and in particular by DSOs. In 2014 the Centre presented a document called Smart Grid Strategy for Research, Development and Demonstration. The document outlines the main priorities for the future research based on EEGI roadmap 0.

Table 11-1- Supported Smart Grids R&D and Innovation projects in Norway

R&D project	Company	Total budget (Million EUR)
FlexNett: Flexibility in the future smart distribution grid – research step	SINTEF Energy Research	App. 2 mil Euro
SPESNETT: Power quality in Smart Grids	SINTEF Energy Research	App. 1 mil Euro
Demonstration & deployment Project	**Company**	**Total budget (Million EUR)**
FlexNett: Flexibility in the future smart distribution grid–demonstrators foreseen	SINTEF Energy Research	App. 2 mil Euro

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[ref_NO5] European Association for Battery, Hybrid and Fuel Cell Electric Vehicles (AVERE) (2012-09-03). "Norwegian Parliament extends electric car initiatives until 2018".

[ref_NO6] IEC/TR 60725 Consideration of reference impedances and public supply network impedances for use in determining the disturbance characteristics of electrical equipment having a rated current ≤75 A per phase

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12 Portugal

12.1 Landscape of Smart Grids R&D in Portugal

Electric power systems are facing significant changes due to the increasing levels of distributed energy resources penetration. This new scenario affects the way how power systems, in particular distribution grids, are managed, ranging from technical issues related with operation and planning to economic and regulatory aspects. In this context, the Smart Grids (SG) vision has been pointed out as a possible solution to exploit available infrastructures, while maximizing distributed energy resources integration and extending consumers' participation in the overall electricity value chain.

12.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

To a large extent, small scale distributed energy resources – Electric Vehicles (EV), microgeneration units, energy storage devices and flexible loads – are widely spread and usually connected to Low Voltage (LV) distribution networks, requiring the implementation of local control solutions to mitigate technical problems resulting from their integration. Simultaneously, LV distributed energy resources can be aggregated in order to globally provide new functionalities to system operators, based on Microgrid (MG) and Multi-Microgrid (MMG) concepts. The implementation of such concepts enables the coordinated control and management of distributed energy resources, exploiting their flexibility. The level of control required to achieve this goal requires the utilization of cost-competitive technologies and new communication systems. The deployment of Smart Meters (SM) is also an important factor that can be seen as a way of pushing forward the development of the SG concept by providing the infrastructure to support advanced control and management functionalities within the distribution system. This is the pathway followed by the Portuguese Distribution System Operator (DSO), EDP Distribuição, by supporting two nationwide SG projects: InovGrid and REIVE.

The InovGrid project main purpose was to develop an advanced metering system and define a set of functionalities to endow the distribution grid with the necessary intelligence to tackle the paradigm change in the electric industry. In this project, a strong focus was devoted to microgeneration management and control in LV grids, while providing customers the necessary conditions to access new services. The project was supported by a conceptual architecture, followed by the functional and technical specification of the different controllers. The specification was dully supported through advanced system studies extensively exploiting simulation tools to better demonstrate the potential benefits of the control solutions. The specifications of InovGrid project were rolled-out in Évora, in a pilot site designated as InovCity, where devices, functionalities and the control architecture were tested in a real-world scenario, providing both a test bed and a demonstration site.

The REIVE project was headed by INESC Porto and aimed at developing a technological framework towards the integration of EV in Portuguese distribution grid. This project is intrinsically an extension of InovGrid, with a specific target regarding the identification, specification and testing of innovative solutions within the SG concept to allow an enhanced technical and market integration of microgeneration and EV. Within this framework, a laboratory infrastructure was designed and implemented to develop and test solutions and prototypes, promoting an active and intelligent grid management in scenarios characterized by a progressive integration of microgeneration units and EV.

The functionalities envisaged for Smart Grids in Portugal reference architecture were (and are still being) implemented in the test sites, being deployed in three main phases. In the first one, several remote services were implemented, such as remote metering, consumer remote connection/disconnection, remote modification of the contracted power, tariff setup, tampering alarms, MV switching etc. Other functionalities tailored for LV consumers were also incorporated in the first phase, such as promotion of customer awareness and their engagement in energy efficiency programmes (in-home displays were provided by the DSO to some clients, providing real-time information of their power consumption and generic energy efficiency advices). The second stage was essentially focused on the public lighting. Old lamps were replaced by a highly efficient public lighting system, based on LED luminaries with automatic dimming and remote control by the DTC.

The third phase is ongoing and includes the integration of several advanced functionalities towards a complete SG vision. As an example, coordinated voltage control strategies (involving all the resources available in the distribution grid), forecasting algorithms for load, EV charging, distributed generation and microgeneration, novel state estimation techniques and remotely controlled bidirectional inverters for storage and EV management are foreseen to be implemented until 2019.

As the smart grid functionalities are supported by the existence of smart meters and an adequate communication infrastructure, the concept is being progressively implemented at the same pace that legacy meters are replaced by smart meters. Although there is no specific date to have the country fully covered by smart meters, the Portuguese DSO, EDP Distribuição, estimates that this is going to happen only after 2020.

12.3 Industry (main industry actors, where in the value chain)

A large number of companies have been active in the sector of RES and Smart Grids over the last years in Portugal. These companies are either associated according to their background and area of interest (e.g. manufacturers, energy producers) or participate independently in the energy market. For instance, the Portuguese Association of Renewable Energies (APREN), that represents more than 90% of the installed renewable power in Portugal, develops its work together with official authorities and other similar entities, nationally and internationally, being an important key player in the development of energy policies for Portugal, promoting the deployment of renewable resources for electricity production.

APREN privileges the coordination and permanent contact with the Portuguese Government, the ministries responsible for energy and environmental issues and their official agencies, as well as a fruitful dialogue with the crucial national stakeholders related to the production of electricity from renewable sources and representatives from the civil society.

APREN has also a strong involvement at European level, manifested primarily through the participation in European projects and through its partnership with several European Associations that defend the technologies that APREN represents, which enable the monitoring of European Energy Policy and developments in the sector in other Member States of the European Union.

The large-scale implementation of Smart Grid at National level - managed by a consortium led by EDP Distribuição, incorporated several companies with skills in the fields of measurement and communications (e.g. Janz), power system automation, communications, SCADA and substation automation (e.g. EFACEC), information systems (e.g. Edinfor/LOGICA CMG) and research institutes (e.g. INESC TEC), etc.

12.4 Public research stakeholders

The number of public research stakeholders active in the Smart Grids area is somewhat low in Portugal. The main institutions are:

- INESC TEC - The Centre for Power and Energy Systems (CPES) of INESC TEC works in emerging areas that are essential for the Smart Grids sector: regulation and electricity markets, integration of dispersed renewable energy generation, technical and economic management of distribution systems, the use of GIS and other IT in Smart Grids planning and uncertainty and risk assessment.
- ISEP/IPP - The research group GECAD, from ISEP/IPP, has developed several research works in the Smart Grids area.
- Fraunhofer Portugal – The Associação Fraunhofer Portugal Research, is a non-profit private association founded by Fraunhofer-Gesellschaft that is currently very active in the areas of ICT, which can be used in Smart Grids.
- INESC Coimbra – INESC Coimbra works in several areas related with Smart Grids, namely: management of energy demand, electricity consumption models, energy management in buildings, electricity markets, among others.
- INESC id - The Power Systems and Energy Policy group of INESC id is devoted to research in advanced concepts and technology development towards power systems industry applications to tackle the emerging engineering challenges related to planning, operation, and regulation of power systems. Special emphasis is given to the challenges related to renewables integration, flexible operation, and future regulation under the smart grid paradigm.

12.5 National R&D strategy

At the base of the Portuguese R&D strategy for Smart Grids are five structuring objectives:

1. Promoting the potential of the scientific and technological knowledge;
2. The promotion of cooperation between public and private R&D institutions, promoting knowledge transfer and exchange, to improve the level of technological developments and services produced;
3. The bet on the internationalization of R&D institutions and companies and on the diversification of markets;
4. The promotion of entrepreneurship, promoting the creation of employment in the area of Smart Grids;
5. The transition to a low carbon economy highly fostered by Smart Grids.

12.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

There are two national programmes that establish the priorities regarding the field of energy and Smart Grids: the ‘National Action Plan for Energy Efficiency’ and the ‘National Action Plan for Renewable Energies’. According to these programmes, the Portuguese priorities are:

- Optimization of energy production and transmission, seeking for complementarities among different energy vectors (renewables, non-renewable, new fuels and hydrogen, fuel cells, CO2 capture and storage, real-time energy management systems; energy storage);

- Energy efficiency (including smart cities, NZEB: Net-Zero Energy Buildings, energy in transportation sector, consumer engagement, foster consumers' behavioural change towards energy efficiency, etc.);
- Applications of new ICT technologies on Smart Grids;
- Integration of the European energy market (modelling, planning, new market models, regulation).

12.7 Funding bodies and programmes

The Foundation for Science and Technology (FCT) is the national public agency to support science, technology and innovation research in all areas of knowledge.

FCT's mission is to continuously promote the progress of scientific and technological knowledge in Portugal, to achieve the highest international standards of quality and competitiveness in all scientific and technological domains, including Smart Grids.

FCT pursues its mission by funding research and development projects, supporting competitive research centres and cutting-edge research infrastructures. FCT assures Portugal's participation in international scientific organizations, promotes the participation of the national scientific community in international projects and stimulates the transfer of knowledge between research centres and industry.

FCT regularly (at least once a year) launches R&D project calls in all scientific fields, including Smart Grids.

12.8 Description of national SET Plan Structure for Smart Grids Research

The Portuguese national research and innovation strategy on Smart Grids is highly related with the 'National Action Plan for Energy Efficiency' and the 'National Action Plan for Renewable Energies'. These programmes' goal is to ensure a positive impact of the energy sector on the national economy of Portugal, while seeking a secure energy supply and sustainable energy sector.

Table 12-1: Supported Smart Grids R&D and Innovation projects in Portugal

R&D project	Company	Total budget (Million EUR)
ESGRIDS – *Enhancing Smart Grids for Sustainability*	INESC TEC, UBI, Univ. Coimbra	2.1
SmartGuide – *Defining Planning and Operation Guidelines for European Smart Distribution Systems*	INESC TEC	0.2
GReSBAS – *Grid Responsive Society Through Building Automation Systems*	INESC TEC	0.4
SusCity: *Urban data driven models for creative and resourceful urban transitions*	INESC TEC, Univ. Minho, Univ. Coimbra, IST, Nester, EDP Distribuição	1.2

Best Case – *Better Science Through Cooperative Advanced Synergetic Efforts*	INESC TEC	7
Demonstration & deployment Project	**Company**	**Total budget (Million EUR)**
InovGrid	INESC TEC, EDP Distribuição, EFACEC, Janz, Logica	N/A
REIVE: *Smart Grids with Electric Vehicles*	INESC TEC, LNEG, EDP Distribuição, GALP, REN	3.5

13 Poland

13.1 Landscape of Smart Grids R&D in Poland

The total installed capacity at the end of 2013 is 38.406 MW. The capacity of wind power and other renewable energy sources is 3.504 MW with a new capacity of 887 MW installed in 2013.

The total electrical output from wind power and other renewable energy sources is 5.895 GWh and generates 3,63% of national electricity demand in 2013.

Although the energy production of the wind turbines is at a low level, there has occurred a significant increase. The installed capacity at the end of 2013 is 3.389 MW and the forecast for the end of 2014 is 4.492 MW. It is the increase of 33%.

13.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

The national strategy concerning power energy is contained in Energy Policy of Poland until 2030 (EPP2030). The new Energy Policy of Poland until 2050 (EPP2050) is under preparation. The Primary directions of energy policy include, among others:

- to develop the use of renewable energy sources, including biofuels;
- to reduce the environmental impact of the power industry.

One of the main energy policy objectives in the field of using renewable energy sources is increasing the use of renewable energy sources in the final energy use to at least 15% in 2020 and further increase in the following years. According to the EPP2050 project the use of renewable energy sources should be 27% in 2030, which it is a significant challenge.

Positive effects of developing renewable energy sources include the reduced CO2 emission and increased Poland's energy security.

Hard coal plants	19 812
Lignite plants	9 374
Gas plants	934
Hydro plants	2 221
Wind plants and renewable energy sources	3 504
Industrial power stations	2 561
Total **[MW]**	38 406

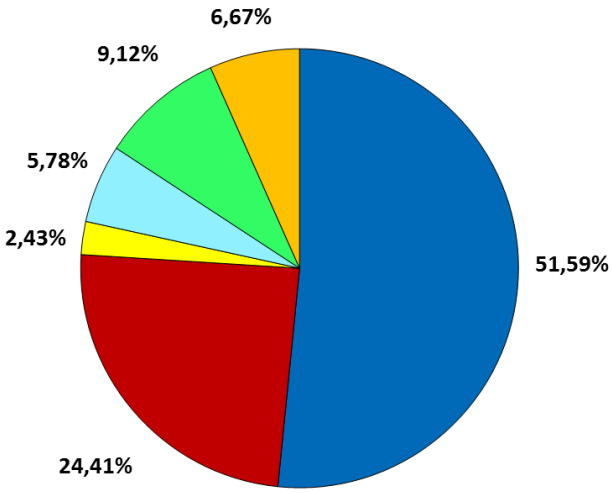

Figure 13-1:Structure of installed capacity at the National Power System (KSE) [MW] (as at 31 December 2013)

13.3 Industry (main industry actors, where in the value chain)

The National Power System (NPS)

Continuity and stability of the energy supply is guaranteed by a group of entities creating the National Power System. These entities are subordinate to different institutions and regulations. Subsystems creating NPS are: generation subsystem, transfer grid and distribution grid.

Production of electricity

According to the Energy Regulatory Office data, the three biggest producers had more than half of installed capacities and produced nearly 2/3 of Poland's electricity. At present, the largest companies in the energy sector include:

Grupa Kapitalowa (GK) PGE – the company manages among others over 40 power stations and heat and power plants, 8 operators of distribution grids, 7 retailers and 3 lignite mines; in 2011 it produced 56.5 TWh of electricity (approx. 40% of the domestic production) and had installed capacity of 13.1 GW;

GK Tauron – installed capacity of the group's coal-fired plant is 5300 MW; the group has 35 hydro plants (132 MW) and two wind farms (61 MW); in 2011 it produced 21.4 TWh of electricity, i.e. 14% of domestic production, and also 16% of thermal energy in Poland;

GK Enea – operator of the coal-fired plant in Kozienice (2.9 GW) and distributor of energy in western Poland; the total installed capacity of the group is 3.1 GW; in 2011 the group produced 12.3 TWH and sold 15.5 TWH of energy to 2.4 million buyers;

EDF – operator of among others the power plant in Rybnik; energy distributor; the group has installed capacity of 3500 MW and produces 10% of Poland's electricity and 15% of network heat; the group was formed thanks to a French investor which entered the Polish market in 1997;

ZE PAK – second biggest producer of energy from lignite; has installed capacity of 2900 MW; in 2010 the group produced 12% of Poland's energy and sold 7.9 TWh of electricity;

GK Energa – operator of 47 hydro plants and of the coal-fired plant in Ostroleka; in 2011 the group produced 4.7 TWh of energy, distributed 19.6 TWh to 2.9 million buyers and sold 19.3 TWh of energy.

Distribution of electricity

Distribution of electricity is based on a transmission grid owned and operated by in Poland by PSE Operator. PSE perform the duties of the transmission system operator using its own transmission grid of the highest voltage, which consists of (as at 31 December 2013):

- 246 lines with a total length of 13,519 km, including:
  - 1 line of 750 kV voltage with a length of 114 km,
  - 77 lines of 400 kV voltage with a total length of 5,383 km,
  - 168 lines of 220 kV voltage with a total length of 8,022 km,
- 103 extra-high voltage (EHV) substations
- under-sea 450 kV DC connection between Poland and Sweden, with a total length of 254 km.

There are four major distribution system operators: ENEA SA, ENERGA SA, PGE Polska Grupa Energetyczna S.A. and TAURON Polska Energia S.A.

Polish labour market potential

Approximately 300 thousand people are employed in the fuel and energy sector in Poland (125 thousand are employed in the coal mining industry are nearly 150 thousand are engaged in supply of electricity and gas).

It is difficult to describe wind power and smart grid industry because many companies are subcontractors or the factories belong to international corporations.

13.4 Public research stakeholders

In Poland there is no organization dedicated to the development of the smart grid, but the issue of the renewal of the power grid has been raised in EPP2030 and EPP2050. The President of Energy Regulatory Office submitted its position in the document “Position of the President of Energy Regulatory Office on necessary requirements with respect to smart metering systems implemented by DSO”.

It is in the interest of TSO and DSO to upgrade the transmission and distribution grid to the smart grid standard. Therefore, the operators cooperate with universities and research institutes in projects which are cofounded from national and EU sources.

13.5 National R&D strategy

According to the principles of development policy Innovation Strategy and Economic Efficiency "Dynamic Poland 2020" (SIEG) is one of nine integrated strategies to implement the provisions of the medium-term National Development Strategy 2020. The coordinator of the Strategy, adopted by the Council of Ministers on 15 January 2013., Is the Minister economy.

The creation of a highly competitive economy (innovative and effective) based on knowledge and cooperation is the main objective of SIEG. It will be implemented on the basis of four specific objectives:

1. to adapt the regulatory environment and financial needs of innovative and efficient management,
2. stimulating innovation by enhancing the efficiency of knowledge and work,
3. increase the efficient use of natural resources and raw materials,
4. increase the internationalization of the Polish economy.

The strategy envisages broader than ever revolving use of the instruments. Achieved thus greater mobilization of private capital will be accompanied by measures to improve the efficiency of public spending allocated to finance R&D&I.

The Strategy is linked to other integrated strategies, one of them being the Energy security and environment strategy. This Strategy relates directly to the implementation of smart grid solutions.

13.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

The main objective of energy policy in the field of generation and transmission of electricity and heat is to ensure ongoing meeting of demand for energy, taking into account the maximum possible use of domestic resources and environmentally friendly technologies.

Specific objectives in the field are as follows:

- Building new generation capacity to balance domestic demand for electricity and maintain the operationally available power surplus during the peak generation capacity of domestic conventional and nuclear generation sources at the minimal level of 15% of the maximum domestic demand for electricity;
- Building intervention sources of electricity generation essential to security of the power system operation;
- Developing the national transmission system enabling sustainable economic development of Poland, its individual regions and ensuring reliable electricity supplies to agglomerations (particularly closing the 400 kV loop and loops circling Poland's largest cities), as well as receipt of electricity from the areas with a large number of planned and newly built generation facilities, including in particular the wind farms;
- Developing cross-border connections coordinated with extending the domestic transmission system as well as the systems in neighbouring countries, which will allow to exchange at least 15% of electricity used in Poland by 2015, 20% by 2020, and 25% by 2030;
- Modernisation and extension of the distribution grid which allows to improve the reliability of power supply and to develop distributed power generation using local sources of energy;
- Modernisation of transmission and distribution grids to reduce failure frequency by 50% by 2030 as compared to 2005;
- Aiming at replacing the heat and power plans supplying the centralised heat distribution systems of Polish cities with cogeneration sources by 2030.

It is predicted that wind power will develop both on land and at sea. Furthermore, it is important to create conditions to facilitate making investment decisions on building off-shore wind farms. Ongoing are preparatory works for the construction of 13 artificial islands in the Baltic Sea, on which 2100 wind turbines will be built.

13.7 Funding bodies and programs

The National Centre for Research and Development is the implementing agency of the Minister of Science and Higher Education. It was appointed as an entity in charge the performance of the tasks within the area of national science, science and technology and innovation policies. It was created as the platform of an effective dialogue between the scientific and business communities. The activity of the Centre is funded by the national treasury and the European Union.

Projects concerning smart grid can be supported by the Centre if they meet the requirements of innovation and comply with the strategic directions of the development of the country. Therefore, the statements about the need to develop smart grid in the EPP2050 are very important.

Co-funded by the Centre, the Institute of Power Engineering has been participating in projects e-Highway 2050 and ELECTRA.

The National Centre for Research and Development agreed to establish a new sectoral program on R&D for power engineering. The program was allocated EUR 250 million. Half the amount is the

Polish Electricity Association's own contribution. The other half of the funding comes from the EU fund (Smart Growth Operational Programme 2014-2020).

Approved study assumes the realization of R&D projects in the five research problems:

- ways to reduce emissions.
- improving the competitiveness of renewable energy generation in the power system.
- improving efficiency and preparing the industry for the development of intelligent energy,
- prosumer activities.

The next source of funds is the National Fund for Environmental Protection and Water Management (NFEP&WM) whose mission is to support environmental action effectively and efficiently. The NFEP&WM may support projects related to smart grid and wind power.

13.8 Description of national SET Plan Structure for Smart Grids Research

Poland does not have a defined structure responsible for implementing the SET Plan. The implementation of the SET Plan is the responsibility of the Ministry of Economy and Ministry of Science and Higher Education, which have their representatives in the European Community Steering Group on Strategic Energy Technologies. The provisions of the SET Plan are reflected in the Energy Policy of Poland.

Table 13-1: Supported Smart Grids R&D and Innovation projects in Poland

R&D project	Company – Polish partner	Total budget (Million EUR)
CIPOWER	AGH University of Science and Technology	20,1
E-BALANCE	University of Lodz OSRODEK PRZETWARZANIA INFORMACJI OPI	5,2
e-Highway2050	Instytut Energetyki	13,0
ELECTRA	Instytut Energetyki	13,1
FINSENY	Telekomunikacja Polska S.A. (Orange. Undetermined location.)	9,1
MANERGY	ARLEG S.A. Regional Development Agency (Poland)	1,2
UMBRELLA	PSE - Polskie Sieci Elektroenergetyczne S.A.	5,3
SALVAGE - Cyber-phySicAl security for Low-VoltAGE grids	Wroclaw University of Technology	—
UPGRID	ENERGA - Operator S.A ATENDE S.A. Politechnika Gdanska Instytut Energetyki	15,6
REAL-SMART	ABB SPZOO, Poland	1,1
IRSG	Elektromontaz-Lublin Sp. z o.o., Lublin Instytut Tele- i Radiotechniczny, Warszawa	1,0

	Politechnika Lodzka,Lodz Transformex Sp. z o.o., Warszawa	
Smart Torun	Grupa Kapitalowa ENERGA	19,4
Demonstration & Deployment	**Company**	**Total budget (Million EUR)**
E3SoHo	Miasto Stołeczne Warszawa MOSTOSTAL WARSZAWA SA POLITECHNIKA WARSZAWSKA	3,6
FINESCE	Telekomunikacja Polska S.A. (Orange. Undetermined location.)	19,3
ICE-WISH	Miasto Stołeczne Warszawa	4,9
SmartRegions	Polish National Energy Conservation Agency	—
VIS NOVA	AGH University of Science and Technology Administrative district of Gorlice Polska Siec Energie Cites. Stowarzyszenie Gmin	2,7
ENERGA LOB	ENERGA Operator SA Instytut Energetyki UNIWERSYTET ZIELONOGORSKI	4,7

Data from Joint Research Centre inventory and public sources.
Budget for all partners.

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[ref_POL8]: The National Fund for Environmental Protection and Water Management, www.nfosigw.gov.pl.

14 Spain

14.1 Landscape of Smart Grids R&D in Spain

The total demand in 2013 was 246.166 GWh, 42% covered by renewable production. Wind generation has reached 21% of the total annual production [ref_ESP1]. In 2020 in Spain the participation of renewable energies in the final energy consumption will be 22.7%, being 42.3% of the electric generation. This estimation fulfils one of the objectives of the 2020 targets [ref_ESP2].

According to [ref_ESP3], it is estimated that Smart Grids in Spain could improve the Spanish Gross Domestic Product by 0.2 – 0.35% (2,300 – 3,800 M€), based among other factors on the development of the power sector, creation of employment, reduction of energy imports, and the increase of country's productivity. Smart Grids will create 40,000 – 50,000 jobs in Spain (20,000 direct and 30,000 indirect jobs), all in high added value activities like manufacturing of communication and electrical equipment, on-site installation and maintenance, and energy management services.

14.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

The initial boost of the Smart Grid in Spain is largely due to the "Plan Contador" ("Smart Meter Plan", which is essentially the roll-out of smart meters at national level. This plan stipulates the progressive replacement of traditional meters with smart meters, and the complete substitution by the end of 2018 of all meters for individual customers with power contracts up to 15 kW (around 28 million smart meters). This mandatory deployment has been seen as an opportunity to develop other concepts of the Smart Grids, like demand side management, smart home technologies, and network automation and advanced supervision among others.

Spain's energy dependence could see a drop of 5.3% (20,800 ktep of primary energy) by 2020 due to the increase of the power system efficiency and the integration of renewable energy sources and electrical vehicles. This has the additional effect of reducing the CO_2 emissions by 3.7% (15 million tons) by 2020.

It is foreseen that the new smart grid applications and efficiencies will generate 1,100 – 1,800 € a year in profits for the power system as a whole from increased supply reliability and quality, more efficient operation and maintenance of the system, greater power performance, optimized use and a longer life of assets, lower energy intensity and a flatter demand curve.

14.3 Industry (main industry actors, where in the value chain)

In Spain, Red Eléctrica de España (REE) is by law the unique Transmission System Operator. Electricity distribution is a regulated activity too, where the main Distribution System Operators are ENDESA, IBERDROLA, GAS NATURAL FENOSA, EDP-HC Energía and VIESGO; there are also around 400 smaller DSOs (less than 100.000 customers). Electricity generation and commercialization (around 135) are liberalized activities in Spain.

The energy sector in Spain is formed by around 350 companies with a turnover of 44 M€, employing approximately 70.000 people, and investing in R&D around 325 M€ (in 2008). More active industries in the smart grid arena are members of FUTURED (Spanish Technology Platform

of Smart Grids): around 70 industrial members, covering all the concepts needed for the implementation of the Smart Grids.

Concerning the technological position in the sector, three Spanish manufacturers (ORMAZABAL, ARTECHE-SAC and INGETEAM) are located within the 10 first companies at European level. First five companies (SCHNEIDER, ALSTOM, ABB, GE and SIEMENS) are not Spanish but have a strong activity in Spain.

14.4 Public research stakeholders

FUTURED (Spanish Technology Platform of Smart Grids) conformed by more than 100 entities, aims at integrating all the stakeholders to impulse the strategies at national level for the consolidation of the Smart Grid in Spain.

In addition to the industrial members, FUTURED is composed by several public organizations, among them CDTI (Centre for the Development of Industrial Technology, of the Ministry of Science and Innovation), CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas, of the Ministry of Economy and Competitiveness), and IDAE (Institute for Energy Diversification and Saving). Around 20 Spanish universities (not all public) also take active part in FUTURED.

The picture of research organizations is completed with 14 R&D centres. Around 700 researchers are working in the field of Smart Grids in Spain (1500 professionals if research inside the industry is considered).

14.5 National R&D strategy

Promotion of the R&D&I on Smart Grids in the near future is implemented through ALINNE, Alliance for the Investigation and Innovation on Energy, a national private-public agreement to respond to the huge challenges of the R&D&i of the energy sector, contribute to the definition of a national strategy to organize public policies and programmes according to the Spanish needs and priorities, and specify the position of Spain at international level [ref_ESP4]. ALINNE activities are aligned with the topic “Secure, clean and sustainable energy” established by the national framework set-up by the *Spanish Strategy for Science and Technology 2013-2020* [ref_ESP5] and the *National Plan for Scientific Research, Development and Technological Innovation* [ref_ESP6], and beyond that with the European “SET Plan” and “Horizon 2020”.

According to FUTURED, in the specific area of Smart Grids the development in Spain should follow three axes [ref_ESP3]:

a) Uses and services, including the following activities:
   - Demand Side Management: demand flexibility management and optimization of the entire power system.
   - Distributed Generation management: maximization of distributed generation (mainly the renewable energy production) connected to the grid.
   - Development of the super-grid: transmission of the extra renewable energy to far regions and reduction of the need for traditional generation as backup.
   - Storage management: as attenuating element for the instantaneous variations between generation and consumption.
   - Electrical vehicle management: as a singular load.

- Power system management: increasing automation and flexibility of the power system.

b) Network architecture:
   - From a radial distribution network to a meshed architecture
   - From a conventional transmission network to a super-grid

c) Key technologies:
   - ICT: interconnection of the diverse components of the power system by means of open architectures and standards, providing real time information.
   - Power electronics: FACTS, HVDC, advanced inverters, etc. with the aim of better controlling the power flows and increasing energy capacity.
   - Storage
   - New components (sensors and materials)

14.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

National priorities are established by the *National Plan for Scientific Research, Development and Technological Innovation 2013-2016* [ref_ESP6]. Its structure responds to the strategic objectives stated by the *Spanish Strategy for Science and Technology 2013-2020* [ref_ESP5]. The Plan is integrated by 4 national programmes divided into 18 sub-programmes developed mainly by means of competitive calls that define the type of participation and funding. In addition, the Plan contains two Strategic Actions for Health and Digital Society and Economy. One of the sub-programmes deals with the secure, clean and sustainable energy, and it is fully aligned with the different European initiatives, specially the SET-Plan (international compromise approved by the European Parliament and the Member States).

Therefore, the energy R&D&i lines are referred to four critical aspects:

a) Active fight against climatic change; reduction of green-house emissions; promotion of renewable energy sources and energy efficiency.
b) Development of the internal energy market as a tool to increase competitiveness and network efficiency.
c) Security of supply.
d) Promotion of social and technological changes towards lower energy consumption.

The scientific and technological priorities for 2013-2016 are:

- Solar energy, wind energy, bioenergy, geothermal energy and marine energy.
- Reduction, capture and storage of CO_2.
- Energy from waste.
- Hydrogen and fuel cells.
- Sustainable nuclear energy.
- Smart Grids.

Regarding the last point, there will be support for the incorporation of technological developments (software and hardware), application of new materials, development of information and communication systems, forecast and optimization systems, power electronics, advanced sensors, and energy efficiency systems.

14.7 Funding bodies and programs

In Spain the development of the Smart Grid needs an estimated investment of 10,200 € over the next 10 years, mainly in smart metering systems, power electronics, advanced applications for network management and operation, network supervision and automation, and energy management systems. This would generate an intrinsic benefit of 2 to 3.5 times the original investment: 19,000 – 36,000 € [ref_ESP3].

According to FUTURED, 10% of the needed investment would be for smart grid technology development and 90% for deployment and demonstration. During the technology development phase, 50% of the investment should be supported by public funding (national and European). Public support must be stronger in the beginning and going down until 2025, from that year new development should be supported by 15 M€/year.

During the period 2009-2013, FUTURED's members obtained 311 M€ of public funding and 68 M€ of credits by means of research projects in national and international competitive calls. Concerning the technological transfer, in the same period, 42 R&D&i projects were carried out with the collaboration of the public sector (providing 85.1 M€) and the private sector (providing 41.6 M€).

Public funding covers the energy R&D path from basic and applied research to pilot and demonstration projects and to facilitating market entry. Before the current recession, public spending on energy R&D has increased year on year, reaching 87 M€ in 2008. As part of the government spending cuts, energy R&D spending then fell by 25%, to 64 M€ in 2011. Out of that total, 30 M€ was spent on nuclear power (47% of the total budget), 26 M€ on renewable energy projects (41%) and 2.5 M€ on energy efficiency (4%). The rest was spent on fossil fuels, energy storage and other areas. Within the renewable energy group, solar energy projects have received the largest part of the budget [ref_ESP7].

The main player in Spain's R&D and innovation policies is the new State Secretariat for Research, Development and Innovation (SEIDI), belonging to the Ministry of Economy and Competitiveness (MINECO), and the Ministry of Industry, Energy and Tourism (MITYC).

R&D is conducted by research institutions, universities, technology centres and private enterprises. The government funds several public research institutions which focus on applied research and pilot and demonstration projects, and these institutions often also receive private-sector funding. Three of the primary institutions are the Centre for Energy, Environment and Technological Research (CIEMAT), the National Renewable Energy Centre (CENER) and the Energy City Foundation (CIUDEN). Most national and international plans involving enterprises are implemented through FECYT Agency (Spanish Foundation for Science and Technology).

As a relevant programme it is mandatory to mention the National Strategic Consortia for Technical Research (CENIT) as one of the main energy-related R&D programmes running under the national framework programme INGENIO 2010. CENIT includes energy research through topics such as design and production technologies; environment, sustainable development and renewable energies; new materials and nanotechnology; aerospace; and sustainable mobility (cars and railways). Between 2006 and 2010, 91 projects received 1,071 M€ in grants, for a total investment of 2,298 M€. In total, over 1,250 companies and over 1,580 research groups have taken part. The budget related to energy was 387 M€.

Since 2014, CIEN Programme (Strategic Programme for National Research Industrial Consortia) has taken over the funding large R&D projects developed by industrial consortia in strategic areas with strong international impact, promoting a public-private cooperation. The Programme requires a relevant subcontracting of R&D activities to research organisations.

Another funding mechanism for industrial companies and research organisations is set by the "National R+D+I Programme oriented to societal challenges" (in Spanish "*Retos-Colaboración*"), which considers "Smart Grids" within its challenge "secure, clean and efficient energy".

Spain has a quasi-federal decentralised political system which is also reflected in its R&D and innovation-related policies. There is no clear division of responsibility between national and regional administrative levels, since nowadays most regions have similar R&D plans and on both administrative levels there coexist a large number of programmes and agencies.

The Basque Country, one of the European regions where Smart Grids are more developed, the Basque Government has developed its own energy strategy (*Energy Strategy for the Basque Country 2020, 3E2020* [ref_ESP8]) and technological plan (Plan for Science, Technology and Innovation*, PCTI Euskadi 2020* [ref_ESP9]) aligned with the European Research and Innovation Smart Specialisation Strategy, RIS3. Energy is a strategic priority and R&D&i in this field are supported by several tools and programmes like ELKARTEK (formerly known as ETORTEK), ETORGAI, GAITEK, HAZITEK. *PCTI Euskadi 2020* foresees a public-private investment (not only in energy R&D&i) of 11,100 M€ during 2014-2020, of which 2,737 M€ will be provided by the Basque Government and 6,609 M€ by the private companies.

14.8 Description of national SET Plan Structure for Smart Grids Research

The SET Plan has a strong influence in the definition of the Spanish strategies for science, technology and innovation. Looking for an efficient coordination and implementation at national level, the SET Plan Working Group, created in 2009, is formed by different national and regional Administrations (among them: Ministry of Economy and Competitiveness, Ministry of Industry and Energy, CDTI, IDAE, CIEMAT), and experts from the industry (among them: REE-ENTSOE, IBERDROLA-EDSO4SG) and the main research organizations in the energy field (TECNALIA among others).

The Ministry of Economy and Competitiveness and the Ministry of Industry and Energy are members (3 people) of the SET Plan Steering Group. There are Spanish experts in all the EII Teams. The Research Centre CIEMAT (dependent of the Ministry of Economy and Competitiveness) is the Spanish representative in the Executive Committee of the EERA, and around 25 Spanish organizations are participating in the different EERA Joint Programmes.

In addition, the aforementioned ALINNE Alliance plays an important role in the definition of the Spanish strategies and alignment with the SET Plan in Spain.

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[ref_ESP2]: Instituto para la Diversificación y Ahorro de la Energía (IDAE), "Plan de Energías Renovables (PER) 2011-2020"

[ref_ESP3]: FUTURED and Boston Consulting Group, "Development of Smart Grids in Spain"

[ref_ESP4]: Alianza por la investigación y la innovación energéticas (ALINNE), "Análisis del potencial de desarrollo de las tecnologías energéticas en España"

[ref_ESP5]: Ministerio de Economía y Competitividad, “Estrategia Española de Ciencia y Tecnología y de Innovación 2013-2020”

[ref_ESP6]: Ministerio de Economía y Competitividad, “Plan Estatal de Investigación Científica, Técnica y de Innovación 2013-2016”

[ref_ESP7]: Energy Research Knowledge Centre, European Commission

[ref_ESP8]: Ente Vasco de la Energía (EVE) y Gobierno Vasco, “Estrategia Energética de Euskadi 2020”

[ref_ESP9]: Gobierno Vasco, “PCTI Euskadi 2020. Una estrategia de especialización inteligente”

Table 14-1: Supported Smart Grids R&D and Innovation projects in Spain

R&D project	Company	Total budget (Million EUR)
GAD project (*Demand Active Management*)	Coordinator: IBERDROLA Funding: CDTI (Ministry of Science and Innovation)	23
DENISE project (*Smart, Secure and Efficient Energy Distribution*)	Coordinator: ENDESA Funding: CDTI (Ministry of Science and Innovation)	30
VERDE Project	Coordinator: SEAT Technical Center Funding: CDTI (Ministry of Economy and Competitiveness)	34
MUGIELEC Project	Coordinator: ZIV Funding: ETORGAI (Basque Government)	7.5
CRISALIDA Project	Coordinator: ORMAZABAL Funding: CDTI	23
PRICE project (*Joint project of intelligent networks in the Henares Corridor*)	Coordinator: IBERDROLA y GAS NATURAL FENOSA Funding: Ministry of Economy and Competitiveness	28.3
OSIRIS project (*Optimization of the smart supervision of the distribution network*) [see ANNEX for details]	Coordinator: UNION FENOSA DISTRIBUCIÓN Funding: Ministry of Economy and Competitiveness	6.6
FUTURE GRIDS 2020 project (*New Technological Offer for 2020 Smart Grids*) [see ANNEX for details]	Coordinator: TECNALIA Funding: Basque Government (ETORTEK Programme)	0.6
HVDC-LINK project (*HVDC links for marine energy evacuation*)	Coordinator: TECNALIA Funding: Basque Government (ETORTEK Programme)	0.7

R&D project	Company	Total budget (Million EUR)
SECURE GRID project	Coordinator: ZIV Funding: Basque Government (HAZITEK Programme)	2
MICROGRID-STORE project	Coordinator: IBERDROLA Funding: Basque Government (HAZITEK Programme)	1
Demonstration & Deployment project	**Company**	**Total budget (Million EUR)**
STAR project (*Network Remote Management and Automation Systems*)	IBERDROLA	--
BIDELEK SAREAK project	IBERDROLA	60
SMART CITY project	ENDESA	31
BIDELEK SAREAK 2 project	IBERDROLA	30

15 Turkey

15.1 Landscape of Smart Grids R&D in Turkey

In the renewable environment, in February 2015, the Ministry of Energy and Natural Resources issued a new national renewable energy action plan which aims to increase the country's renewable energy generation capacity to 61 GW by 2023 (34 GW in the form of hydro, 20 GW in the form of wind, 5 GW in the form of solar generation, 1 GW in the form of geothermal, and 1 GW in the form of biomass). In 2023, it is aimed to have 30% of the total installed capacity from the renewable energy resources. Implementing regulations were adopted to set up a wind-power forecasting center and on water usage rights agreements. Private sector investment in renewable energy, particularly in wind and unlicensed solar, is growing fast [ref_TR1].

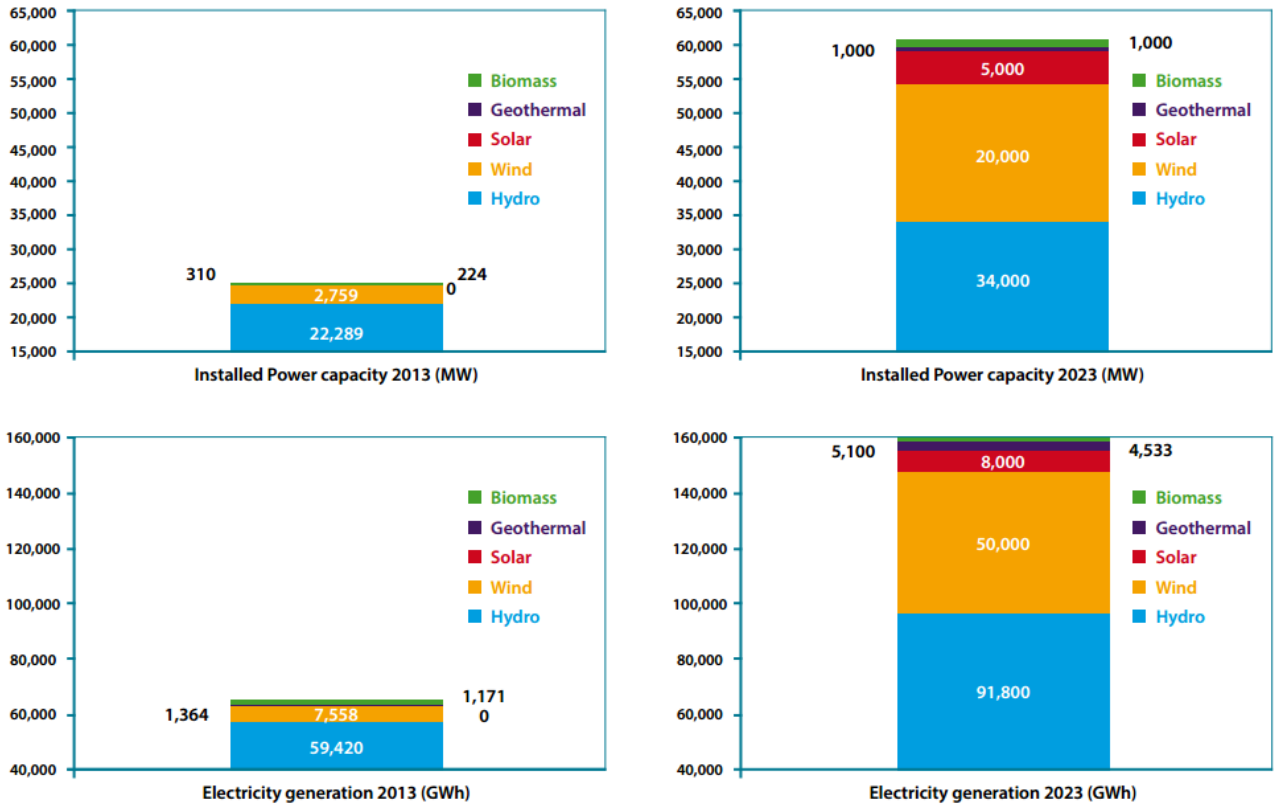

Figure 15-1: Electricity generation and installed capacity from renewable sources: 2013 data and 2023 forecast

15.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

In the smart grid environment, the Ministry of Energy and Natural Resources has recently prepared the "strategy plan 2015-2019" report which includes some strategies related to smart grid that are going to be applied by 2019 [ref_TR2]. They are mentioned under the different aims regarding the main objective: Energy security of supply.

- *Aim:* Reliability. *Strategy:* Investments on technological developments like Smart Grids and storage are going to be taken into account in terms of projections of the yearly electric demand.

- *Aim:* Effective Demand Management. *Strategy:* Demand management is going to be utilized at the customer side by implementing pilot projects like “smart meter-control structure of a home consumption”.
- *Aim:* Efficient Energy in Turkey. *Strategy:* Remote metering systems and smart grid applications are going to be disseminated gradually.

Additionally, Turkish Electricity Transmission Company has recently prepared the strategy plan report, which includes some investment plans and targets aiming to improve the transmission system. Below figure indicates some of targets related to renewable energy installed capacity and smart grid [ref_TR2] and [ref_TR3].

Performance Indicators	Current	2015	2016	2017	2018	2019
Hydro-power installed capacity (MW)	22289	25000	-	27700	-	32000
Wind power installed capacity (MW)	2759	5600	-	9500	-	10000
Geothermal power installed capacity (MW)	311	360	-	420	-	700
Solar power installed capacity (MW)	-	300	-	1800	-	3000
Biomass power installed capacity (MW)	237	380	-	540	-	700
New generation relays having numerical technology (each)	11000	1000	1000	1000	1000	--
Remote transformer monitoring system (each)	250	50	50	50	50	50
New transformer installation in order to response the power demand increases and operate the transmission system in a reliable way. (each)	45	45	40	35	32	30
Number of Power Quality Devices to be installed (each)	450	150	150	150	150	--

Figure 15-2:Targets related to Renewable Energy installed capacity and Smart Grids ([Ref_TR2] and [Ref_TR3]).

15.3 Industry (main industry actors, where in the value chain)

In the industry scope of Smart Grids in Turkey, there are two main topics including the R&D actions conducted by the distribution system operators (DSO) that shape the smart grid concept in Turkey, and the R&D actions and investments which are transacted between the DSOs and International energy companies that are focused on the needs of DSO.

Considering the first topic, one of the main electrical equipment manufacturer in Turkey named Ulusoy Electric, developed a system named as “Transformer Control System (TCS)” which makes any asset in the LV side controllable, manageable and monitorable remotely [ref_TR4]. The main functions of TCS are listed as:

- Fault tracking
- Remote control
- Reporting

- Messaging and having teleconference between actors in LV distribution
- Service Team tracking and guidance for fastest maintenance of faults
- Alarm distinction by location with geographical information system (GIS) support

Considering the second topic, the international companies in Turkey, The Siemens Company is one of the biggest supplier for energy related markets and one of the main actors of energy sector. Additionally, the Deloitte Company also one of the main actors in energy sector in Turkey, specialized on analysing, consulting and specialized software supports for actors of electricity market and energy sector including both governmental and private institutions.

15.4 Public research stakeholders

The Science and Technological Research Council of Turkey (TUBITAK) is the main research organization in Turkey. The organization is managing public research funds and having the biggest research infrastructure in country with 20 different subject research Institutes. One of them is Energy Institute which is mostly dealing with Smart Grid issue and carrying out national and international projects.

Another public body is Energy Market Regulatory Association (EMRA) of Turkey which is arranging and controlling the smart grid R&D projects for 21 different DSO companies serving in Turkey.

The Universities are also realizing Smart Grid R&D research by the way of some projects and some M.S. and Ph.D. Thesis.

15.5 National R&D strategy

National R&D strategies are stated in the technical specification document of “2020 Smart Grid Roadmap”, prepared by EMRA [ref_TR5]. In this document, smart grid roadmap for Distribution Companies are going to be released considering situation, feasibility, and efficiency of current distribution networks and their adaptation into Smart Grids. Basically, the following goals are going to be in the scope of the document.

- Development of a strategy and roadmap specific to Turkish Distribution Networks from the best smart grid strategy examples in the world including the scheduling
- Determination of the benefits of integration and connectivity between IT (Information Technology) and OT (Operational Technology) for all stakeholders
- Preparation of a guideline for the cost benefit analysis of the smart gird strategy that will be developed regarding Distribution Companies, EMRA, Stakeholders, and the whole country and then carrying out the analysis.
- Recommendation on the network upgrading that enables the establishment of smart grid systems considering the relevant energy and communication regulatory. In this direction, it is aimed to enhance the vision of smart girds.

15.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

Priorities regarding the R&D in Smart Grids and renewable energy generations are developing national RES power plants consisting of PV, wind power and hydropower by utilizing at least 80%

domestic resources and technology. In this concept there are 3 projects started and in progress which are listed as:

- MILGES (National PV Power Plant): aimed to research and develop national PV power plant technologies.
- MILHES (National Hydro Power Plant): aimed to research and develop national hydro power plant technologies.
- MILRES (National Wind Power Plant): aimed to research and develop national wind power plant technologies.

Considering the RES targets of Turkey by 2023, it is planned to deploy 3 GWp solar PV power plant in city Konya, Karapınar region [rev_TR6].

Concerning the 20 GW in the form of wind, 5 GW in the form of solar generation targets for 2023, partial tenders are conducted to evaluate the offers from generator companies:

- PV power plant projects having 600MW total capacity were approved in 2014
- Wind power plant projects having 5.5GW total capacity were approved in 2011

EMRA supported project named "The definition of Smart Grids' strategy and vision of Turkey for 2023" aims to evaluate possible smart gird applications and develop a smart grid strategy that users will actively participate in. In order to reach a cost-benefit smart networks, a case analysis determining the maturity and sufficiency level of candidate systems to be used will be performed considering various needs of DSOs.

One of DSO in Turkey named Akdeniz EDAŞ, starts an R&D project by December 2015 for 1 year which is focused on developing an engineering algorithm for facility planning to be used on the connection points between the transmission system and the distribution system. The algorithm is planned to be developed to be used on the mentioned connection points which are the substations and medium voltage lines for investment planning and by optimizing the algorithm, the service quality and the benefit-cost are aimed to be increased. In the scope of the project, a pilot region will be selected and by combining the topographic, atmospheric and statistical data of the DSO in that region; their effects to the distribution system will be analysed and an algorithm which estimates the possible power outages and failures will be developed. And by using the algorithm, the service quality and the customer satisfaction are planned to be maximized. In addition, by evaluating the benefit costs, dissemination of the algorithm will be determined [ref_TR7].

Moreover, USTDA - U.S. Trade and Development Agency, supports Smart Grid Technology Pilot projects in Turkey. For Instance, another DSO in Turkey, Kayseri ve Civarı Elektrik Türk AŞ (KCETAŞ) has secured a grant from the USTDA to deploy a US-supplied software system for real-time data infrastructure. The Data Integration and the Automated Demand Side Management Pilot Project (ADSM) at KCETAŞ will provide a data infrastructure to enable better understanding of the availability and demand for electricity. The project will deploy California-based operations software company OSIsoft's PI system, an industry standard in enterprise infrastructure for management of real-time data and events [ref_TR8].

Furthermore, The Energy Market Regulatory Authority (EMRA) in Turkey, has a support program for R&D projects about distribution systems of electric and natural gas. In the scope of this program, there are two approved projects related with smart grid first of which is named as “Smart Energy Aware System” and second of which is named as “Design of Protection/Control System for Closed Ring Operation of Medium Voltage Grid”. The aim of first project is developing a system for measuring and managing the weather conditions, cost of electricity and generator-consumer behaviours by utilizing smart buildings, micro grids. And the aim of second project is, designing a

system for closed ring operation of medium voltage grid that maintains the adaptation of renewable energy resources (RES), distributed generations (DERs), electrical vehicles and energy storage to the grid, and supports bi-directional energy flow, increases the reliability, power quality, sustainability and efficiency of electricity distribution system [ref_TR9].

15.7 Funding bodies and programs

According to the results of R&D Activities Survey 2014 conducted by TurkStat, R&D Expenditures (GERD) in Turkey increased by 18.8% compared to the previous year and reached to 17.6 Billion TRY in 2014. The share of GERD in GDP was 1.01%, total number of full time equivalent (FTE) R&D personnel was 115,444 and FTE researchers was 89,657 in 2014.

There is no specific funding program for Smart Grid R&D in Turkey. The main organization is TUBITAK for funding all scientific and technological researches and development projects and programs. TUBITAK supplies Academic Research funds in National and International programs. Other supporting mechanisms of TUBITAK are Business/Industry funds and the Public Institution funds. TUBITAK Total R&D budget was 1.7 Billion TRY in 2014.

In addition, Energy Market Regulatory Association of Turkey – EMRA's arranging and controlling budget of R&D projects was 100 Million TRY between 2011-2016 years.

15.8 Description of national SET Plan Structure for Smart Grids Research

In the "strategy plan 2015-2019" report, there are some strategies related to Smart Grids, which have already stated in Section 15.5. Additionally, there are specific targets regarding the installed capacity of renewable energy, shown in Table 15.1.

Table 15-1: Supported Smart Grids R&D and Innovation Projects in Turkey

Project /Target	Theme	Description	Funding Type
MILGES Project	National PV Power Plant	Research and develop national PV power plant technologies.	Public
MILHES Project	National Hydro Power Plant	Research and develop national hydro power plant technologies.	Public
MILRES Project	National Wind Power Plant	Research and develop national wind power plant technologies.	Public
Energy Market Regulatory Authority (EMRA) R&D Project	Multi-inputs smart distribution automation system	Distribution network management (voltage regulation, load flow, grid losses, reliability) for distributed generation.	Public
Energy Market Regulatory Authority (EMRA) R&D Project	Smart grid node	Design of an interoperable control device (one device for all control units) for substations.	Public
Energy Market Regulatory Authority (EMRA) R&D Project	Cyber security standardization for Smart Grids	Determination of standards and roadmap for reaching a cyber security maturity model.	Public
Energy Market Regulatory Authority	Support program for R&D projects about distribution	"Smart Energy Aware System" and "Design of Protection/Control	Public

Project /Target	Theme	Description	Funding Type
(EMRA) R&D Project	systems of electric and natural gas	System for Closed Ring Operation of Medium Voltage Grid"	
Akdeniz EDAŞ DSO R&D Project	Developing an engineering algorithm for facility planning to be used between transmission and distribution systems	The service quality and the benefit-cost are aimed to be increased	Private
USTDA & KCETAŞ DSO R&D Project	Support for Smart Grid Technology Pilot projects in Turkey	Deploy a software system for real-time data infrastructure	Private
Hydro Power Installed Capacity Target	Reaching the installed capacity targets by 2017 and 2019.	2017: 27.7 GW 2019: 32 GW	Public & Private
Wind Power Installed Capacity Target	Reaching the installed capacity targets by 2017 and 2019.	2017: 9.5 GW 2019: 10 GW	Public & Private
Solar Power Installed Capacity Target	Reaching the installed capacity targets by 2017 and 2019.	2017: 1.8 GW 2019: 3 GW	Public & Private
Geothermal Installed Capacity Target	Reaching the installed capacity targets by 2017 and 2019.	2017: 420 MW 2019: 700 MW	Public & Private
Biomass Installed Capacity Target	Reaching the installed capacity targets by 2017 and 2019.	2017: 540 MW 2019: 700 MW	Public & Private

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16 United Kingdom

16.1 Landscape of Smart Grids R&D in UK

The electricity grid in the UK is faced with many significant challenges resulting from a changing generation mix, penetration of distributed generation, an ageing infrastructure, increased uncertainty, and the anticipated electrification of heat and transport. At the same time it is attracting billions of pounds of investment, and so provides a major opportunity for the adoption of smart technologies and solutions to deliver the required change. It is thus possible to deliver the desired decarbonisation and increased reliability in a cost-effective fashion including increased consumer participation.

16.2 Evolution towards Smart Grids (main figures, strategy, plans and key challenges)

Analysis shows that the UK has been particularly supportive of major Smart Grids projects, and is especially recognized for investments in demonstration and deployment projects. For example over €150m of Smart Grids projects were reportedly started in the UK in 2013/14 [ref_UK1]. This environment is strongly facilitated by the regulatory environment in the UK.

A number of incentive schemes have been established over the years by the regulator (Ofgem) in order to stimulate innovation within the networks sector. A number of schemes have operated under previous price control arrangements and have stimulated major project activity. The Low Carbon Networks Fund (LCNF) provided up to £500 million over the review period's five years. The Innovation Funding Incentive (IFI) provided funding for projects primarily focused on technical development of the networks that can deliver value (e.g. financial, quality of supply, environmental, safety) to end consumers. Registered Power Zones provided a framework in which specific areas of the network could be defined where innovative solutions could be more readily applied.

The current distribution price control period (from April 2015) runs for eight years and reflects Ofgem's RIIO (Revenue = Incentives + Innovation + Outputs) model for network regulation. This provides a strong incentive to step up and meet the challenges of supporting the transition to a low carbon UK energy sector [ref_UK2]. In particular, it is aimed at promoting a step change in the way network operators think about the future and plan investments. It encourages a focus on efficient costing, using Smart Grids tools and techniques, whilst providing good service to new and existing customers. The companies are further incentivised to manage their carbon footprint and will have to report on how their actions have contributed to broader environmental objectives.

The UK grid is already subject to significant change. While a 4% drop in electricity supply was in evidence in the year to 2014, the penetration of renewable sources continues to increase year on year. Of the 339TWh of total electricity available for supply in the UK in 2014, 5.8TWh was from hydro power, 36.1TWh from wind and solar, and 19.6TWh from other renewables. This accounts for over 19% of electricity generated in the UK, with gas, coal, and nuclear representing 29%, 28% and 17% respectively. Electricity generation from renewables increased by 21% from the year before, with solar PV more than doubling. In addition to electricity generation, a further four million tonnes of oil equivalent or primary energy use was sourced from renewables. Figure 16-1 illustrates the position in 2016. As of 2017, the proportion of electricity supplied from renewables is largely unchanged from 2014, but the share of electricity supplied from coal fell from 21% to 9% due to two major plant closures in March 2016 (which, in April 2017, resulted in the first "coal-free"

day of generation in the UK since coal generation was introduced in 1882); the share of electricity supplied from gas rose from 29% to 42% as an alternative to coal fired generation [ref_UK9].

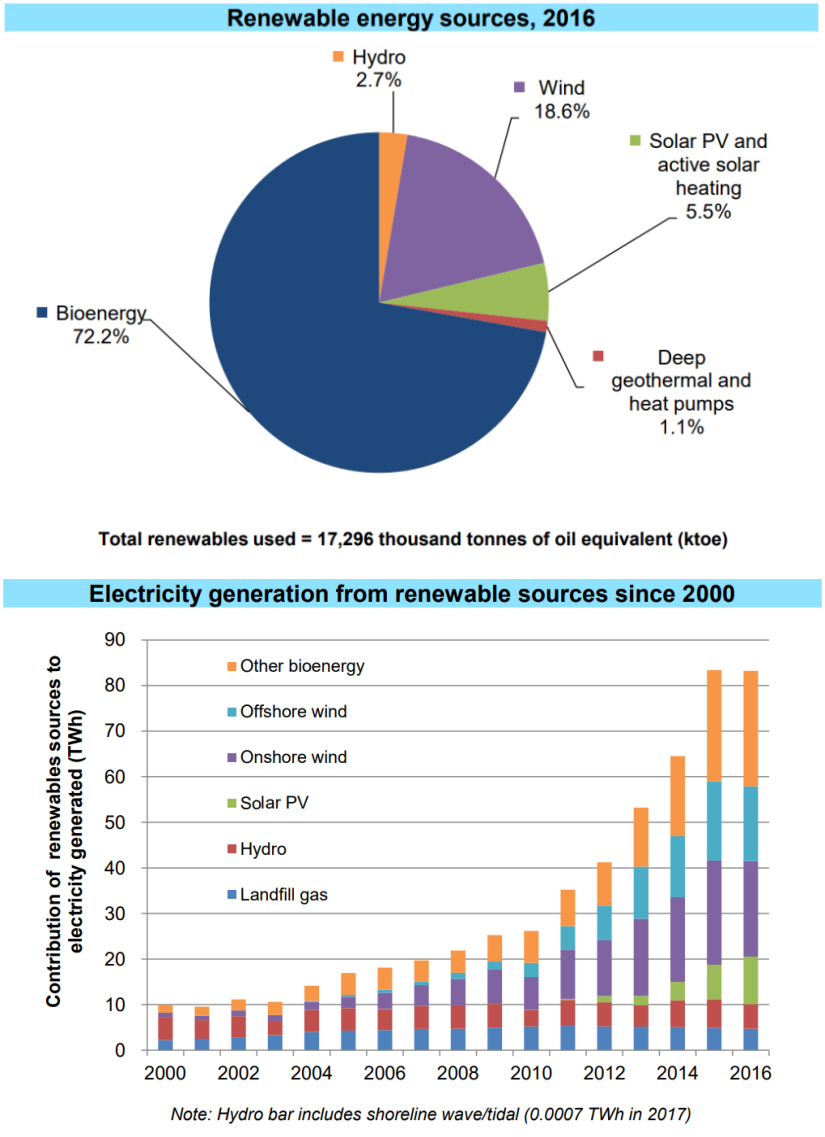

Figure 16-1: Illustrations of the changing generation mix in the UK [ref_UK3] [ref_UK9]

The volume of distributed generation continues to increase. The UK Feed in Tariff scheme (FiTs), has supported over 5.6GW of eligible small-scale low carbon electricity technologies generation (approximately double the amount compared with 2014). The majority of this growth has been through solar PV. In terms of smart meters, 8.6M domestic smart meters were installed to September 2017, representing a small proportion of the planned 53M.

Recent policy announcements are changing the landscape. In June 2015 the UK government announced that it was ending subsidies for onshore wind projects. This would see an end to the Renewables Obligation to new onshore wind from 1st April 2016 (a year earlier than planned). A further announcement identified a resetting of UK energy policy that will see the closure of all coal-fired power plants by 2025. The capacity gap created by this will be largely filled with new gas and nuclear plants rather than cleaner alternatives. Furthermore the further regression of FITS income levels is impacting community level and domestic sector renewable deployment.

16.3 Industry (main industry actors, where in the value chain)

The network operators, with the support of the innovation incentive schemes of the regulator, have been active in many large smart grid projects. There are a total of seven DNOs, three regional transmission companies, and a single transmission system operator, present in the UK. These organisations operate in a regulated market, with operating and investment plans that are agreed in advance with the regulator Ofgem. A separate competitive offshore transmission regulatory regime has been established to stimulate the investment and innovation required of the new offshore networks.

Innovation strategies are required of the network operators by Ofgem, and the publication of these provides a valuable steer as to the priority areas for the companies. Each distribution network operator has its own priorities, influenced by diverse factors such as prior investment strategies, geography of license area, age of assets, etc, but a number of common themes come out strongly such as:

- Demand-side response – using generation, load and storage
- Enabling new, fast-acting types of ancillary services to address the reduction in system inertia. In particular, National Grid is developing new frequency response and reserve products to enable greater flexibility and levels of participation from potential resources [ref_UK14].
- Active network management techniques, operation of meshed and reconfigurable networks (at MV and LV) and distribution system state estimation
- The use of converters to provide “soft open” points at MV and LV
- Voltage control and support through the use of distributed generation, tap-changer and power electronics devices
- Novel protection and automation solutions and interoperability
- Condition monitoring and asset management
- More extensive measurement and employment of communications to provide enhanced information relating to network state and spare capacity
- Smart EV charging and use of EVs as storage media
- Use of smart meters and smart metering data

A number of systems challenges face the UK grid as renewable generation and demand changes continue to grow, and the National Grid System Operability Framework provides a regular update on the key challenges [ref_UK13]: frequency stability associated with reduced system inertia, harmonic content associated with the increased penetration of power electronic loads and generation interfaces, fault levels and their variability, the need for improved reactive power management. The IET report “Transforming the Electricity System” [UK4] provides an interesting insight into the systems implications of the smart grid transition and the readiness of structures and stakeholders to support this change.

The UK Smart Grid Forum (UKSGF) [ref_UK5] has recognized the contributions that can be made to this change from across the supply chain, and indeed are critical to it. While it is recognised that the UK electricity network companies have traditionally relied upon the large international manufacturers for purchasing equipment, they argue that innovation is often pioneered from the SME community. Consequently, concerns are expressed that more attention needs to be given to factors that restrict this contribution such as the treatment of Intellectual Property, procurement processes, contracts, and delays in programmes. By addressing these, an environment can be created to stimulate involvement from across the supply chain that will support the development of appropriate standards and the commercialization of results in home and export markets.

In addition to the utility companies, regulator and government departments, a number of other key industry organisations or groups are actively engaging. These include:

- Smart Grid Forum – formed by Ofgem and DECC to support the transition of the UK energy system. A portal has been created to offer a hub for the sharing of learning and information relevant to smart grid innovators and stakeholders.
- Energy Innovation Centre (EIC) – established to stimulate the engagement of DNOs with new providers of innovative solutions. Established as a not for profit company.
- Smart Grid GB, now SmarterUK – seeks to establish engagement across the UK economy to drive the uptake of smart solutions that will deliver the infrastructure for a sustainable low carbon transition.
- Energy Networks Association (ENA) – offers a collective voice for the transmission and distribution network operators for gas and electricity in the UK and Ireland. Their Energy Networks Futures Group provides a forum for the companies to collectively contribute to smart grid developments. In 2017, the ENA has established the "Electricity Network Innovation Strategy" to steer innovation activities to best accommodate the future requirements of the whole energy system [ref_UK10]. In particular, this has established priority areas for future innovations projects, including: improved network visibility and controllability; establishing value from smart meter deployments; facilitating the transition from DNO to DSO and the associated new market mechanisms; developing better power system planning tools; improved digitisation; improved cybersecurity; new business models for renewable generation; and enabling customer choice.
- Regional efforts are also underway across the UK, including through the Scottish Smart Grid Action Group, which has published the Scottish Smart Grid Sector Strategy.
- Local Energy Scotland – supports the delivery of community and locally owned renewable energy projects in support of Scottish Government targets[25].
- Private innovation providers and consultants have similarly been heavily engaged such EA Technology.

Attempts have been made to quantify the potential benefit to be had across the UK value chain. Analysis led by Smart Grid GB (now SmarterUK) indicates that 57% of the economic value is likely to be in the manufacturing part of the supply chain, while 27% is anticipated in the ICT sector. This is shown in Figure 16-2.

[25] The Scottish Government aims to reach a target of 500 megawatts of community and locally owned renewable energy by 2020.

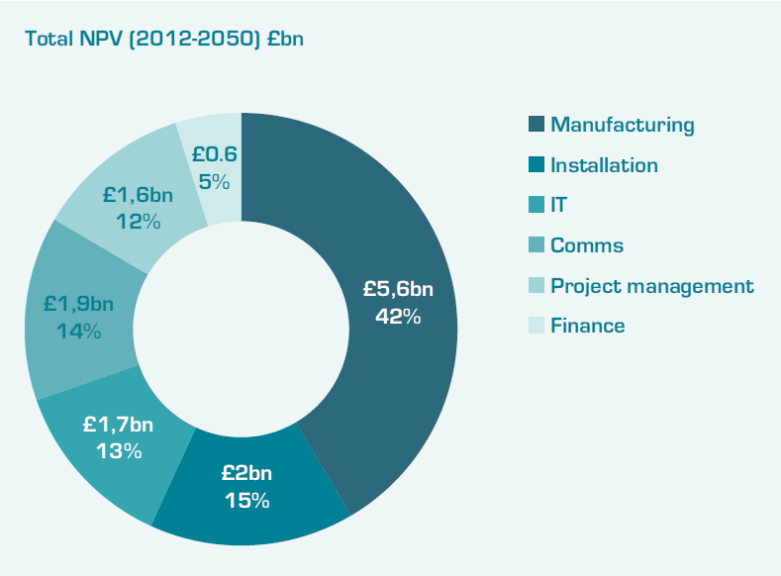

Figure 16-2: Total UK economic impact by value chain components [ref_UK6]

16.4 Public research stakeholders

The UK has a thriving community of public stakeholders active in Smart Grids research that are actively involved in a broad range of projects spanning applied industry-led projects, international multinational and bilateral collaborations, and medium/long term national programmes. This includes:

- Individual University research and funding.
- The Research Councils UK, including the Engineering and Physical Sciences Research Council (EPSRC), provide support for academic research.
- Energy Technologies Institute (ETI), a public-private partnership between the UK government and member energy and engineering companies.
- Regional pooling or collaboration such as Scotland's Energy Technology Partnership (ETP), Midlands Energy Group, etc.
- UK Energy Systems Catapult, a new public-private initiative whose mission is to bring the academic, industry and government stakeholders together to support the development of new technology based products and services while adopting a whole systems approach.
- UKERC, UK Energy Research Centre, which conducts research into sustainable future energy systems, acts as a focal point for UK energy research, and a gateway between the UK and the international energy research communities.
- The Power Networks Demonstration Centre (PNDC): a centre for collaborative smart grid research and development incorporating an HV and LV test facility that accelerates the adoption of smart grid technologies.

16.5 National R&D strategy

The objectives of operating the grid securely and efficiently while accommodating a multitude of new smart grid technologies and participants present challenges for the current UK grid institutional landscape. To this end, a joint stakeholder working group (Power Network Joint Vision, PSJV) proposes the introduction of a 'system architect' entity which assumes a comprehensive role of defining the system architecture choices necessary to deliver the government's energy

policy in a flexible and resilient manner, while ensuring technological innovation fits within commercial and regulatory frameworks. This model of a system architect is illustrated in Figure 16-3. Research constitutes an important part in defining the future grid requirements for the system architect to effectively approach its integration role.

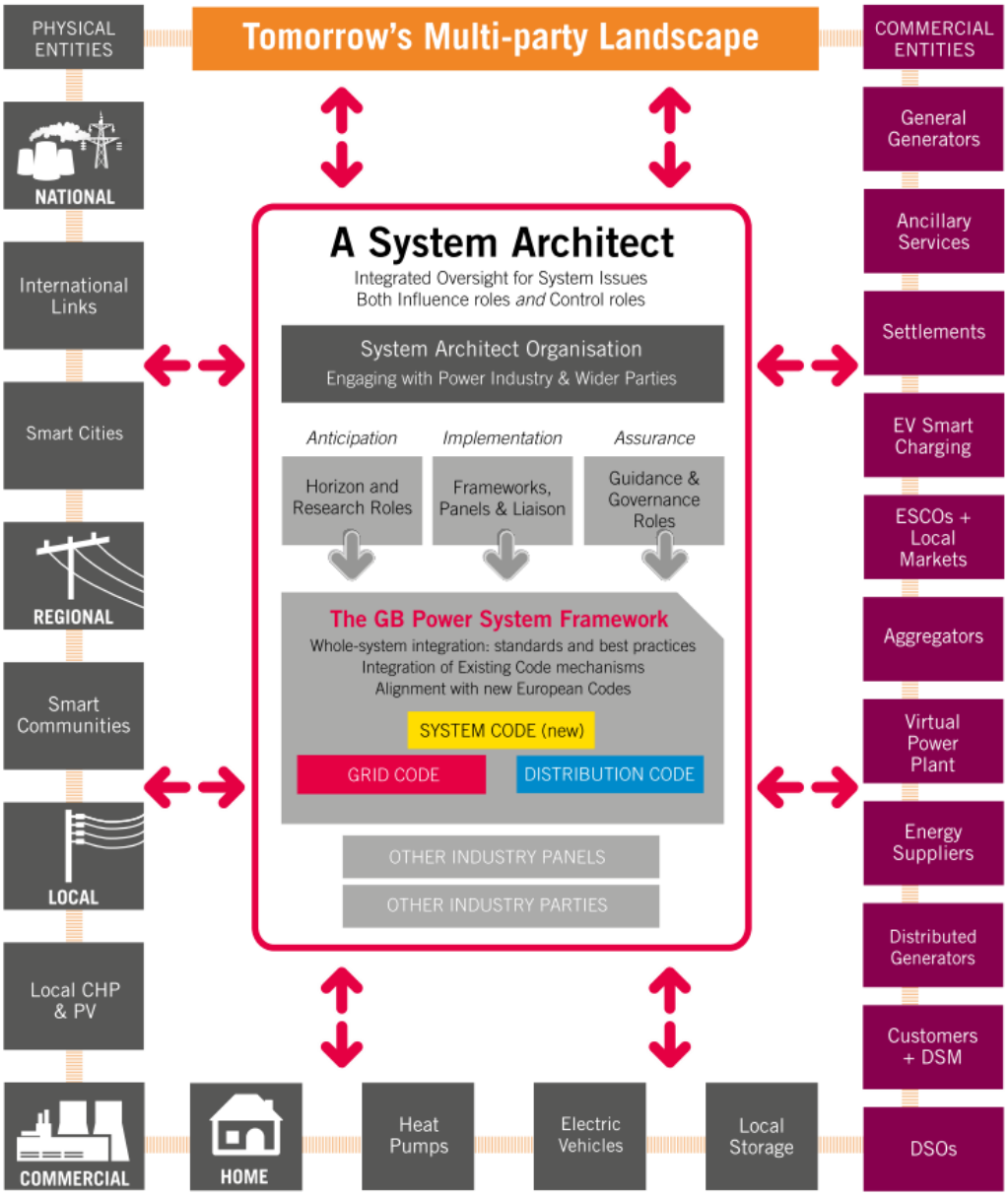

Figure 16-3: Integrated model of a UK system architect [ref_UK7]

The national strategy for R&D is more widely reflected in the efforts of the many public programmes and agencies described earlier.

The Energy Systems Catapult and the Institution of Engineering and Technology (IET) have established the Future Power System Architecture (FPSA) programme to anticipate new developments and assess their significance, in order to understand the requirements of the future power system and how these can be met. “FPSA1”, the first stage of the project, identified 35 new or significantly modified functions required to meet the 2030 power system objectives. “FPSA2”, the second stage of the project, has investigated these functions in greater detail, including the associated requirements and challenges [ref_UK15]. In particular, recommendations are given for future research, development, and demonstration activities, including:

- Engaging a wider group of stakeholders
- Market designs for promoting policy objectives
- Monitoring customer behaviour; aggregation of black start and cold start capabilities
- Improved modelling and forecasting to address increasing uncertainties in future energy systems
- Cost-effectively maximising network capacity
- Improved monitoring and metering
- Significant investment in IT, communications, control, and cybersecurity

16.6 National priorities (examples of programmes, centres, large projects and their thematic focus)

The Smart Grid Forum [ref_UK4] has set out the challenges for the electricity system in the UK with a particular focus on the electricity distribution network operators (DNOs). It articulates the benefits and opportunities for consumers, businesses, network operators and the wider energy industry, both day-to-day and in the transition to a low carbon economy, i.e.:

- **Reduced costs to consumers through savings on network costs** – Smart Grids are estimated to reduce the cost of additional reinforcement associated with electrification of heat, DG penetration and transport by 20-30%.
- **Supporting economic growth and jobs** with faster and cheaper connections to the network and an estimated potential £13bn of Gross Value Added (GVA), £5bn of potential exports to 2050; and 9,000 jobs to 2030 associated with Smart Grids.
- **Increased energy security and integration of low carbon technologies** through greater monitoring and control of the network, enabling network companies to anticipate and identify problems more quickly and manage supply and demand at a local level.

Priorities for ongoing effort have been highlighted: the provision of strategic direction on the future of the electricity system and value of Smart Grids; ensure regulatory and commercial frameworks enable and support the deployment of smart technologies and new commercial practices; and ensure that consumers understand and are convinced by the benefits of installing smart meters and shifting demand. These should further maximise the economic opportunities for jobs and growth through continued investment in research and development.

Furthermore, in July 2017 the UK Government and Ofgem announced a significant drive to ensure that energy systems are consumer-focused i.e. taking advantage of the opportunities arising from the efficient adoption of new technologies, to create new business pathways and minimise consumer energy bills [ref_UK12]. In particular, this applies to taking advantage of energy storage technologies – providing consumers with more control and flexibility, and providing system operators with new types of resources for smart ancillary services.

Major demonstration and deployment projects continue to be supported through the RIIO model. Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) projects are being commissioned with clear focus on outputs and learning. For example, Table 16-1 lists recent projects selected for funding through the NIC.

Table 16-1 - Supported Smart Grids R&D and Innovation projects in the UK

R&D project	Company	Total budget
Enhanced Frequency Control Capability (EFCC)	National Grid Electricity Transmission	£8.5m (€9.6m)[26]
Celsius	Electricity North West	£4.7m (€5.3m)
FITNESS	SP Energy Networks	£8.3m (€9.4m)
ANGLE-DC	SP Energy Networks	£13.1m (€14.8m)
Offgrid Substation Environmental for the Acceleration of Innovative Technologies (OSEAIT)	National Grid Electricity Transmission	£12.0m (€13.6m)
EPSRC Centre for Doctoral Training in Smart Grids	EPSRC, University of Strathclyde, Imperial College London, Rolls Royce, ABB, SP Energy Networks, SSE, UKPN, Northern Powergrid, S&C Electric	£4.4m (€4.98m)
Demonstration & Deployment Project	**Company**	**Total budget (Million EUR)**
Core Programmes (Asset Management, Communication and Systems Integration, Network and Demand-Side Management, Power Electronics and Distributed Energy, Protection and Control, Sensors and Measurement)	Power Networks Demonstration Centre, University of Strathclyde	N/A
Wide-Area Instrumentation of Power Networks using Existing Infrastructure	University of Strathclyde, Bellrock Technology Limited NPL Management Limited Synaptec Ltd EPSRC	~£413k [€168k 11/12/2017]
Low-Cost Distributed Multi-Parameter Sensing for Energy Networks	InnovateUK Catalyst EPSRC	~£148k [€468k 11/12/2017]

The Low Carbon Networks & Innovation (LCNI) conference provides an annual opportunity for the sharing of key outcomes and learning from major industry projects in the UK.

A number of academic projects and initiatives are funded as part of the Research Councils UK (RCUK) Energy Programme. The programme aims to position the UK to meet its energy and

[26] Using exchange rate as of 11/12/2017.

environmental targets and policy goals through world-class research and training, with support to the value of £625M. It is led by the Engineering and Physical Sciences Research Council (EPSRC), and the following components are of relevance to smart grid:

- The EPSRC hub for energy networks research, HubNet. The associated UK Smart Grid Research Symposium offers an annual event for sharing academic research with industry stakeholders.
- EPSRC Grand Challenges: major national consortium projects including Autonomic Power Systems, Top and Tail Transformation, Energy Storage for Low Carbon Grids.
- Centres for Doctoral Training: two national centres of excellence for training doctoral students have been established for power networks. One is realised through a partnership between University of Strathclyde and Imperial College, and the other is based at the University of Manchester.

Relationship of major EFCC UK R&D programme to ELECTRA and the Web-of-Cells concept

The Enhanced Frequency Control Capability (EFCC) innovation project, led by National Grid Electricity Transmission, is very closely aligned with some of the R&D work within ELECTRA and particularly with the objective of achieving real-time decentralised frequency control during major system disturbances in networks with diminishing inertia. Figure 16-4 provides an overview of the EFCC solution. For the purposes of validating EFCC, the GB grid has been modelled as divided into multiple regions (analogous to cells within ELECTRA)[27]. Local measurements from Phasor Measurement Units are aggregated within each region, and shared with other regions for event detection. A backup event detection method based only on local measurements is also possible, but is subject to additional delays. If an event is detected, resources can be activated within approximately 500 ms, and this response is coordinated across all regions to minimise angular changes in the system. The EFCC approach has been validated using real-time simulation and power hardware-in-the-loop testing.

[27] The choice and size of these regions is somewhat arbitrary, but has been designed such that each bus within a region should be relatively “tightly-coupled” in terms of power system angle changes during major disturbances.

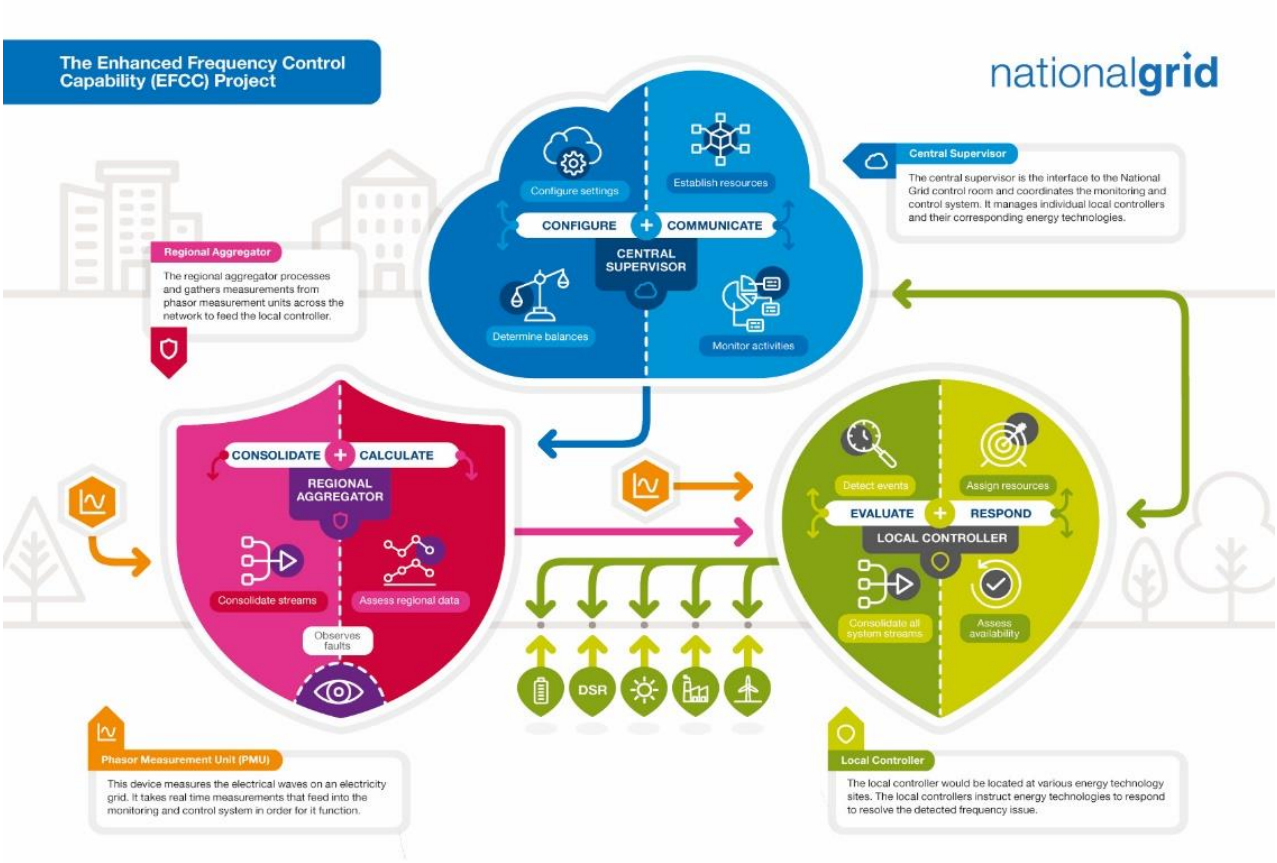

Figure 16-4: Overview of EFCC technical solution [ref_UK11]

16.7 Funding bodies and programs

According to the JRC report “Smart Grid Projects in Europe – Lessons Learned and Current Developments”, the UK has attained a leading position in terms of levels of investment in smart grid research and demonstration projects. Some of the schemes follow:

- Department for Business, Energy & Industrial Strategy (BEIS) (formally Department of Energy and Climate Change (DECC)) Energy Entrepreneurs Fund - £10M scheme offering a call-based funding competition with particular emphasis on SMEs
- Ofgem NIA – supporting relatively small industry projects focused on technical, commercial or operational innovation, with a value of around £26M per year
- Ofgem NIC – supporting larger projects aimed at trialling new technology of operating/commercial arrangements in the real environment, with up to £68M per annum (example projects listed in the table above)
- Ofgem Innovation rollout mechanism for the support of rolling out proven innovations
- InnovateUK Energy Catalyst – continually open funding mechanism for collaborative projects
- InnovateUK Smart Awards – for high growth potential pre-start, early stage, micro and SME
- InnovateUK innovation competitions
- Regional supports, such as Scottish smart grid project funding
- Interface standard innovation vouchers: A Scottish Funding Council scheme supporting SME and academic collaboration to help the companies expand and offer solutions that are not commercially available
- UK Energy Systems Catapult – provides collaboration and energy systems innovation support to SMEs, energy industry companies, research institutes, and government.

16.8 Description of National SET Plan Structure for Smart Grids Research

The UK Government's Department for Business, Energy & Industrial Strategy (BEIS) (formally Department of Energy and Climate Change (DECC)) has been actively involved in the efforts to reinvigorate the SET Plan, and remains committed to the objectives of productive effort. For example, the SET Plan Steering Group's Bureau currently is currently chaired by the UK. And efforts to identify and pursue opportunities to significantly increase joint actions and collaborations between Member States are further supported by a Member States' Joint Actions Working Group (JAWG) which is also chaired by the UK. The UK participates in the smart grid initiative under the ERA-Net Co-Fund that has been established between national programmes and Horizon 2020, as well as a number under other themes. More widely, UK organisations are in place to benefit from at least €77m of the Horizon 2020 Energy Work Programme for 2015, representing around 15% of the budget. Together with the aforementioned national programmes, initiatives, and strategy papers, this demonstrates a strong commitment to delivering across the SET plan priorities.

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17 Europe as a whole

The traditional electricity grid is undergoing significant changes and it is evolving in order to cope up with the constantly growing technological demands. The necessity to reduce the CO2 emissions and the need to accommodate an increasing number of Renewable Energy Sources (RES) implies that an effective energy management should take place. Therefore, the grid should be controlled and monitored through advanced ICT tools so as to facilitate the so-called digitalization of energy. Apart from accommodating the energy from RES in the most effective way, the modern smart grid will be required to facilitate load shifting, in order to avoid load peaks. All the above imply that there is a vast field of research in order to realize the future smart grid.

The last years there has been an increasing trend in smart grid research in terms of demonstration and deployment activities as well as research and development projects. The Energy Security, Distribution and Markets Unit of the Joint Research Centre (JRC) has recently developed an updated database (2017) on Smart Grid projects that are ongoing or that have been realized in Europe [1]. The database now includes 950 projects with a total investment of around 5 billion euros. The database focuses on the 28 EU Member States (MS) as well as Switzerland and Norway. It should be noted that other countries appear as well, provided that they have a collaboration project with one of the 28 MS, Norway or Switzerland. The following graph gives an overview of the results, as presented in [1].

Figure 17-1: Smart Grid projects overview [1]

As it is obvious, Smart Grids attract the interest of the scientific community with 2900 organizations from 36 countries participating in smart grid projects and a total of 800 implementation sites used for their realization. It is also noteworthy that the number of projects has increased a lot with respect to the previous available database (2014), which included 459 projects. The following graphs show the distribution of projects and investments in time.

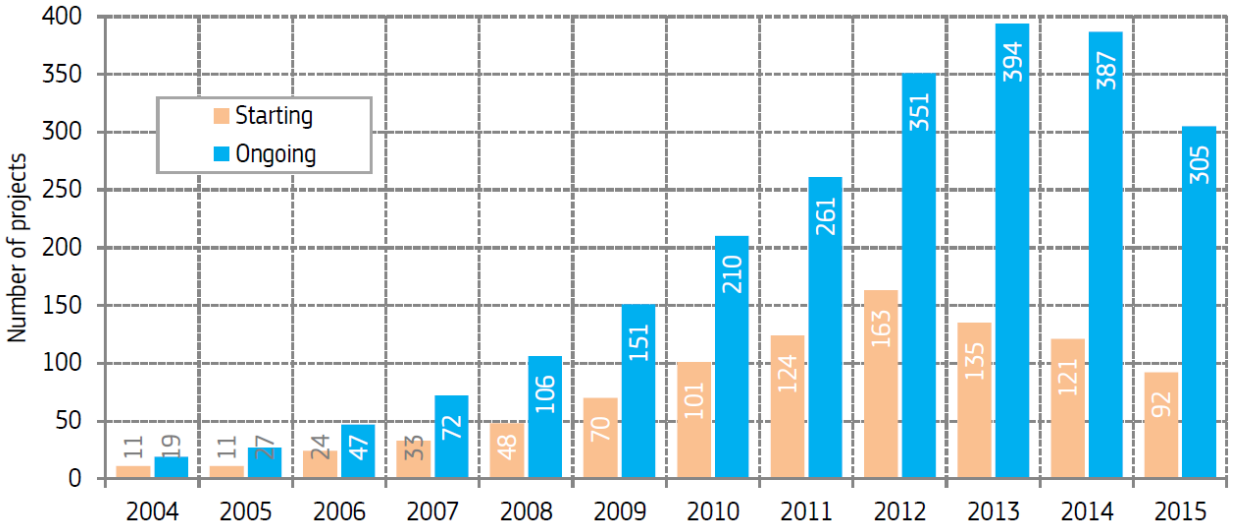


Figure 17-2:Time distribution of projects [1]

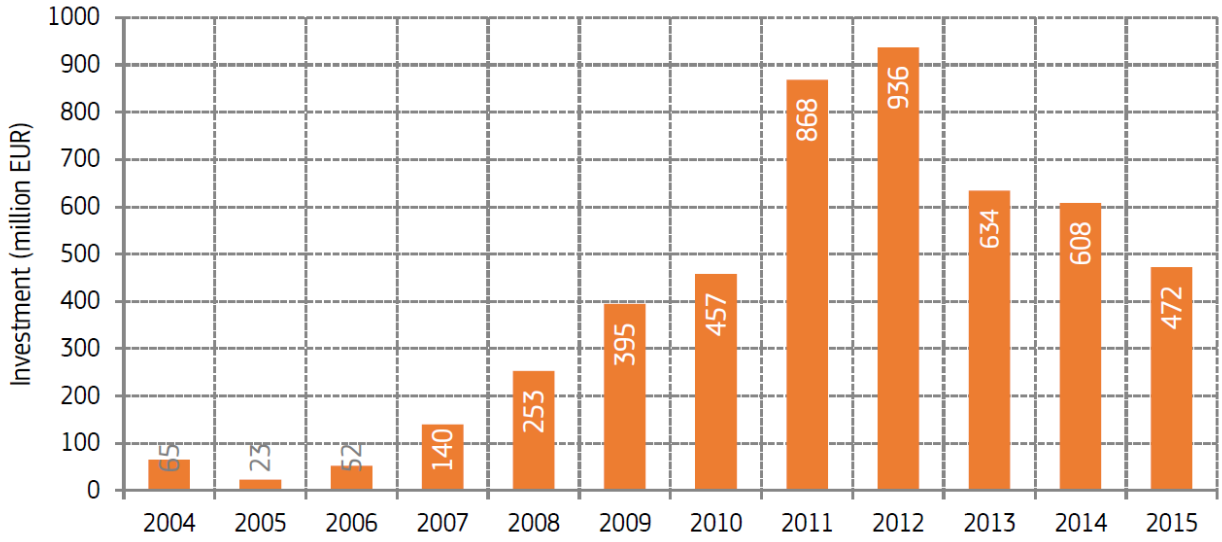


Figure 17-3: Time distribution of total investment [1]

As it can be observed, the projects that are launched every year are in the order of 100 or more. However, there is great variation among countries with respect to the number of projects that are realized.

The following graphs show the situation of number of projects and investments per country.

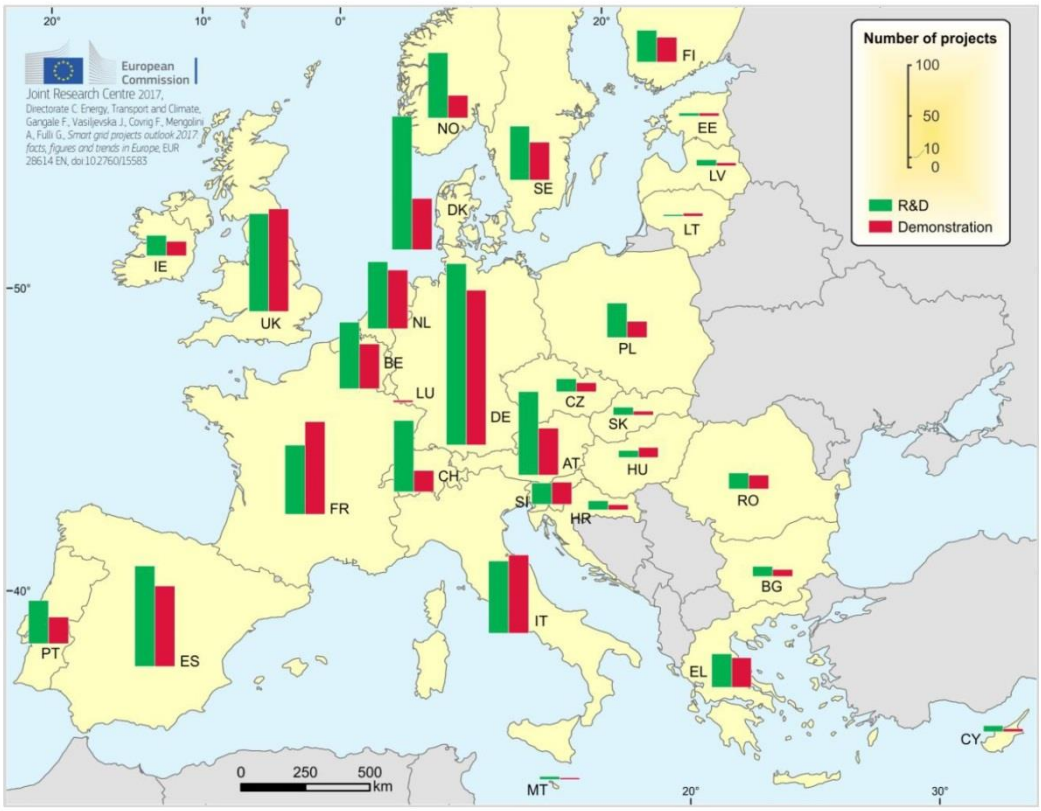


Figure 17-4: Number of projects in the EU [1]

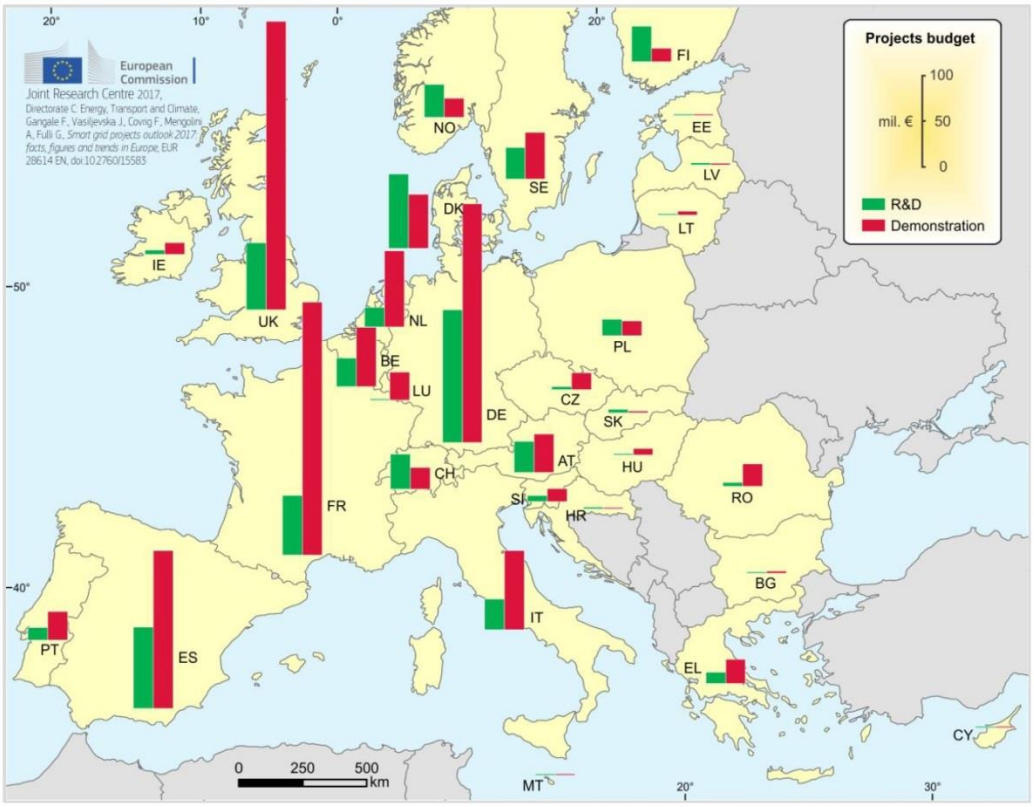
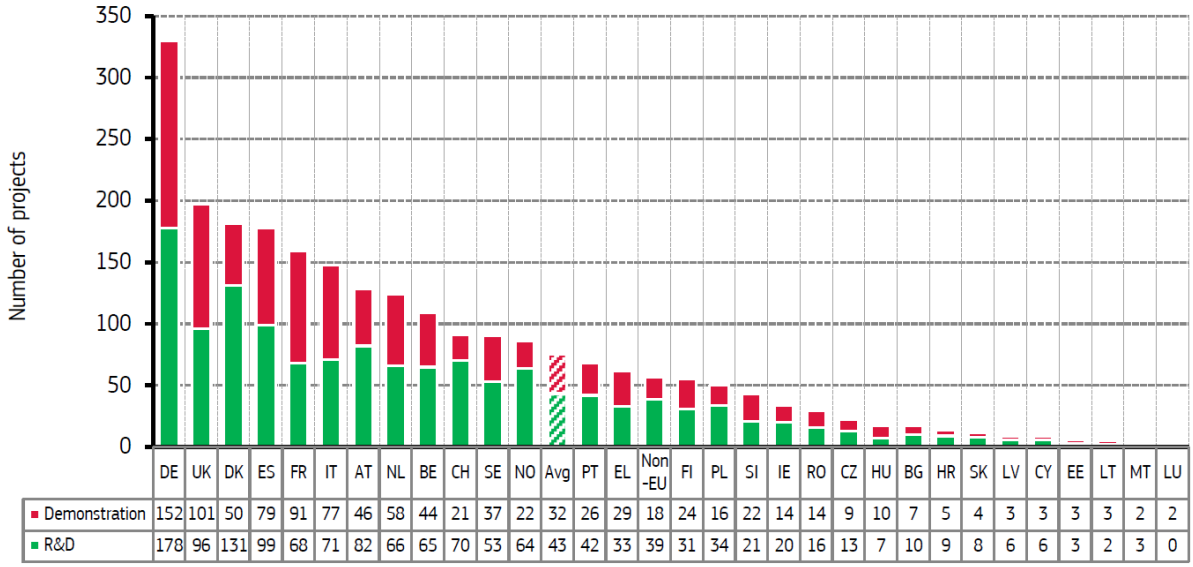


Figure 17-5: Investments in the EU [1]

As it can be observed, R & D projects are more numerous than demonstration projects in most countries, with the exceptions of France, Italy, Luxembourg and the United Kingdom. Looking at investments we can observe that the majority of countries show a higher level of investment in

demonstration activities, except for Denmark, Finland, Norway and Switzerland. Figure 17-6 shows the exact number of projects per country.



	DE	UK	DK	ES	FR	IT	AT	NL	BE	CH	SE	NO	Avg	PT	EL	Non-EU	FI	PL	SI	IE	RO	CZ	HU	BG	HR	SK	LV	CY	EE	LT	MT	LU
Demonstration	152	101	50	79	91	77	46	58	44	21	37	22	32	26	29	18	24	16	22	14	14	9	10	7	5	4	3	3	3	3	2	2
R&D	178	96	131	99	68	71	82	66	65	70	53	64	43	42	33	39	31	34	21	20	16	13	7	10	9	8	6	6	3	2	3	0

Figure 17-6: Number of projects per country [1]

There are 10 Member States, along with Switzerland and Norway, which are over the EU average, with Germany, the United Kingdom, Denmark and Spain being the countries with the highest number of initiatives. This finding implies that organizations in these countries are very active, taking the decision to invest in a large number of initiatives within their country of establishment as well as in other Member States. It is noteworthy that some countries, like Germany, Denmark and the United Kingdom all have a very high number of projects and a high share of national projects. This can be explained by the fact that the same countries are indeed known for the favorable national or regulatory environment they have created for the development of Smart Grids. In the United Kingdom for example, the interaction between the national regulatory authority (Ofgem) and the DSOs has generated a drive and funding for innovation that lies at the heart of the smart grid developments in the United Kingdom.

As it has been aforementioned, the decision to invest and the level of investment is influenced by a combination of different factors and country-specific circumstances. Comparing Member States with different characteristics — e.g. size, population and electricity consumption — would not be fair and it could be misleading. Countries with very different population sizes for example, can face very different challenges when it comes to ensuring the reliability and efficiency of power system operations. Just to give an indication of the influence of such country-specific circumstances, Figure 17-7 and Figure 17-8 present the situation when population and electricity consumption are taken into account.

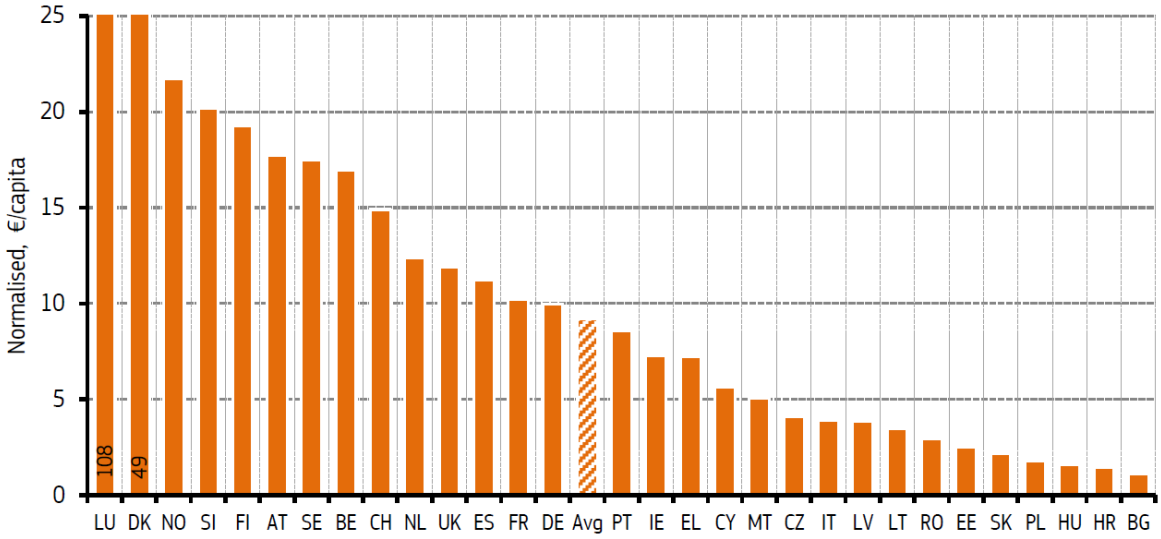


Figure 17-7: Investment normalized per capita [1]

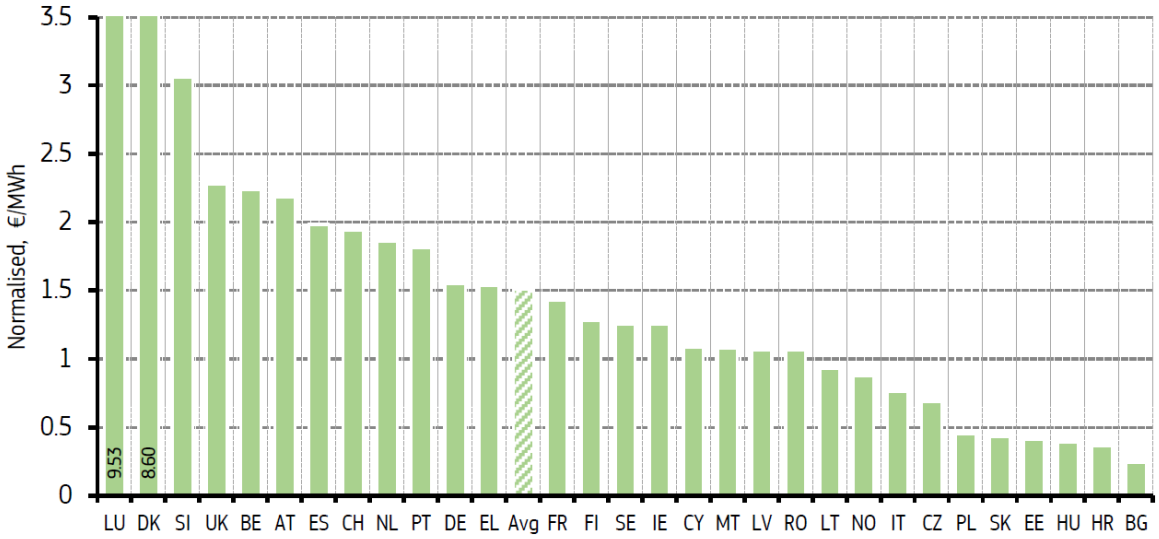


Figure 17-8: Investment normalized per electricity consumption [1]

The above figures verify the importance of different factors and highlight their effect on the total numbers with respect to the smart grid projects and the investments by country. The graphs presented in this chapter give an overview of the current situation in Europe regarding Smart Grid projects and investments. It is noticeable that different countries experience different trends and that the total budget invested can excessively vary in-between EU member states. Other information on smart grid projects, like how big a project is, how many participants it involves and the main topics of interest are aspects that are worth examining since they describe the current trends in the field and they can vary from country to country.

Reference:

[1] F. Gangale, J. Vasiljevska, C. F. Covrig, A. Mengolini and G. Fulli, “Smart Grid Projects Outlook 2017 – Facts, figures and trends in Europe,” European Commission. Joint Research Centre, 2017.

18 MISSION INNOVATION and the Innovation Challenge on Smart Grids (IC#1)

18.1 The Initiative: "*Accelerating the Clean Energy Revolution*"

Mission Innovation (MI) is a global initiative of 22 countries and the European Union to dramatically accelerate global clean energy innovation. It was announced on November 30th, 2015, as world leaders came together in Paris to undertake ambitious efforts to combat climate change.

As part of the initiative, **participating countries have committed to seek to double their governments' clean energy Research and Development (R&D) investments over five years**, (compared to a baseline established on R & D expenditure incurred in 2013) while encouraging greater levels of private sector investment in transformative clean energy technologies. These additional resources will dramatically accelerate the availability of the advanced technologies that will define a future global energy mix that is clean, affordable and reliable.

Importance is given by the Initiative to *Private Sector and Business Leadership* and participating countries commit to work closely with the private sector which increases its investment in the earlier-stage clean energy companies that emerge from government research and development programs.

In June 2016 the first plenary meeting of Mission Innovation took place in San Francisco to define the general framework of the collaborations and the involvement of the various participating Countries. Starting from the Research priorities highlighted by the different nations according to their energy strategies, the main technological challenges were agreed upon which future additional R & D financing could converge. In particular, in November 2016 seven Innovation Challenges were agreed and approved, on which the different nations expressed their commitment to participate, with roles that vary, depending on their interests, from coordination (Leader/co-leader) to active participation in Challenge activities up to the simple position of observer.

Mission Innovation is then organized in **seven Innovation Challenges (IC**), which represent the main technological sectors on which research and development investments are concentrated, with objectives to which the acceding States intend to strive:

1. Smart Grids
2. Off-Grid Access to Electricity
3. Carbon Capture
4. Sustainable Biofuels,

5. Converting Sunlight
6. Clean Energy Materials
7. Affordable Heating and Cooling of Buildings.

The Initiative *Organization* foresees high-level leadership provided by member governments Ministers with responsibility for clean energy innovation. The MI Steering Committee, comprised of member government representatives, provides strategic guidance to foster implementation of the Enabling Framework, while core administrative functions are carried out by the MI Secretariat.

Moreover, three *MI Sub-Groups* carry out specific tasks: *Information Sharing* ; *Analysis and Joint Research* and *Business and Investor Engagement* http://mission-innovation.net

18.2 The Innovation Challenge on Smart Grids (IC#1)

The transformation of the energy system taking place in many countries across the world is featuring the surge of renewable energy's share and the need of a dramatic reduction in greenhouse gas emissions, higher energy and economic efficiency, fostering a wider independence from fossil fuels. Renewable energy sources (RES) integration and advanced technological solutions related to power systems (e.g., storage, HVDC connections, smart meters etc.) are among the key solutions needed to reduce greenhouse gas emissions and tackle climate change. Research and development in the field of Smart Grids is needed to develop technology solutions in order to optimally balance supply and demand in this context of a high-penetration of renewable energy sources (characterized by an intermittent nature).

The Smart Grids Innovation Challenge (IC#1) will support this transition from today's power grid to tomorrow's grid, powered by affordable, reliable, decentralised, renewable electricity systems, able to balance supply and demand at any time, even when primary energy sources are not available.

18.2.1 IC#1 Goal and approach

IC#1 goal is to enable future Smart Grids powered by affordable, reliable and decentralized renewable electricity systems. In particular, IC#1 aims to accelerate the development and demonstration of smart grid technologies in a variety of grid applications, including demonstrating the robust, efficient and reliable operation of regional grids and distribution grids as well as micro grids in diverse geographic conditions, in order to facilitate the cost effective uptake of renewable energy.

The goal in 2030 is to be able to develop technological solutions to host up to 100% of large-scale renewable generation and to implement solutions that facilitate the achievement of the climate protection objectives that the States have committed to adhering to Mission Innovation.

The Innovation Challenge operates using existing knowledge from its members to identify opportunities for Research, Development & Demonstration activities to support the goal of substantially increase government investment in the field of Smart Grids and build a collaboration network of institutes, businesses and investors to expand its influence

18.2.2 IC#1 Participation

IC#1 is co-led by China, India and Italy and involves 19 participating countries (out of the 22 in Mission Innovation) and the European Union.

Participant Countries include: Australia, Brazil, Canada, *China*, **Denmark, Finland, France, Germany,** *India*, Indonesia, ***Italy*****,** Mexico, **Norway**, Saudi Arabia, South Korea, **Sweden, The Netherlands, United Kingdom**, United States of America and the **European Union**-

Figure 18-1: **IC#1 participating Countries:**
the European Union is involved together with 9 European Countries

18.2.3 IC#1 Activities and main achievements

Work under IC#1 is guided by the following general objectives:

1) Building an improved and shared understanding of what is needed to address IC#1 and how to define measurable targets and track progress towards them;
2) Identifying key gaps and opportunities not sufficiently addressed by current activities;
3) Promoting opportunities for researchers, innovators and investors in order to build support and excitement around IC#1 and boost engagement;
4) Strengthening and expanding collaboration between key partners, including governments, researchers, innovators, and private sector stakeholders.

A work Plan has been defined, including the activities foreseen from short to longer term (November 2020). In particular, the main yearly foreseen activities are: two IC#1 Workshops, Annual Country Reports, Annual version of MI IC#1 General Report, Disseminate progress and organize events of MI Smart Grids Innovation.

Among the actions and achievements in IC#1 so far, the following can be mentioned:

- **Questionnaire Q1 "*Smart Grids Challenges Priorities***" implemented with the aim to identify the most important Smart Grids R&D priorities in the national strategies of the IC#1 members-The questionnaire replies allowed to identify TOP 10 Smart Grids R&D priorities shown in the following figure:

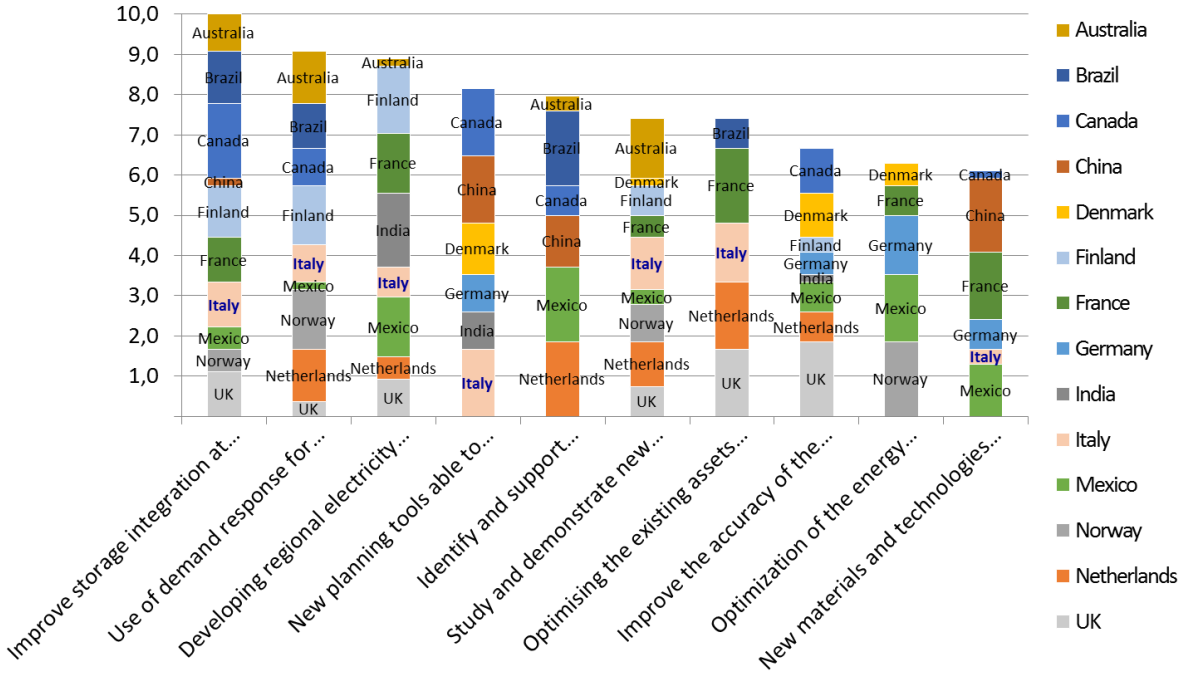


Figure 18-2: TOP 10 Smart Grids R&D priorities identified within IC#1

- Identification of **six R&D tasks to be launched by early 2018**. In particular, the following themes were considered and the relevant Programs of Work (POW) are under definition: *Storage Integration, Demand Response, Flexibility Options, Regional Electricity Highways, New Grids Architectures and Power Electronic-*

- **Questionnaire Q2** implemented with the aim to identify the most important RD&D priorities in the National strategies of IC#1-member Countries within smart grid field. The proposed challenges covered various aspects of the Smart Grids field and were clustered in the following four research areas: Operation and control, ICT & Cyber security, Devices and Technology, Distributed Energy Resources, storages & deployment issues.

- releasing of the **IC#1 Country Report 2017** - with the contribution of 14 countries– an official document which collects information about strategies, trends, projects and ongoing actions in the field of Smart Grids worldwide

- definition of a set of **Key Performance Indicators (KPIs**) to monitor the progress of the Challenge activities

- official commitment in IC#1 through the signature by all IC#1 members, co-leaders together with Chinese, Indian and Italian Government representatives of two important documents: the **"Beijing Consensus**" and the "**New Delhi declaration**" (see IC#1 Workshops)

- **R&D Cooperation Agreements** signed among participating Countries

- launching of **Founding Opportunities** for joint IC#1 projects (Australia, India, Norway and Mexico)

- design and creation of a **Service Platform** to support IC#1 activities.

18.2.4 IC#1 Workshops

Two deep-dive Workshops have been held, bringing together a group of international experts, policy makers and innovators in the field of Smart Grids. Each Workshop consisted in a two-day closed door meeting, w and a public event-

The **First IC#1 Deep Dive Workshop** (4th-6th June 2017), held in Beijing as a side event of CEM8 & MI-2. where IC#1 was officially launched-

Moreover, the "*Beijing Consensus*" was completed. This Consensus document states the objectives of MI IC#1, identifies the selected four sub-challenges on Smart Grids, confirms the near term deliverables and promises to strengthen collaborative network among all member countries-It was shared and signed by the IC#1 participants. During the public event on June 6th , the Consensus was signed by the Deputy Ministers of the co-leading countries (China, India and Italy), witnessing the strong commitment on this initiative by all the participating countries.

MI Smart Grids
1st WS Beijing 2017

And the **Second IC#1 Deep Dive Workshop** (16th-18th November 2017), where the IC#1 Country Report 2017 was officially released and distributed.

Moreover, the "*New Delhi Declaration*" was completed. This document attests the commitment of IC#1 members to continue the cooperation activities launched in Beijing and to explore new opportunities for collaboration with the International Agencies and involving the private sector in order to contribute to the Mission Innovation objectives-It was shared and signed by the IC#1 participants and co-leaders and officially released during the public event on November 18th-

MI Smart Grids
2nd WS New Delhi 2017

Work is going on and the **3rd IC#1 deep-dive workshop** is being organized in Malmo (Sweden) and Copenhagen (Denmark) to be held on 20-22 May 2018, as a side event of CEM9 and MI-3.

18.2.5 IC#1, ELECTRA and International Cooperation

IC#1 activities are fully aligned with the International Cooperation strategically carried out in ELECTRA, making more possible their implementation and ELECTRA strongly supported the activity of this Challenge.

The nine European Countries participating to MI IC#1 are all actively contributing to the Challenge activities, providing the European view on Smart Grids under technical, business and policy points of view.

A space for IC#1 repository and working area has been provided in ELECTRA web site. In particular, at present, a temporary website/repository can be found at http://www.electrairp.eu, with public documents and a members-only restricted area with MI IC#1 documents.

IC#1 recognizes also the importance of interacting with and leveraging the work of other ongoing initiatives in this area such as the International Energy Agency (IEA) and a number of its Technology Collaboration Programmes (TCPs), IRENA (International Renewable Energy Agency) and other frameworks at European and national level including: ETIP SNET and EERA JP SG.

Close interactions have already been established with the IEA TCP ISGAN and also with other IEA TCPs such as DSM (Demand Side Management), HEV (Hybrid and Electric Vehicles), PVPS (Photovoltaic Power Systems).

19 National R&D Projects and ELECTRA objectives and activities

An important step has been made to understand what is happening in R&D area in the different countries - with special reference to medium-long term Smart Grids research - and how ELECTRA can interact with programs at National level.

In particular, with reference to the R&D projects relevant to each country the different partners were asked to highlight those which, according to their considerations, are in line with the ELECTRA Research activities (with a consequent TRL in the range 2 – 4/5) so to meet the network needs for a 2035 implementation.

For this purpose and to standardize the different contributions, a template was defined where the different R&D National projects could be described with a special focus on highlighting the relevant topics for future exchanges/interactions with ELECTRA and the added value expected by cooperation at European level. The relationships with the SET Plan Integrated Roadmap topics were also emphasized.

All the participating countries gave their contribution evaluating, for the different projects, the actual value given to the identified focus taking into consideration aspects like the phase of development and the duration of the R&D projects.

The interest was on recently-completed and ongoing R&D projects and projects on different topics have been presented.

A total of 61 R&D projects were presented by the different participating countries. The detailed contributions are reported in **ANNEX I**.

Here, in order to summarize and highlight the main fields covered by the reported research projects we propose the following graph where the relation between the SET Plan themes and the projects is underlined, representing the percentage of occurrences of each theme accounted in the different projects over the whole number of projects. In particular, from the analysis of the projects presented by the different partners, it turned out that some projects cover a few SET-Plan themes others cover a broad range of themes.

In the following the Strategic Energy Technology (SET) Plan CHALLENGES and THEMES are listed.

Challenge 1: Active consumer at the centre of the energy system

- Theme 1: Engaging consumers through better understanding, information and market transformation
- Theme 2: Activating consumers through innovative technologies, products and services

Challenge 2: Demand focus – increasing energy efficiency across the energy system

- Theme 3: Increasing energy efficiency in buildings
- Theme 4: Increasing energy efficiency in heating and cooling sector
- Theme 5: Increasing energy efficiency in industry and services

Challenge 3: System optimisation

- Theme 6: Modernizing the European electricity grid and establishing synergies between the various energy networks

- Theme 7: Unlocking the potential of energy storage and conversion of electricity to other energy carriers
- Theme 8: Providing the energy system with flexibility, demand response, security and cost-effectiveness
- Theme 9:Development and demonstration of holistic system optimisation at local/urban level (Smart Cities and Communities)

Challenge 4: Secure, cost-effective, clean and competitive supply

- Theme 10: Accelerating the development of Renewable electricity and heating/cooling technologies
- Theme 11:Enabling carbon capture, CO2 utilisation and storage technologies and increased efficiency of the fossil fuel-based power sector and energy intensive industry
- Theme 12: Supporting safe and efficient operation of nuclear systems, development of innovative reactor concepts and sustainable solutions for the management of fissile materials and radioactive waste
- Theme 13: Developing sustainable biofuels, fuel cells and hydrogen and alternative fuels for the European transport fuel mix

The graph reported in **Figure 19-1** wants to **highlight how much each SET-Plan theme is covered by the presented projects** - expressing the occurrence of each theme in percentage over the total number of projects, resulting useful also for comparisons with other projects analysis (e.g.-Theme Energy System Flexibility in M48: once counted the occurrences of the in the different projects description, the number is divided by the total number of projects (61), resulting in 0.62: this means that 62% of the R&D projects relates to SET-Plan theme Flexibility).

In particular a comparison between the results relevant to the R&D Projects presented in the first half of the ELECTRA Projects (M24) and the results relevant to the R&D Projects presented at the end of the ELECTRA Projects (M48).

The graph shows an alignment of the themes addressed by National R&D projects in the Smart Grids field with the European strategic lines for the Energy sector.

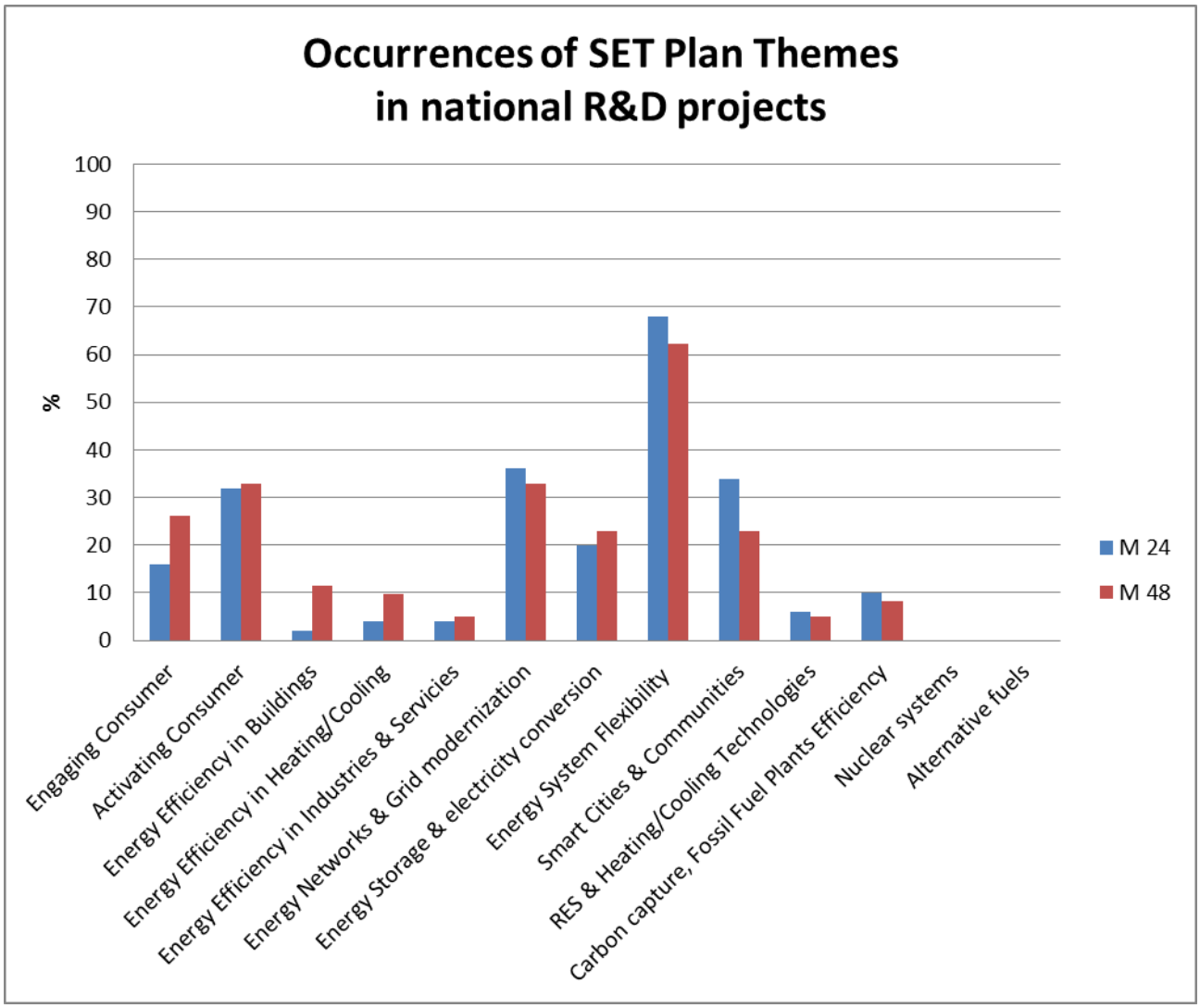


Figure 19-1 - National R&D projects: percentage of occurrence of SET-Plan Themes (M24 & M48 R&D projects comparison)

TOP 3 SET-Plan Themes addressed by National R&D Smart Grids projects

As we can see from the above graph, National R&D Smart Grids projects are mainly focused on the themes relevant to the following SET-Plan Themes:

- Energy system flexibility (challenge 3- theme 8)
  "*Providing the Energy system with flexibility, demand response, security and cost-effectiveness"*
- Energy networks and grid modernization (challenge 3-theme 6)
  "Modernizing the European electricity grid and establishing synergies between the various energy networks"
- Activating consumer (challenge 1- theme 2)
  "Activating consumers through innovative technologies, products and services"

The trend of the R&D projects developed in the last few years, shows a confirmation of the Top 3 SET-plan themes occurrence, while a more spread distribution in the SET-Plan themes can be

seen, with an increase of Projects in the Set-Plan Themes Energy Efficiency and Engaging consumer.

It is noteworthy to observe that the **themes** tackled at National level a**re in line with the R&D Smart Grids priorities expressed at International level.** In particular, the R&D needs expressed by the different contributing Countries through their Projects are part of the TOP 10 Smart Grids R&D priorities identified within the Innovation Challenge on Smart Grids (IC#1) of Mission Innovation, witnessing the contribution given by ELECTRA IRP and the participating European Countries to MI IC#1.

The R&D topics of greatest interest (e.g. the Top 3 themes mentioned above) are also included in the Smart Grids Tasks that will be launched in 2018 (see Chapter 18.2.3), confirming the commitment of the ELECTRA IRP participating countries in developing and investing in R&D in the field of Smart Grids, fostering Smart Grids deployment.

National R&D Projects and the Web-of-Cells (WoC) concept

The R&D projects developed by the different countries have shown to be related to the Web-of-Cells (WoC) concept, developed within ELECTRA in order to develop the power system of the future and support the change from a centrally managed system to a distributed one, identifying a model for electrical grid operation, and addressing the active grid that will prevail with the penetration of distributed energy resources - wind, solar, storage etc. (see Deliverable 5.3 – "*The Web of Cells control architecture for operating future power systems*" for details).

ELECTRA introduced this new grid control architecture with the paradigm to solve local problems locally (an ELECTRA Cell is a portion of the power grid able to maintain an agreed power exchange at its boundaries by using the internal flexibility of any type available from flexible generators/loads and/or storage systems. The total amount of internal flexibility in each cell shall be at least enough to compensate the cell generation and load uncertainties in normal operation). For that reason the power system is divided in cells representing geographical area, that can span multiple voltage levels, and that are connected with each other through one or multiple tie-lines. In each cell, a cell system operator is responsible for the real-time voltage and balance (power imports/exports) control of its cell (a schematic example of the architecture is given in Figure 19-2).

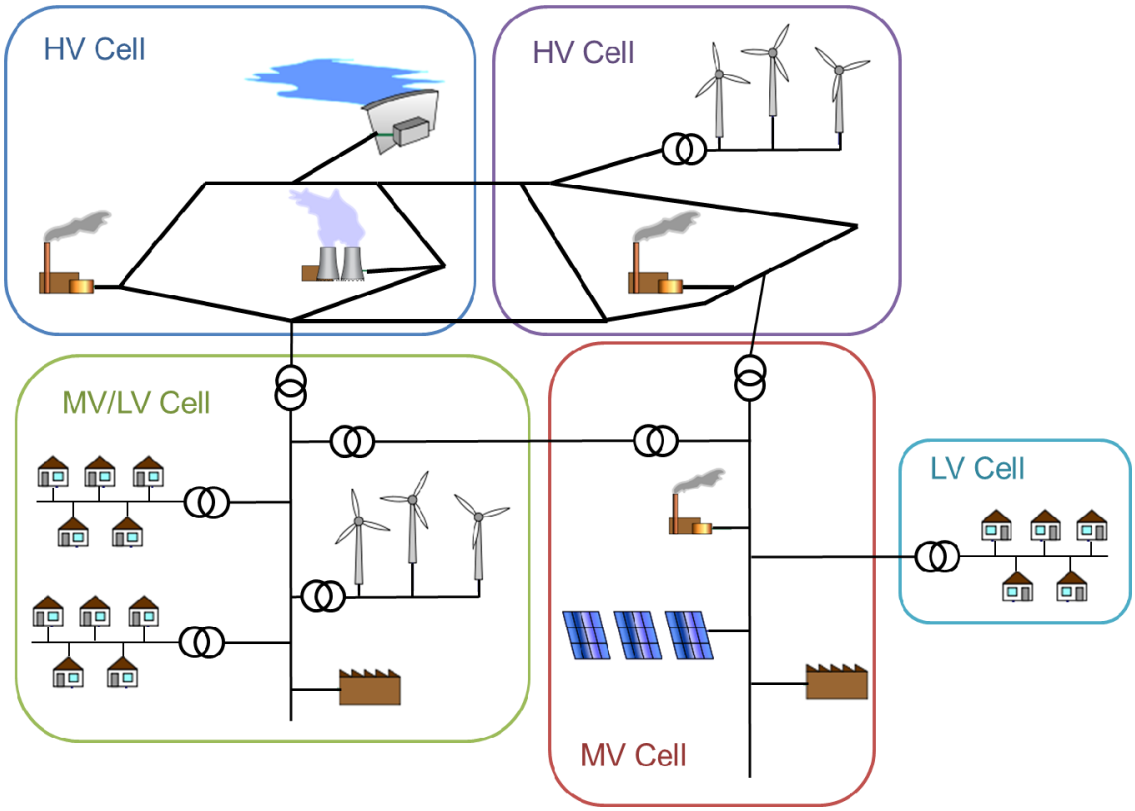


Figure 19-2: Schematic example of ELECTRA proposed "Web-of-Cells" architecture (source: ELECTRA IRP)

The WoC concept, capable of capturing the requirements of the new families of technologies constituting the emerging energy mix of 2030 and beyond, has the shown to be an interesting Research issue for many European countries.

In the following, as result of the analysis of the contributions provided by the different participating countries, some comments and considerations on the main items covered by the document are made.

20 Considerations on the main items addressed in the deliverable

National energy scenarios have been highlighted by the different participating partner taking into account country's peculiarities; data/information has been provided at different level of detail, ranging from a broad energy picture to specific "smart grid" topics.

In this chapter some considerations on the main items addressed in the deliverable are made and some common lines and approaches are identified, also taking into consideration trends emerging from the scenario depicted in the first half of the ELECTRA Projects (2015) and the one at the end of the ELECTRA Project (2017).

National R&D strategies and plans are mainly targeted at providing clean energy (e.g. zero emission), including Smart Grids as enablers and with R&D Projects and policies focused on an integrated approach in a vision towards 2030 and 2050. Roadmaps and Research Programs covering different energy topics are defined in all countries, linked with European programs and initiatives. Projects in the field of Smart Grids are developed in all countries (both R&D and Demonstration & Deployment) and an increase in R&D projects have been observed in the last few years.

National priorities and R&D strategies include a broad spectrum of topics, but we can summarize saying that the main steering issue which is driving the innovation and research actions towards a development of the electric grid is the integration of renewable and distributed energy sources.

Concerning sources for electricity production, a general overview of the various national and future trends can be made: all countries are aiming at a development of renewable sources pointing out objectives in terms of reduction of carbon emissions and R&D projects are developed focusing on the development of best practices enabling 100% renewable energies with innovative energy technologies.

R&D Smart Grids projects tackle different issues, but common themes of interest can be identified among the different projects developed at National level and an alignment with the **SET Plan** themes can be found. In particular, three main common topics have been identified, namely: Energy system flexibility, Energy networks & grid modernization and Activating consumer.

Energy Efficiency, prosumers involvement and demand side management are also research fields that show up in a priority for many country. Other themes and thematic areas of interest are the Energy Market development, Smart Cities & Communities, Energy Storage, the development of the distribution network and the control and management of the grid.

Increasing **funds in Smart Grids R&D** are foreseen in the different countries, compared to the first half of the ELECTRA Project. To this respect, it is interesting to highlight that more than half of the countries contributing to this deliverable have joined the global initiative Mission Innovation, where participating countries have committed to seek to double their governments' clean energy Research and Development (R&D) investments over five years- and have an active role in the Innovation Challenge on Smart Grids (IC#1).

An important trend that have been observed is the development of collaboration among countries for the development of joined projects and funding on Smart Grids topics (e.g. bi-national projects between Germany and Finland and Austria/Switzerland and bi-lateral projects with Greece)

Concerning the **main actors of the energy value chain**: TSO and DSO are the first ones involved with all countries characterized by a monopoly in the transmission field and a number of DSOs ranging from about 4 to more than one hundred.

Industry of the energy sector is characterized in all countries by the presence of technology providers and manufactures of the largest international companies (e.g. ABB, SIEMENS, SCHNEIDER, ALSTOM and ICT companies) and many national enterprises which, in many countries, supply technical solutions for Smart Grids implementation (e.g. grid automation and control technology; IT solutions, inverters, storage systems, e-mobility devices).

Some countries give an overview of the industry sector related to power generation and manufacturing focused on territorial features (for example Denmark highlight the importance of wind industry). Another aspect that emerges through the contributions is a strong involvement of the ICT industries.

A possible Industry trend and need can be identified in the development of service providers (including aggregators) and in technology providers involvement in R&D topics while the acquisition of knowledge on planning, setting-up and managing energy grids by the technology providers seems to be still under development.

Most of the countries have set Industrial Initiative in the Smart Grid sector at National level (e.g. Smart Grids National Platforms and Energy Clusters) with different specific goals among which the main ones are: network bringing together Smart Grid stakeholders, sharing of knowledge and promotion of technology and innovation.

21 Conclusions

The very ambitious goal of ELECTRA IRP work package 1 was to encourage all IRP partners to make an additional effort in order to boost the different grid stakeholders efforts with the perspective:

- to steer the national smart grid research programs;
- to consolidate the results of those programs in direct support of the European strategic energy objectives;
- to promote involved research institutes to focus and contribute in specific complementary areas of R&D;
- to leverage resources to address subjects not yet covered by the EERA JP SG, addressing also the development and proof of new concepts which will be needed in the management of the future electricity system.

To this purpose a step-by-step approach has been followed in performing the different activities, where the following outcomes can be progressively achieved:

- Initial exchange of information about ongoing Smart Grids programs and projects
- Sharing of vision, strategy and priorities
- Selection of R&D topics of mutual interest
- Exchange of publicly available data and results
- Identify specific topics where cooperation with ELECTRA can be achieved
- Selection of areas/topics for potential joint R&D collaborative projects
- Identify tools/rules for cooperation mean
- Definition and launching of joint R&D tasks
- Execution of joint R&D activities involving the use of research infrastructures and researchers exchange

This deliverable can be considered as an important milestone to achieve the above mentioned outcomes: an additional step is made for the different European Countries to achieve an effective exchange of information and results about ongoing Smart Grids programs and projects, sharing of vision, strategy/priorities and a selection of R&D topics of mutual interest and possible collaborations.

The information collected thanks to the contribution of the different partners (14 participating Countries) is crucial to get a general picture of the national energy strategies, policies, priorities, main actors, on-going programs and R&D activities for the evolution towards Smart Grids.

Moreover, an important step has been made to understand what is happening in Smart Grids R&D areas in the different countries - with special reference to medium-long term research - and how ELECTRA interacted with R&D programs at National level, taking into consideration on-going and recently completed R&D National Projects.

Thanks to the contributions of the different participating countries, information on more than 60 R&D projects has been collected. National R&D projects related to a great range of topics have been identified as interesting sources of interactions with ELECTRA, also being related to the Web of Cells concept (WoC) developed within ELECTRA.

The ELECTRA partners countries profiles collected in this deliverable show structured strategies and effective actions through elaborated projects and infrastructures, revealing a high EU Smart Grid and Smart Energy potential.

Indications that will be provided through the circulation of the present document will be an input for possible future analysis and activities useful to enable the evolution of Europe towards a Smart Energy System.

22 Disclaimer

The ELECTRA project is co-funded by the European Commission under the 7th Framework Programme 2013.

ANNEX - NATIONAL R&D PROJECTS relevant to ELECTRA objectives and activities

	Austria
1	**R&D PROJECT TITLE: Leafs - Integration of Loads and Electric Storage Systems into advanced Flexibility Schemes for LV Networks** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Flagship project –Energieforschung 2015/FFG/85041/11/2015 until 10/2018 ***Total Budget (M€) / Involved Partners*** 2.2 (requested funding)/ Austrian Institute of Technology – Lead; partners from Industry DSOs and Universities ***Project objective, topic and results*** Leafs evaluates the effects of increased costumer and energy market driven utilization of energy storage systems and load flexibility on power distribution grids focusing on low voltage level. Technologies and operation strategies are developed that enable optimal use of distribution grid infrastructure by activating flexibilities using direct or indirect control also by the local grid operator (ELECTRA use case post primary voltage control - PPVC) or even incentives. The results will be validated in three different low voltage demonstration sites ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 1: Theme 1, Theme 2, Integrated Challenge 3: Theme 6, Theme 7, Theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Leafs is focusing on the integration of flexibility from loads and storages systems in rural low voltage grids. So it is supporting in answering the question how technical solutions on a local level (low voltage network) can contribute to future power system operation and how to integrate flexibility on the three levels i.) increasing self-consumptions, ii.) grid friendly behaviour and iii.) market participation in the ELECTRA WoC concept? It contribution to the WoC related use case on post primary voltage control and related observables and control concepts. The benefit expected by the cooperation at European level is in ensuring scalability and replicability of the developments by including experiences from other countries.
2	**R&D PROJECT TITLE: DeCAS - Coordination of ancillary services covering different voltage levels and the integration in future markets** ***Funding Frame / Funding Agency / Contract number / Project Duration*** ERA-Net Smart Grid+/National Funding FFG/852064/Ongoing – 02/2016 until 01/2019 ***Total Budget (M€) / Involved Partners*** Austrian Share 1.8 (requested funding)/ AIT-Lead, Industry, DSOs, Universities from Austria ***Project objective, topic and results*** DeCAS aims to research and analyse system services such as demand response and coordination of individual Volt/Var control concepts crossing traditional boundaries from high voltage, medium voltage to low voltage, as well as the market integration. It will further include the integration of related monitoring and controls in process-control systems. The result will be an orchestration of the power system via hierarchical and integrated network control, taking into consideration the market integration

	Austria
	of flexibility and stakeholder involvement focusing on consumers and networks operators. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** DeCAS still relies and is based on the hierarchical power system from HV to MV and LV. The interesting aspect concerning the interaction with ELECTRA is how to map the solutions and results from DeCAS with the WoC concept. What is necessary to include a more horizontal approach in DeCAS, but also what can be the lessons learned for the WoC concept? This considers the WoC integration in hierarchical control schemes.
3	**R&D PROJECT TITLE: ABS4TSO – Advanced balancing services for transmission system operators** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Energieforschung 2017/FFG/tbd/03/2018 until 2/2021 ***Total Budget (M€) / Involved Partners*** 2.7 (requested funding 1.8) / TSO lead, AIT, University, Industry ***Project objective, topic and results*** Within the scope of this project, the characteristics of highly dynamic system services, sup-porting future system stability and security shall be analysed. Based on an estimation of future system needs an appropriate general framework as well as conditions for provision of specific services are examined. Special focus is given to a technology-neutral design of such system services. The following applications are examined: - Frequency stabilisation via synthetic inertia - Enhanced frequency response - Attenuation of system oscillations - Fast post fault active power recovery - Reduction of deterministic frequency deviations - Frequency stabilisation according defence plan - Frequency stabilisation in case of system restauration Due to their characteristics, battery storage systems are optimally suitable to provide these system services. Additionally they can provide the necessary mobility and scalability within this project. Therefore within the scope of this project a battery storage system (approx. 1MW/500 kWh) will be installed as a reference implementation in order to assess the defined applications and services ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 7 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project is going to consider the simulation and lab-scale experiences on the ELECTRA use cases frequency containment control (FCC) and inertia response power control (IRPC) on lower TRL level in order to develop control functions on device level (battery storage system demonstrator in the Austrian Transmission system) on higher TRL level (verify functionalities in real environment TRL5). Aim is to enable flexibility in order to provide frequency stabilisation via synthetic inertia and enhanced frequency response. The experiences in providing related services at transmission system level have in

	Austria
	general European dimension and the results are going to be discussed at European level. The results are going to be from interest when discussing the migration path of the ELECTRA WoC concept.
4	**R&D PROJECT TITLE: BatterieSTABIL – Battery storage in multi-modal operation for ancillary services and system stabilisation** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Energieforschung 2015/FFG/853558/09/2016 until 02/2019 ***Total Budget (M€) / Involved Partners*** 1.1 (requested funding 0,56) / DSO lead, AIT, University ***Project objective, topic and results*** The goal of the BatterieSTABIL project is to demonstrate how the potential of battery storage technologies can be completely exploited by multimodal operation, where further ancillary services for system stabilization in addition to the already established ancillary services (primary energy control (frequency containment reserve), voltage support and supply restoration process) can be provided in combination. The focus is on power systems with a high share of fluctuation generation (like wind). Spinning reserve, dynamic-reactive power compensation and symmetrical behaviour count to such further ancillary services for system stabilisation. Especially the interaction of certain control strategies for the realization of an operation strategy is going to be investigated to demonstrate universal future battery operations. After the development of the control functions and extensive lab-scale testing the system has been installed in the field for verification of the operation modes by end of 2017 (in HV/MV substation next to a wind farm). ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 7 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project has relation to several ELECTRA use cases for balancing and voltage control in a power system with high share of fluctuating generation. System level discussion and experiences from ELECTRA have been already considered in the development of control function at device level. Potentially this control functions can be integrated in a future WoC architecture as well. The results are going to be from interest when discussing the migration path of the ELECTRA WoC concept.
5	**R&D PROJECT TITLE: FACDS – Power system stabilization and optimization by applying "Flexible AC Distribution Systems"** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Energieforschung 2015/FFG/853555/02/2016 until 07/2018 ***Total Budget (M€) / Involved Partners*** 1.7 (requested funding 1.15) / DSO lead, AIT, university, energy supplier, industry ***Project objective, topic and results*** Beside the definition and prioritisation of grid service functionalities, to secure the grid quality and stability, of future strongly distributed decentral storage systems in the electrical distribution networks, the FACDS project is focusing on a technical simulation validation at the system level (usage of the functionalities, storage system placement etc), technical simulation validation at the component level (controller development etc.) and also a laboratory validation of communication and operating modes. The major part of the FACDS project is the real implementation of the test-facilities in the ASCR test-bed in the Lakeside City of Aspern (in Vienna) to validate everything on a field level (MV/LV

	Austria
	substation). ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 7 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** System level discussion and experiences from ELECTRA have been already considered in the development of control function on device level (connected to the low voltage grid). Potentially this control function can be integrated in a future WoC architecture as well. The results going to be from interest when discussing the migration path of the ELECTRA WoC concept
6	**R&D PROJECT TITLE: DG DemoNet Smart LV Grid - Control concepts for active low voltage network operation with a high share of distributed energy resources** ***Funding Frame / Funding Agency / Contract number / Project Duration*** National Funding FFG/829867/finished in 2015 ***Total Budget (M€) / Involved Partners*** 2.2 /AIT – Lead, Industry, DSOs, Universities ***Project objective, topic and results*** In the field of intelligent network planning and intelligent monitoring new possibilities for the allocation of the available voltage band have been developed, which allow the utilization of significant, available reserves in distribution grids. Already existing and in future much more occurring problems are going to be controllable with the step-by-step integrated smart grid technologies in the field test areas. After utilization of existing reserves from medium voltage level as well as low voltage level, local voltage control concepts are economic compared to conventional network reinforcement. In case these measures are not sufficient more complex ICT based controls (distributed control and coordinated control) are possible. From today's perspective these controls are not or still not economical. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** It is very much the same like already indicated for the project LEAFS. Practically DG DemoNet is fully integrated in LEAFS. In DG DemoNet the focus was on enhancing the DER hosting capacity in LV grids by enabling flexibility from PV (volt/var control), partly E-Mobility and flexibility from power system assets like OLTC secondary substation transformers alongside with new planning and monitoring approaches. Within LEAFS additionally DSM and Storage is considered (see above)
7	**R&D PROJECT TITLE: AIT Research Field "Power System Planning and Operation"** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Institutional funding AIT/AIT Research Field "Power System Planning and Operation"/Ongoing ***Total Budget (M€) / Involved Partners*** ~0,4 a year/Topics are updated and further developed every year according to a 4 years strategy plan, which has been updated in 2017 (for the period 2017 – 2021)

	Austria
	Project objective, topic and results - Inertia provision in an inverter dominated power system - Observables in the power system and controller parametrization - Integration of Low Voltage grids in power system operation tools - Methods for a robust evaluation of Smart Grids technologies scalability and benefits ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** To further integrate and develop the AIT models in order to enable the simulation, validation and to a certain extent testing of the WoC. Benefits for the cooperation are the integration of European developments in the national research as well as discussing the early stage results in an international environment in order to further improve the methods, approaches and finally the results.

	Belgium
1	**R&D PROJECT TITLE: SMILE-IT - Stable Multi-Agent Learning for Networks** ***Funding Frame / Funding Agency / Contract number / Project Duration*** IWT-SBO#140047 Jan/2015 – Dec/2018 ***Total Budget (M€) / Involved Partners*** Total National Belgian Funding : **2,5M€** (*note : this is not only for Smart Grids*) VUB (coordinator), **VITO,** KULeuven, UGent, Univ. Antwerp ***Project objective, topic and results*** There are many networked systems, consisting of many collaborating and competing agents. Smart Grids are one example of such networked systems. As the complexity and size of these networks increases, automated techniques for configuring, guiding, and managing them becomes increasingly important, in order to limit operational costs and guarantee optimality. The SMILE-IT project aims to develop an automated network management framework, based on multi-agent reinforcement learning (MARL) techniques. Two application domains, important in the Flemish economic landscape, have been selected for concrete valorisation tracks, telecommunication networks and smart grid applications. . Specifically, interactions with the Smart Grids industry showed the essential need for multi-agent systems to enable smart grid applications like demand response. Different stakeholders (e.g., consumer, DSO, BRP) can be represented by a network of interacting agents, avoiding the inevitable increase in cost and calculation time of a centrally controlled system. The overall project's goals is to develop a MARL framework and a specific sub-goal is to apply this to the Smart Grids application domain. Specific research questions include dealing with uncertainty, learning over long periods of time, self-healing and robustness. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 1 : Theme 1, Theme 2 Challenge 3 : Theme 7, Theme 8, Theme 9 Challenge 4 : Theme 10 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Applying MARL techniques to grid management.
2	**R&D PROJECT TITLE: CALLIA – Open Inter-DSO Electricity Markets for RES Integration** ***Funding Frame / Funding Agency / Contract number / Project Duration*** ERA-NET Smart Grids Plus #77616 Jun/2016 – May/2019 ***Total Budget (M€) / Involved Partners*** Total Budget : 5,2M€ Belgian Budget : 902K€ Belgian Funding : **673K€** ISC Konstanz (Germany – Coordinator), devolo (Germany), University of Stuttgart (Germany), Salzburg Research (Austria), Vienna University of Technology (Austria), blue.sky energy gmbH (Austria), REstore (Belgium), **VITO (Belgium),** Bogazici Electricity Distribution Inc (Turkey), Pavo

	Belgium
	Tasarim Uretim Elektronik Tic.A.S (Turkey), EnBW ODR (Germany), TransnetBW (Germany) ***Project objective, topic and results*** In order to achieve European energy targets, the **enablement of grid-secure integration of RES at all voltage levels** is one of the major challenges. Curtailment need to be limited while respecting the grids transfer capacity and limiting grid reinforcement investments. In the Callia project, we will develop and pilot a **grid operational management approach, based on local DSO area balancing and implementation of agent-based RES components**, combined with **improved DSO-TSO coordination** supplemented with (cross-border) inter-DSO power exchanges. The latter will reduce the strain on the TSO-DSO connection points, but above all limits losses by enabling the balancing of local production and consumption in adjacent regions without the need of crossing all voltage levels in an up-horizontal-down trajectory. The project results will be validated both in co-simulations and a pilot of the RES-DSO-TSO interfaces. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 1 : Theme 2, Challenge 3 : Theme 6, Theme 8 Challenge 4 : Theme 10 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Local Balancing and coordinated local balancing with neighbouring areas (solve local problems locally).
3	**R&D PROJECT TITLE: GREDOR - Gestion des Réseaux Electriques de Distribution Ouverts aux Renouvelables (note : VITO is not involved)** ***Funding Frame/Funding Agency/Contract number/Project Duration*** Public Service of Wallonia – Department of Energy and Sustainable Buildings, Jan/2013 – Dec/2017 ***Budget/Partners*** Total Budget: 4,8M€, Total Funding: 3,4M€, Partners: University of Liege (Coordinator), ORES, Tractebel Engineering SA, Elia System Operator S.A., EDF Luminus, Tecteo RESA, University of Mons ***Project objective and/or results*** Smart Network Management to support the integration of more RES. In Europe, concern on the environmental impact of the electricity industry is currently driving the growth of renewable electricity generation through a class of financial support mechanisms. Such incentives have resulted in the ongoing installation of wind and solar generation resources at the distribution level of the electricity network. This development calls for the evolution of the distribution network planning and operational strategies in order to accommodate the energy inflow from such DG resources. The dominant doctrine for the distribution network planning and operation has been the fit and forget approach. Under this approach, enough investments in network components (i.e., lines, cables, transformers, etc.) must be made in order to always avoid congestion and voltage problems. To that end, network planning is made with respect to a set of critical scenarios consisting of DG production and demand levels. In this manner, sufficient operational margins are always ensured. Nevertheless, with the rapid growth of DG resources, the preservation of such conservative margins comes at continuously increasing network reinforcement costs. In order to avoid prohibitively high network reinforcement costs, active network management (ANM) strategies have recently been proposed as alternatives to the fit and forget approach. The principle of ANM is to address congestion and voltage issues via short-term decision

	Belgium
	making policies, developed on the basis of the optimal power flow (OPF) problem formulation. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3: Theme 6, Theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Local Balancing and coordinated local balancing with neighbouring areas (solve local problems locally).

	Denmark
1	**R&D PROJECT TITLE: ACES** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EUDP/2017-20 ***Total Budget (M€) / Involved Partners*** 1.37M€ total, 0.7M€ support, DTU, Nissan, BEOF, NUVVE ***Project objective, topic and results*** The ACES project intends to holistically investigate technical and economic system benefits and impacts by large scale electric vehicles integration in Bornholm, aug-mented by real usage patterns, grid data and field testing for across continents repli-cability. A full scale penetration scenario of electrical vehicles at Bornholm will be simulated in order to assess how new aggregating functionalities - both technically and economi-cally - can support a successful integration of electric vehicles into the energy sys-tem. The testing will be augmented by real usage patterns, grid data, and field testing for across continents replicability. It will also initiate a small scale pilot project involving up to 50 publicly and privately owned Nissan vehicles and V2G chargers for proving that EVs can be used for effec-tively balance the system. This small scale pilot will be based on useful insights from the Parker project that "is applying grid-balancing services to a fleet of electric vehi-cles to demonstrate their potential to support the electricity grid as power resources". ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 7 Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project includes both technical and economic aspects of advanced control of the integration of EVs that could benefit in a more decentralized control approach as ELECTRA.
2	**R&D PROJECT TITLE: EcoGrid 2.0** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EUDP, EUDP, 3.5 years 2016-2019 ***Total Budget (M€) / Involved Partners*** 13M€, 7M€, Danish Energy Ass. Østkraft, IBM, DTU, Insero, Uptime-IT ***Project objective, topic and results*** The project will develop and test new market methods and develop support tools for the market participants. The project will investigate flexibility from heat pumps and electric space heating. It will further investigate interoperability to support end users to change aggregators. The project will carry out the tests at Bornholm using the infrastructure developed and installed as part of EcoGridEU. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project can contribute with flexibility descriptions of temperature controlled space heating, interoperability, operation of end user devices.

	Denmark
3	**R&D PROJECT TITLE: DSO role in Electricity market** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EUDP/2017-19 ***Budget/Partners*** Total Budget & funding 2013-2016: 1.1 M€ (Radius, DTU, Eurisco, HOFOR, Markedskraft) ***Project objective, topic and results*** The project targets specific problems faced by DSOs in the future energy system where flexibility assets provide grid services to the transmission and distribution grid. The objective of the project is to define the role of the DSO as well as the in-formation exchange between different actors under these scenarios and demonstrate tools for congestion management. The project will support the move to a more intelligent energy system with a high penetration of renewable energy by improving the coordination between actors (DSO, TSO, BRP, aggregator and asset owner) in the context of delivering grid ser-vices from flexible assets. The project will identify inefficiencies in the operation of the energy system caused by conflicts of interest between actors. It will develop and demonstrate solutions for an improved coordination and information exchange between actors in order to miti-gate these inefficiencies. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 6 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project can provide input of the derived changes in the role of DSOs as more advanced control concepts are developed and implemented.
4	**R&D PROJECT TITLE: Ancillary services dfrom renewable energy plants (RePlan)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** ForskEl,/2015-2018 ***Budget/Partners*** Total Budget & funding 2013-2016: 0.8 M€ (DTU Wind, DTU CEE, AAU ET, AAU WCN, Vestas) ***Project objective, topic and results*** The RePlan project is a development project, intended to evaluate, improve and veri-fy the grid support service provided by renewable generation plants to maintain the stability of future entire renewable energy integrated power systems. The purpose is to explore the suitability of coordina-tion between the grid support services provided by renewable generation (ReGen) plants in order to ensure the security and reliability of power supply. The overall objective of this project is to contribute to the integration of large share of renewable energy in the Danish power system and thus to enable a resilient power system in the future by developing technical solutions for the provision of ancillary services by renewable power plants. RePlan focuses on WP and PV plants since they are expected to jointly produce the lion's share of renewable energy generation capacity needed to reach the Danish government 2050 targets. The novelty of RePlan consists in the investigation and verification of: 1) the ancil-lary services provision from WP and PV plants and 2) the suitability to coordinate their services provision to power system operator. In this respect, RePlan strives to identify and analyze the strengths and limitations of WP and PV plants, anticipating new challenges and exploring some of the more complex issues and uncertainties related to the coordination of their ancillary services. The services with great con-cerns in

	Denmark
	the future include: voltage, frequency and rotor angular stability support. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project is developing and testing control concepts and controllers that allows renewable energy plants to provide ancillary services to the power system.

	Finland
1	**R&D PROJECT TITLE: Flexible Energy Systems – FLEXe** ***Funding Frame / Funding Agency / Contract number / Project Duration:*** Tekes – the Finnish Funding Agency for Innovation /2015-2016 ***Total Budget (M€) / Involved Partners*** Budget is 13,7 M€. The FLEXe consortium consists of 18 companies and 10 research institutions or universities. The consortium consists of strong industry and research players covering a broad spectrum of competences and including the whole value chain for the energy system. ***Project objective, topic and results*** FLEXe program creates novel technological and business concepts that enhance the radical transition from the current energy systems towards sustainable systems which combine smartness, flexibility, environmental performance and economic success with customer acceptance and engagement. Sustainable energy system will be a complex combination of centralized and local generation combining a wide variety of energy resources including renewables and energy storages. Increasing the intermittent energy like wind and solar will pose a challenge to the balance management of the power system. New solutions to increase flexibility are required at all levels of the energy system. At the generation side, better load following capability is required to mitigate the short notice generation ramps of intermittent production. Also, more flexibility is required to successfully exploit a wide variety of fuels in the future; the significance of gaseous fuels, for example, will grow considerably already in the near future. For extensive integration of renewables, flexibility must be looked at from the customer side as well. Activating the customer and harnessing the flexibility in the demand side is a very complicated and multi-disciplinary issue. In addition, future energy system must not only be sustainable, but also affordable and reliable. All these goals can be achieved by clever coordination of various energy markets and energy carriers, i.e., electricity, heat, cool and fuels. Including optimal utilization of combined heat and power generation at different system levels as well as the development of local energy efficiency management based on Internet of Things (IoT) provide opportunities for new kinds of systemic solutions. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3; theme 8 and partially theme 6 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The possible topics for future exchanges of information comprises of different control mechanisms and control architectures for the aggregation of the flexibility so that it can be utilized for the balance management of the energy system. Interactions can also include different control mechanisms for the optimization of the local energy use taking into account the local limitations and customer preferences. The cooperation at national and European level will provide added value in definition of the current status and changes needed for the transition to the future flexible system. Important aspect is also arriving at common vision for a common European market design to describe the interplay between market and legal and regulatory mechanisms.
2	**R&D PROJECT TITLE: Improved Modelling of Electric Loads for Enabling Demand Response by Applying Physical and Data-Driven Models (RESPONSE)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Academy of Finland, 2015-2018 ***Total Budget (M€) / Involved Partners*** The total budget of the project is about 1 M€. Involved partners: VTT Ltd, Tampere University of

	Finland
	Technology (TUT) and University of Eastern Finland (UEF) ***Project objective, topic and results*** The aim is to develop enhanced models for load and control response forecasting required by dynamic on-line optimisation of demand response (DR) actions and network operation in a future sustainable energy system. DR is one of the key issues in adaptation of energy production and consumption and in creating flexibility to integrated energy systems which are main themes of the "New Energy" research programme of the Academy of Finland. The results of the project include improved understanding and methodologies for developing electric load forecasting methods, and assessment of methodologies' reliability and applicability, in terms of DR scenarios and different spatiotemporal forecasting scales ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3; theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Electra project designs and develops control functions for power system based on web of cells concept. The main focus is in the balance and voltage control at the system level, but control objectives and contributions from the distribution level, will be fully considered. The inherent and controllable flexibility across multiple resources and control boundaries is important research aspect also. For example, Cell state estimation is one of the control functions needed. For managing cell balance different forecasting methods including load forecasting and control responses are needed. One expected value in cooperation is to exchange information of control responses.
3	**R&D PROJECT TITLE: Smart Grids and Energy Markets – SGEM** ***Funding Frame / Funding Agency / Contract number / Project Duration:*** Tekes – the Finnish Funding Agency for Innovation and Industrial companies /2009-2015 ***Total Budget (M€) / Involved Partners*** Budget is 54 M€. The SGEM consortium consists of 20 companies and 10 research institutions or universities. Coordinator was Cleen Oy. The consortium consists of strong industry and research players covering a broad spectrum of competences and including the whole value chain for the energy system. ***Project objective, topic and results*** The first research theme focused on architectures, concepts and vision of Smart Grids as the second theme dealt with primary network solutions. Active resources of the third theme (i.e. distributed generation, loads, storages and electricity vehicles) actually change the traditional passive distribution network to be an active one. Fourth theme dealt with network operation and asset management by secondary systems (i.e measurement, protection, control, ICT etc.), which provide intelligence (i.e. Smart) to active networks. The fifth theme of energy market related to active market participation and changes in business environment. The main general results of the research program can be listed as follows: • created an innovation foundation for new solutions, products and services to enable the implementation of the Smart Grids vision • demonstrations of solutions in real environment, not limited to Finnish grids, were an essential part of the research • the relevance of the research was measured on global basis, i.e. the targeted solutions shall be applicable on the international market • cultivated the competence accumulation in the research and business environments to secure the long term competitiveness • international research cooperation was a pre-requisite to achieve the objectives

	Finland
	Topics addressed in SET Plan Integrated Roadmap Challenge 1; theme 2 Challenge 3; theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The possible topics for future exchanges of information comprises of R&I actions needed to develop and deploy more intelligent and interoperable control systems of network and equipment and services (e.g. user friendly energy management systems, smart appliances) to enable consumers and prosumers becoming more energy efficient and active. Important market changes have occurred in the past years with the emergence of smart meters, wireless sensors, small scale renewable energy systems, smart functions in appliances and their integration with Internet, home networks, smart energy infrastructures or local energy storage systems, setting the path towards smart systems. All these new technologies, products and services should help consumers better manage their energy demand (e.g. by detecting malfunctions or optimising intelligent control and automation) and energy supply

	France
1	**R&D PROJECT TITLE: FractalGrids - Towards the future Smart Grids** ***Funding Frame/Funding Agency/Contract number/Project Duration:*** ANR (Agence Nationale de la Recherche) (ANR-15-CE05-007-02) 15/01/16 – 14/06/19 ***Budget/ Partners***: 737 613€, Lead partner: G2Elab/INPG Grenoble, ARMINES, LMI, ThéMA ***Project objective and/or results***: The project proposes to use fractality as a core concept to model, analyse and design future Smart Grids. It develops new analysis tools and design concepts based on fractal geometry to improve both the control of highly distributed loads and generators in power systems and the resilience of the future grid. This will lead to a new architecture of Smart Grids. It aims to show how the self-similar topology can benefit to the electrical system, from consumers to utilities. A simulation framework for the coordinated management of a fractal power system will be developed considering the different spatial and temporal scales associated to the power grids, meteorological system and energy market. http://fractal-grid.eu ***Topics Addressed in SET Plan Integrated Roadmap:*** Challenge 3: Action 6, Action 7, Action 8, Action 9 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The long-term goal of the Fractal Grid methodology is to provide a framework for the development of international standards for Smart Grid technologies and to facilitate the multi-scale deployment of Smart Grids. For this purpose, it will consider aspects ranging from weather systems and market organization down to communication and electrical networks with a particular attention paid to the latter aspect. The project aims to examine how new architectures for the grids of the future may facilitate the large scale integration of renewable energies and smart grid technologies. This is an objective that should be investigated at a European level. The vision and results of this project should be benchmarked to other similar projects and evaluated on test cases from other countries.
2	**R&D PROJECT TITLE: Development of a global approach for the integration if energy storage systems in urban areas (Storage4City)** ***Funding Frame/Funding Agency/Contract number/Project Duration:*** ANR – Carnot, AAP3 - AAP Carnot 2015, (053501), 01/01/15 – 30/04/17 ***Budget/Partners*:** 230.876€, Lead partner: ARMINES – MINES ParisTech. ***Project objective and/or results:*** The first objective of the project is the identification of storage technologies (electrochemical, thermal etc.) for urban integration and develop detailed models for them. Then the project aims to develop an approach for the management of storage devices in the grid taking into account the different actors and their interactions. This aims on the one hand to help to dimension and manage the storage integration to the grid. It is aimed to develop a generic approach replicable to specific local territories. The last objective is to evaluate the developed simulator on realistic test cases of different territories, market conditions and future scenarios for RES integration. ***Topics Addressed in SET Plan Integrated Roadmap*:** Challenge 3: Action 7, Action 8, Action 9

	France
	Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level The project is focusing on the role of storage in the electrical network as a mean of flexibility and an enabler for large scale RES integration. The storage dimensioning and localisation at different scales is considered. Management strategies are proposed. Understanding these aspects is important for the grids of the future. The problematic of storage integration at different scales from building, community microgrid or larger areas is present in several projects carried out today at national or European level. A holistic approach is needed to address jointly all the technologies involved in the context of smart grids.
3	**R&D PROJECT TITLE: Improvement of Renewables-based System Services Through Better Interaction of European Control Zones (REStable)** ***Funding Frame/Funding Agency/Contract number/Project Duration*:** ERA-Net Smart Grid Plus National funding in France by ADEME, Grant No (1582C0258), 01/04/15 – 30/04/17 ***Budget/Partners:*** 3.5 Mi€, ARMINES Coordinator, Partners: (FR): ARTELYS, Hespul,, Hydronext, Maia Eolis, (DE): ENERCON, Fraunhofer IWES, Solar World, (PT): Inesc Tec. ***Project objective and/or results:*** This project addresses two important problems faced today by power systems with high penetration of renewable energy sources (RES): the provision of ancillary services by RES and the European-wide frequency containment reserve. This is done by demonstrating advanced solutions for a Virtual Power Plant. The benefits of these new solutions will be evaluated considering improved estimation of weather events and short-term prediction at EU-wide scale. The relevance of this project to the call lies on: 1) the sharing of previous experiences between the partners and across EU borders and 2) the increase of the TRL for the technologies previously developed by the partners. In a short time scale this will: 1) allow RES developers to add additional revenue streams to their existing and future power plants, 2) remove barriers to additional development in systems with a high penetration of renewables and 3) reduce the cost of the reserve for network operators. ***Topics Addressed in SET Plan Integrated Roadmap*:** Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project deals with the offer of ancillary services from RES considering large geographical zones. It is of high interest to consider how such management schemes for renewables can be developed in conjunction with architectures like the proposed web of cells. Knowledge sharing, common approach, validation in different EU contexts.
4	**R&D PROJECT TITLE: *Smart Grid Vendée*** ***Funding Frame / Funding Agency / Contract number / Project Duration*** This project coordinated by SyDev was launched in 2013 for 60 months. http://www.smartgridvendee.fr/ (the website hasn't English version) ***Total Budget (M€) / Involved Partners*** The budget granted for this project is 27.7M€. This project involves: SyDev, ERDF, RTE, Actility, GE, Engie Ineo, Legrand, Le CNAM.

	France
	Project objective, topic and results This project aims to test new concepts connected to distribution network optimization. The demonstrator should show the relevance of new economic models taking into account technical, economic and social aspects. The optimization need strong coordination between partners to schedule, to forecast, to estimate in real time and in each level (regional vs local). The coordination should be supported by new interfaces, new information systems and new algorithms. The project is a deployed in Vendée (1.3% of the size of France) where the electricity network is mostly rural with wind farms and PV on roofs connected to the low voltage grid and HVA network. These networks are already undo constraints and need frequent renewable production on the HVB network. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3 : Action 9 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project is the main one regrouping all the actors of the smart grids to play together on a large size. The economic aspects targeted by the project should be relevant for ELECTRA (WP3). The interfaces put in place should also give perspectives for ELECTRA to have a relevant design.
5	**R&D PROJECT TITLE: PAESI** ***Funding Frame / Funding Agency / Contract number / Project Duration*** This project coordinated by EDF SEI (island electricity system department) was launched in 2013 for 60 months. http://www.smartgrids-cre.fr/index.php?p=microgrids-edf-maire-lambrot (the website hasn't English version) ***Total Budget (M€) / Involved Partners*** The budget granted for this project is not available. This project involves: EDF, Capenergie, local collectivities. ***Project objective, topic and results*** This project encourages the use of local energy sources in micro grids in case of isolation due to climatic reasons. The project should perform biomass system (electric power less than 100 kW), install it and put in place the management rules into the local micro grid in case of disconnection to the network. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3 : Action 9 Challenge 4 : Action 10 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project is focused to the energy mix to ensure the electricity in micro grid so some concepts maybe can be taking into account in large size for smart grid. The ELECTRA project has to take into account local balance found by micro grid between reduced production and demand.
6	**R&D PROJECT TITLE: *Live Grid Paris*** ***Funding Frame / Funding Agency / Contract number / Project Duration*** This project coordinated by Université Paris Saclay (academic coordinator) and EDF (industrial coordinator) was launched in 2015. http://www.livegrid.fr/ (the website hasn't English version)

	France
	Total Budget (M€) / Involved Partners The budget granted for this project is not available. This project involves: Université Paris Saclay (coordonnateur académique) - EDF (coordonnateur industriel) - Air Liquide - Alstom - Centrale Supélec - CCI Essonne - CEA - École polytechnique - EMBIX - ENS Cachan - Établissement public Paris-Saclay - ERDF - INRIA - Institut Mines-Télécom (Télécom ParisTech - Télécom SudParis) - IRT SystemX - ITE PS2E - RTE - Synchrotron Soleil - System@tic - Loria - Université Paris-Sud - Université Versailles Saint-Quentin. ***Project objective, topic and results*** The University of Paris-Saclay, the largest university of Europe with 80 000 teachers, students and researchers aims to imagine the future smart grid by testing innovative solutions proposed in real context. The network involved should combine heat and power networks. This network should supply all the buildings on Paris-Saclay aera. The solutions could be proposed by any partner what can be various research centers, academics, start'ups. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3 : Action 6 Challenge 3 : Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** All the actors participating in smart grids have been regrouped into Live Grid project and this context is very stimulating. For Electra, according the time to put in place the project, Live Grid can be an interesting comparison or a solution to test the ELECTRA concepts linked to urban area.

	Germany
1	**R&D PROJECT TITLE: Proaktives Verteilnetz (Proactive Distribution System)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Zukunftsfähige Stromnetze (BMBF) / BMWi resp. BMWT, BMUNR, PtJ / 03ET7521A / 36 months ***Total Budget (M€) / Involved Partners*** 6,5 Mio. € / RWE Deutschland AG, Rheinisch-Westfälische Technische Hochschule Aachen (RWTH), Technische Universität Dortmund, Venios GmbH, BTC AG ***Project objective, topic and results*** The project explores an innovative, open, discrimination-free, standardized, and transferable electrical energy distribution and transmission system. To that end it develops a resource-efficient and optimized platform for the integration of regenerative energy and smart market tasks. The platform employs a stateful management system for power consumption, power creation, and information exchange on all voltage levels. By managing these aspects on this platform, the project contributes to increasing the dependability of the electrical power system as well as to lowering the cost caused by extending the electrical power system. Instead of risking network congestion or extending the power system, the distribution network operator will be able to provide and activate flexible power using the platform. A real system will realize the project's results prototypically. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: System optimisation, Theme 8: Providing the energy system with flexibility, security and cost-effectiveness, Flexible Generation ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project employs a stateful model of operating the power system, as described in the BDEW's "Kapazitätsampelkonzept" (capacity traffic light concept). The main focus lies on the "yellow" phase, in which the distribution system operator has to rely on independent power plant operators to ensure a safe grid operation. The measurements necessary to detect this situation and the actions needed to avoid network congestion overlap with the control and protection functions considered in ELECTRA. The project aims at determining the future role of the distribution network operator. The project may find an answer in operating the platform, as it is tightly coupled with constructional measures. ELECTRA has answered this question within the web of cells concept. Here cell operators control the network infrastructure on all voltage levels in a geographical area. The project uses Use Cases to describe how the platform will be used for coordinating power. In ELECTRA, use cases describe, how control and protection functions influence certain operational aspects of a cell and the electrical energy network as a whole. This project will employ simulations to accompany the field tests, while ELECTRA will use simulations for the integration of control and protection functions in order to identify possible controller conflicts. This projects depends heavily on grid state estimation and prediction. In ELECTRA these mechanisms lie within the control and protection functions. Since multiple voltage levels are concerned in both projects, the problem of determining the grid state is very similar. In these outlined topics ELECTRA and Proaktives Verteilnetz may mutually benefit from each other. In many cases, knowledge gathered from working with one organisational design of future power grid operation can be transferred to the equivalent problem. The expected benefits include: Sharing metrics for grid state estimation, exploring the implications of different organisational grid designs, exchanging experience in working with use cases in power grid contexts, and using various models of grid components in smart grid simulations.

	Germany
2	**R&D PROJECT TITLE: NETZ:KRAFT** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Zukunftsfähige Stromnetze / BMWi / 0325776A / 42 months ***Total Budget (M€) / Involved Partners*** 12 M€ / Fraunhofer IWES, 50Hertz Transmission GmbH, TenneT TSO GmbH, Amprion GmbH, Transnet BW GmbH, EnergieNetz Mitte GmbH, MITNETZ Strom GmbH, HanseWerk AG, DREWAG Netz GmbH, Avacon AG, ENERCON GmbH, Energiequelle GmbH, SMA Solar Technology AG, ÖKOBIT GmbH, PSI AG, Dutrain GmbH, GridLab GmbH, Friedrich- Alexander-Universität Erlangen-Nürnberg, Universität Kassel, DERlab e.V. ***Project objective, topic and results*** NETZ:KRAFT develops new black start concepts for future power plant structures. The aim is to enable the integration of renewable energy resources (RES) during the reconstruction of the grid. The project is in pursuit of two main subjects: on the one hand the further development of the existing black start concepts of the TSO's with respect to the behaviour of RES. On the other hand fundamental investigations in using decentralized generation actively within supply islands in the distribution grid in order to shorten blackout times. And overall the coordination of both main subjects will be considered. Concepts, methodologies and technologies were developed where RES and intelligent network components can evolve to active functions units. Different scenarios of supply situations are investigated within case studies. Technological developments from requirements out of the case studies will be implemented in six demonstrations ***Topics addressed in SET Plan Integrated Roadmap*** Integated Challenge 3:theme 6 and theme 9. Theme 6: Modernising the European electricity grid and establishing synergies between the various energy networks. Theme 9: Development and demonstration of holistic system optimisation at local/urban level (Smart Cities and Communities). ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The subjects of both ELECTRA and NETZ:KRAFT are overlapping in defining scenarios and case studies for the future power system operation as well as development of control schemes for the use of flexibility. Both projects are in pursuit of a proof of concept, where NETZ:KRAFT even aims to perform field demonstrations. The process of the development of control functionalities in an synchronous simulations environment and transcription to an asynchronous real-time environment is comparable. In these outlined topics ELECTRA and NETZ:KRAFT may mutually benefit from each other. In many cases, knowledge gathered from working with one organisational design of future power grid operation can be transferred to the equivalent problem. The expected benefits include: Sharing metrics for grid state estimation, exploring the implications of different organisational grid designs, exchanging experience in working with use cases in power grid contexts, using various models of grid components in smart grid simulations, grid operation with limited reserves, energy management respectively demand side management, transcription of in simulation environments developed control functions to real-time testing environments.
3	**R&D PROJECT TITLE: Designetz** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Smart Energy Showcases – "Digital Agenda for the Energy Transition" (SINTEG) / BMWI / 48 months

	Germany
	Total Budget (M€) / Involved Partners 230 M€ (whole SINTEG) / All partners are listed here: https://www.designetz.de/ueber-designetz/zusammenarbeit/projektpartner/ ***Project objective, topic and results*** The project Designetz aims at finding solutions for a future secure and efficient energy supply to support the energy transition. Flexibilities are used in an optimised way taking into account market, grid and system constraints. To this end, tools are developed that bring individual solutions together to a holistic model for the energy transition. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3: Theme 8 "Providing the energy system with flexibility, security and cost-effectiveness" ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** In the Designetz project, partners develop concepts of "cells", "combs" and "prosumers". Within Designetz, a cell is thought of as a section of a distribution grid, which can provide flexibility to the cells in its grid topological neighbourhood. Combs aggregate the flexibilities of such cells further on the regional transmission grid. Cells and Combs exchange their flexibility with other cells and combs in their grid topological neighbourhood, respectively. Since both cells and combs can produce and consume power provided by flexibilities, they are both considered "prosumers". An important result of the ELECTRA project is the concept of a "web of cells", which also is a new paradigm for structuring the energy grid. This concept abolishes the traditional borders of grid levels and instead separates regions of the power system into "cells". These cells are assumed to be of such size and contain such power units that they can provide a certain load profile on their tie lines with reasonable certainty. Therefore both Designetz and ELECTRA are concerned with the future organisational structure of the power grid. Since Designetz is in an early project phase, it can still benefit from the related work done in ELECTRA by using it for reference and comparison. One expected benefit for Designetz is to draw the implications of restructuring the power grid in a manner which is equivalent to ELECTRA's. In particular, Designetz will need to design new control functions and new markets for electricity products inside and between the new organizational units, which were already examined in ELECTRA.
4	**R&D PROJECT TITLE: enera** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Smart Energy Showcases – "Digital Agenda for the Energy Transition" (SINTEG) / BMWI / 48 months ***Total Budget (M€) / Involved Partners*** 230 M€ (whole SINTEG) / 3M Deutschland GmbH, avacon AG, bfe e.V., BTC AG, Mauell GmbH, devolo AG, EEX AG, ENERCON GmbH, energy & meteo systems GmbH, Energy Brainpool GmbH & Co. KG, EPEX SPOT European Power Exchange SE, EY Ernst & Young GmbH, EWE AG, EWE Netz GmbH, TU Darmstadt, Fraunhofer IESE, Beton- und Energietechnik Heinrich Gräper GmbH & Co. KG, IABG Industrieanlagen-Betriebsgesellschaft mbH, Rheinisch-Westfälische Technische Hochschule Aachen (RWTH), Hochschule Fresenius, Jacobs University Bremen, Landis+Gyr GmbH, LIKRON GmbH, Maschinenfabrik Reinhausen GmbH, Nexans Deutschland GmbH, DLR-VE, OFFIS – Institute for Information Technology, Öko-Institut e.V., OOWV Oldenburgisch-Ostfriesischer Wasserverband, PPC Power Plus Communications AG, ProSyst Software GmbH, SAP AG, SCHULZ Systemtechnik GmbH, Siemens AG, Software AG, Space-Time Insight, swe - Stadtwerke Emden GmbH, Stadtwerke Lingen GmbH, TenneT TSO GmbH, Teradata Operations, Inc., the peak lab. gmbh & co. Kg, Theben AG, Universität Duisburg-Essen, Viessmann Werke GmbH & Co. KG, WEMAG AG, Younicos AG

	Germany
	Project objective, topic and results The project enera considers the three interconnected areas grid, market and data. The concepts will be applied to a model region in north west Germany. The area grid deals with operating the power grid in a reliable and efficient way using flexibility of producers, consumers and storage as well as intelligent operational equipment. Furthermore, the use of intelligent metering technology is explored. The area market focuses on market extensions especially for distribution grid compatible products. The area data organises data streams to enable data analysis and new services ***Topics addressed in SET Plan Integrated Roadmap*** Integrated challenge 1: Theme 1, Integrated Challenge 3: Theme 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** In the enera project, using flexibilities provided by decentralised producers, consumers and storage devices plays a central role. One use case for the available flexibilities is the provision of regional ancillary services, i.e. services provided within distribution grids. Moreover, new market structures for extending the intraday market are explored in order to provide regional products (provided by flexibilites in the distribution grid) using appropriate market mechanisms to support secure grid operation within the yellow phase of the capacity traffic light concept. The Web of Cells concept developed in ELECTRA also constitutes local, i.e. possibly regional, and decentralised control schemes for ancillary services voltage and balancing control using flexibilities from loads, generators and storage units. Whereas in ELECTRA a cell can consist of voltage levels from low to high voltage, enera considers services provided from the distribution grid. However, the ELECTRA results can provide valuable insights to possible structures for the enera projects. Furthermore, in ELECTRA economically optimal control of flexibility options has been investigated which could derive insight for market design in the enera project.
5	**R&D PROJECT TITLE: ENSURE** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Kopernikus project for the energy transition / Federal ministry of Educatin and Research / 36 months ***Total Budget (M€) / Involved Partners*** 120 M€ (all Kopernikus projects for first funding phase) / KIT, RWTH Aachen University, E.ON Energie Deutschland GmbH, TenneT TSO GmbH, Siemens AG, ABB AG, Bergische Universität Wuppertal, CAU University Kiel, Deutsche Umwelthilfe e.V., DVGW e.V., ewi ER&S, FGH e.V., Fraunhofer IWES, F.-A. University Erlangen-Nürnberg, Germanwatch e.V., LUH University, Maschinenfabrik Reinhausen GmbH, Nexans Deutschland GmbH, OFFIS e.V., Öko-Institut e.V., Stadtwerke Kiel AG, TU Darmstadt, TU Dortmund ***Project objective, topic and results*** In the funded research projects, technological and economical solutions for the transition of the energy system are developed involving participants from science, economy and society. The goal of the project ENSURE is to provide new structures for the energy system. In a holistic approach the energy system will be optimized considering relevant energy sources and corresponding infrastructures. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3: Theme 6 “Modernising the European electricity grid and establishing synergies between the various energy networks” ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** One focus of the ENSURE project is to investigate and develop new structures for the energy system. This regards the electrical power system as well as a coupling of different sectors such as power, gas,

	Germany
	heating and transportation. Within ENSURE, it is investigated what a good combination of central and decentral system parts in the power system is. Accordingly, concepts for stable operation strategies are developed. In ELECTRA, the Web of Cells concept has been developed which is a decentralised, organisational structure that enables decentralised control schemes in order to solve local problems locally. The project ENSURE could benefit from this concept and the project's results as related work since it constitutes decentralised grid structures on which the ENSURE project can build or with which it can compare its results. The same holds for the local control functions which are part of both projects.

	Greece
1	**R&D PROJECT TITLE: The Smart Grids Project in Five Aegean Sea Islands under the ELENA Programme** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EU (90% of 800k€ for the first phase, 2011-2014) ***Total Budget (M€) / Involved Partners*** 800k€/HEDNO, DAFNI (Network of Sustainable Aegean and Ionian Islands), National Technical University of Athens (as DAFNI's consultant) and ECCO int. as consultant ***Project objective, topic and results*** ELENA (European Local Energy Assistance) is part of the European Investment Bank's (EIB) broader effort to support the EU climate and energy policy objectives and aims to encourage local authorities to implement energy efficiency and renewable energy projects that can be replicated across the EU. The ELENA project regards the power system evolution of five Greek islands, namely Lesvos, Limnos. Milos, Kythnos and Santorini. The technical objectives of the project involve development of Energy Control Centres (ECCs), Advanced Metering Infrastructure (AMI), Electric Vehicle Charging Stations (EVCS) and Energy Efficiency in street lighting. All in all, the project aims to shift from the current paradigm in which autonomous power stations of the islands play the de facto role of system operator, and RES are secondary in terms of system operation to a paradigm in which the non-interconnected island operator becomes system operator and RES play a crucial role in the system's operation while autonomous power stations maintain a back-up role. In terms of market operation, the project aims to develop and consolidate a new paradigm with at least a rudimentary market model for the island operators (currently there is no such a model), with the use of already known procedures and functions such as Day-Ahead Scheduling and ancillary services. To this end, Energy Management Systems and Market Management Systems are to be deployed. The systems' requirements and overall design has been thoroughly covered by the first stage of the ELENA project, funded by the EU. Topics covered in this phase were the state-of-the-art of Energy Control Centres, regulatory framework that governs islands, high-level architecture of the functionalities of the ECCs such as optimal scheduling and dispatching, management of DER, real-time operation, market operations and other supporting mechanisms. Last but not least the first stage covered the system's design and the tender document's preparation for the second (roll-out) stage. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The overall objective of the ELENA project for the selected Greek islands is pretty much in line with the ELECTRA approach and objectives in terms of system operation. The concepts of Cell and Web-of-Cells developed in ELECTRA constitute an ideal solution to the abovementioned paradigm shift which requires new roles for system operation to be developed. Also, technically speaking ELECTRA could provide a set of readily available solutions in terms of functions which cover most of the ECC requirements. The ELECTRA solutions described in the use cases for Balance and Voltage control as well as the functionalities developed in WP8 (Future Control Room) are key enablers to the solutions and implementation ideas selected for the roll-out phase, since the first-stage study of the project provided the high-level concepts and requirements of these functionalities.
2	**R&D PROJECT TITLE: Technical Assistance for renewable energies and energy efficiency in Greece (TARES+)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EU (54%) and German Federal Ministry for Economic Affairs and Energy (BMWi) (46%)/

VS/2015/0353/Duration:2016-2017

Total Budget (M€) / Involved Partners

2,78M€/ Greek Ministry of Environment and Energy (YPEN), Structural Reform Support Service, (SRSS), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, BMWi, Centre for Renewable Energy Sources and Saving (CRES) (as subcontractor), National Technical University of Athens (NTUA) (as subcontractor).

Project objective, topic and results

The project "Technical Assistance for Renewable Energies and Energy Efficiency in Greece" (TARES+) was initiated in the context of the Strategic Partnership between Greece and Germany in the field of renewable energy sources (RES) and energy efficiency (EE) and in the framework of the Structural Reform Support Service (SRSS) of the European Commission (EC). The TARES+ project was implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) on behalf of the Federal Ministry for Economic Affairs and Energy of Germany (BMWi). The main beneficiary of the project was the Greek Ministry of Environment and Energy (YPEN).The TARES+ project has been initiated in the context of the Strategic Partnership between Greece and Germany in the field of renewable energy sources (RES) and energy efficiency (EE) with the support of the Structural Reform Support Service (SRSS) of the European Commission. The main beneficiary of the technical assistance provided under the TARES+ project was the Greek Ministry of Environment and Energy (YPEN). The project has been jointly financed by the European Commission and the German Federal Ministry for Economic Affairs and Energy (BMWi). The total budget of the project amounted to 2,775,521.98 €, of which 1,500,000 € were provided by the EC under the Grant Agreement VS/2015/0353 and 1,275,521.98 € were provided by BMWi. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has been commissioned by BMWi with the implementation of the project. The project had a duration of 22 months from January 2016 to October 2017.

The project objectives as reflected in the various activities of it are among others the following:

- Transition to a new RES support scheme, in particular detailed analysis of the LCOE from RES investments in terms of project and equity taking into consideration the new project categories as set by the 2014 EU state aid guidelines for energy and environment.
- Transfer of forecasting and balancing obligations to RES generators with a view to improving forecasting in order to limit deviations between day-ahead scheduling and actual dispatch, and thus leading to a near-optimal operation of the system.
- Support a pilot project for the cost-competitive integration of RES in an island electricity system with an analysis of technical and economic data for maximizing penetration of RES in non-interconnected islands.

Topics addressed in SET Plan Integrated Roadmap

Integrated Challenge 3: Action 8

Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level

Some of the main topics addressed by the specific project are fully in line with the ELECTRA activities. These topics involve stable operation of island power systems at high RES penetration, analysis of control methods to ensure the frequency and voltage stability of the system, as well as flexibility of resources that could be used as reserves to ensure power stability. The ELECTRA project has been in details presented to partners of the consortium and, in particular, one representative of the funding company has visited CRES in the frame of the 2nd REX call in order to implement and conduct simulation tests related to the inertia response and stability of islanded systems. Overall, the exchange of expertise through the REX activity as well as the participation of CRES to the project facilitated the significant knowledge transfer from ELECTRA to the TARES+ project.

3	**R&D PROJECT TITLE: The Green Island Project- AI STRATIS** ***Funding Frame / Funding Agency / Contract number / Project Duration*** National Strategic Reference Framework 2007–2013 (NSFR 2007-2013) (100%)/Duration 2013-2015 Development Framework 2014-2020 (PA 2014-2020) (100%)/Duration 2017-2022 ***Total Budget (M€) / Involved Partners*** 8,5M€/Centre for Renewable Energy Sources and Saving ***Project objective, topic and results*** The project objectives involve among other activities the significant upgrades of the power system of the island in order to be able to accommodate a significant amount of RES. The target penetration is deemed at 100% starting gradually from levels 60% of RES energy and above until the complete deactivation of the island's diesel generators. The analysis of the resources portfolio and control strategies of the project has been completed in the first phase and the following stage of it involves the implementation and demonstration of the selected solutions. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The analysis of the system operation in the frame of the project involved solutions that will ensure stability of the system as well as infrastructure that could accommodate future, state-of-the-art control strategies. The involvement of CRES in the analysis of the power system operation facilitated the knowledge transfer from ELECTRA to the Green Island project, and thanks to the ELECTRA work new insights were gained with regard to the system behaviour and analysis under high RES penetration in addition to ideas about control strategies that could be used in the specific study.

	Italy
1	**R&D PROJECT TITLE: F.E.R.G.E.- Devices, techniques enabling the utilization of renewable energy sources driving towards a green economy (High tech district "Smart Power System)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** PON R&C 2007-2013 / Ministry of Education, University and Research (MIUR)/ PON03PE_00177_1 / 3 years. ***Total Budget (M€) / Involved Partners*** 10.4M€ Smart Power System Scarl, AIRMEC S.r.l, Interuniversity Consortium for Research on metrics and measurement technologies of the electrical systems - Me.S.E., ENEA, Second University of Naples - SUN, University of Naples Federico II, University of Salerno. ***Project objective, topic and results*** The strategic objective of this research project is to design, develop and manage devices, enabling technologies, innovative processes and systems for the production of energy from renewable energy sources and smart integration into electrical systems. These issues play a crucial role in the context of a new energy model that has to be environmentally sustainable (Green Economy), based on RES, Distributed Generation and Smart Grids. The attention of the proposed topics is focused on the study, analysis and development of the following issues: i) technology and engineering of energy production systems from solar photovoltaic, wind (mini-micro wind generators) and water (micro hydroelectric turbines), with the indispensable electronic energy conversion systems, the measurement and control devices for network integration and delivery of produced energy; ii) strategies for management and control of production plants and for their optimized integration in microgrid, even in presence of electric storage systems; iii) technologies and techniques for the development and management of electric storage systems to be used in multisource RES systems; iv) methodologies for evaluation of LCA of devices, components and generation systems; v) technologies and processes for photovoltaic modules recycling at the end of their life and for the sustainable recovery of raw materials. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 2: Theme 3 Integrated Challenge 3: Theme 7 Integrated Challenge 4: Theme 10 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The strategic objective of FERGE covers a wide research area with a common denominator: the enhancement of the efficiency in the use of energy; this target is pursued both in terms of improvement in the production of energy from renewable energy sources and consequent smart integration into electrical systems and by the development of innovative solutions for building efficiency applications. Therefore, many common actions connect FERGE and ELECTRA even if at a different geographic level (respectively national and European). The advanced results reached in ELECTRA researches could integrate in FERGE results (methodologies, devices and laboratories). A deeper analysis should be conducted to understand the effective benefits of a potential (even if partial) integration.
2	**R&D PROJECT TITLE: M.I.C.C.A. – D.C. and A.C. Hybrid Microgrids (High tech district "Smart Power System)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** PON R&C 2007-2013 / Ministry of Education, University and Research (MIUR)/ PON03PE_00178_1/ 3 years.

	Italy
	Total Budget (M€) / Involved Partners 6.4 M€ Smart Power System Scarl, CNR - National Research Council, CO.M.E.A. Consortium, E.C.U. S.r.l., ENEA, Euro_Soft S.r.l., Getra Group, Polo Tecnologico dell'Ambiente S.c.p.A., Second University of Naples – SUN, Sudgest Ambiente S.c.a.r.l., University of Naples Federico II, University of Naples Parthenope, Wattsud L.E.P. S.p.A. ***Project objective, topic and results*** The main goal of MICCA project is to develop innovative technologies and management/control strategies aiming to increase performances and functionalities of the different components and subsystems of a micro-grid, moreover to improve the energy quality and efficiency. Traditional electric components/subsystems have actually good performance and efficiency but significant improvements can be still obtained by introducing innovative components with a smart regulation, while other improvements can come by setting up proper control and management techniques acting at "system" level. In the MICCA Project the following activities will be mainly developed: 1. new components will be developed to be utilized in a so-called "smart-power substation" MV/LV, in order to manage bidirectional power flows, monitor and regulate voltage, increase the robustness of the grid against power quality problems and, them increase service availability. In particular electromagnetic components/subsystems will be set up, together with power electronic devices, sensors, based on properly adapted hardware and software for the data acquisition platforms and local and remote control. 2. development of integrated systems including high overall performance micro-cogenerators with a reduced environmental impact, combined with electrical energy smart storage systems to be installed in multi-users systems guaranteeing high energy efficiency, good power quality level, autonomy of the electrical grid, reduced weights and volumes and compatibility with domestic installations. 3. development of innovative hardware devices and software for the monitoring, management and control of micro-grids having variable extension and composition; development of proper transducers and apparatuses for the energy measurement in presence of high variable and non-sinusoidal parameters of the network; analysis and management of data; reliability and availability of the service; coordination of production and storage sources. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Theme 6, Theme 8. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The issue of instruments oriented monitoring and managing the microgrid, pursued with MICCA corresponds with the actions of SET PLAN Integrated Challenge 3. In particular, the advanced research results reached in ELECTRA about the following actions: i) development of new methodologies/tools to improve asset management and operation of distribution and transmission grids; ii) planning of innovative and original grid topologies, could represent an important basis for MICCA. Therefore, any progress in this field can benefit by these developments. More in detail, ELECTRA could theoretically advantage the design of the "smart power components" in order to transmit correspondent specific knowledge.
3	**R&D PROJECT TITLE: METER - Metrology for Energy and Net (High tech district "Smart Power System)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** PON R&C 2007-2013 / Ministry of Education, University and Research (MIUR)/ PACPON03PE_00175_1/ 3 years.

	Italy
	Total Budget (M€) / Involved Partners 8,1 M€ Business Solution s.r.l, COMEA Consortium, CORISA consortium, Ditron s.r.l, ENEA, ITALDATA S.p.A., Interuniversity Consortium for Research on metrics and measurement technologies of the electrical systems - Me.S.E., Second University of Naples - SUN, SUDGEST AMBIENTE S.c.a.r.l., University of Salerno ***Project objective, topic and results*** METER project aims to develop solutions (e.g., systems and hardware /innovative software platforms), methods (e.g., information processing algorithms, certified measurements) and technologies (sensors, control and adaptive protection) to improve the control processes and management of modern power grids, increasing penetration and efficiency of distributed generation of energy, coordinated and synergic management of geographically distributed energy resources. The project will produce new knowledge and innovative technological tools to support the development of modern energy networks, with particular attention to the following areas: - Power Quality Metrics for the Smart Grid. - Semantic technologies for the sharing of information between systems contributing to the electricity grid management. - Cooperative sensor networks for proactive control structures in presence of uncertainty grid operation (e.g. renewable generation). ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 1: Theme 1 and Theme 2. Integrated Challenge 3: Theme 6. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Among the results of the project, METER considers the acquisition of advanced knowledge about the development of solutions and methods (algorithms of information processing of the latest generation) aimed at increasing the efficiency of processes of control and management of modern power grids in line with the objectives of Integrated Challenge 3: Theme 6. At the same time, other results expected from the project concern technologies connected with distributed smart meters and in particular the design of advanced system to real time measurement in smart grid context. Therefore, a profitable connection between ELECTRA and MICCA results could represent a good starting point for advanced research into intelligent automation sector as in Actions of Themes 1 and 2 (Integrated Challenge 1).
4	**R&D PROJECT TITLE: Development and management of distribution grid** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Approved project at Ministerial level with National funding *(RdS- Research Fund for the Italian Electrical System)* ***Budget/Partners*** Total Budget & funding 2015-2017: 5 M€ / RSE (Some activities involve collaboration with DSO and industrial manufacturers) ***Project objective, topic and results*** The project aims to develop a microgrids control framework for both grid connected and island mode operation. Both MV and LV microgrids are considered. The project tackles control issues related to uncertainties due to renewable sources, grid congestions, network constraints, together with energy management optimization. The EMS includes economic optimal dispatching of the microgrid resources taking into account the availability and the current status of each resource. Load and

	Italy
	generation forecasts, are the input data to the microgrid management system. For renewable resources, meteorological forecasts algorithms are developed and integrated in the system. Automatic switching to island operation when needed, and seamless resynchronization with the main grid are also considered in the project. Another topic is about the possible organization and regulatory framework that can enable the real deployment of microgrids in the distribution networks. In addition to theoretical studies and simulations the project implements the proposed control and management solution in a LV Distributed Generation test facility able to actively interact with the DSO for joint research activities. The project develop an aggregated management of the energy resources connected to the same distribution grid behaving as a single unit for the rest of the grid. This enables a decentralized control system architecture for the distribution system. Each microgrid can be also considered as subject for ancillary services bids and dispatching. The possibility of island operation, by controlling the load and generation balance into the microgrid, increases the network reliability for the users in case of major outages. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The main topics for interaction with ELECTRA include: algorithms for voltage control, optimal management of flexible resources, load and generation forecasts including meteorological forecasts algorithms, standard data model and protocols for information exchange and interoperability, models, simulation environments and test infrastructures. The relationship between the national project and ELECTRA activities about the Web of Cells (WoC) concept may be bidirectional. The national project can share knowledge and results related to the relevant topics. The ELECTRA project can lead to a possible generalization of the concepts and results already obtained in the national project and design a path for convergence and harmonization of national emerging solutions in a common European framework. The expected added values are: an integrated vision of the different architectural concepts, with possible view of microgrids as specialization of the WoC concept, and the identification of possible regulation and business models, at European and National level, facilitating the integration and the deployment of the solutions.

	Latvia
1	**R&D PROJECT TITLE: CloudGrid (Transnational Cloud for Interconnection of Demonstration Facilities for Smart Grid Lab Research & Development)** ***Funding Frame/Funding Agency/Contract number/Project Duration:*** ERA NET Smart Grid +/ funded / 01.03.2016- 31.03.2019. ***Budget/ Total Budget:*** € 2,300,000. (Funding: € 1,900,000.-) Project Coordinator: STRI (Sweden). Project Partners: NTNU (Norway), Chalmers (Sweden), ZHAW (Switzerland), IPE (Latvia). ***Project objective and/or results:*** In the CloudGrid project, R&D on smart grid solutions is focusing on three main areas: - System stability - Ancillary services & energy management - Converter interoperability The method used in the CloudGrid project to improve the research is to increase the cooperation between the partners based on an interconnection between smart grid labs. The establishment of this transnational smart grid cloud shall facilitate possibilities to validate research result in different laboratory environment, in this way the project will be able to provide solutions with a broader level of validation and suitable for a wider range of equipment. Relation and contribution to the proposed activity: These three research areas are highly complementary, providing the project with a holistic view of the challenges of the future grid: i) Stability is a prerequisite for operating the power system, and there is a need to develop new solutions and methods in order to maintain system security in a system which is utilised in an increased and altered manner, ii) With new components and systems integrated in the power system, there will be new opportunities to support the system through additional ancillary service solutions and novel strategies for energy management and market concepts. Iii) An increased amount of power electronics in the system is an enabler for increased flexibility. However, this implies increased requirements on compatibility and interoperability between the various converters. ***Topics Addressed in SET Plan Integrated Roadmap:*** Integrated Challenge 3: Theme 6. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Added value expected by the proposed cross-European cooperation: Smart Grid Lab interconnection, resource and grid solutions integration. www.stri.se/cloudgrid

Norway

1 R&D PROJECT TITLE: FlexNet - Flexibility in the future smart distribution grid

Funding Frame / Funding Agency / Contract number / Project Duration:

National innovation/research project within the ENERGIX program of the Norwegian Research Council. Additional funding from Norwegian DSOs, TSO, vendors and community.
Project period: 2015-2017 (3 years)

Total Budget (M€) / Involved Partners

The total budget is app. 2 mill. Euros (including in-kind from partners).
The main involved partners are: BKK (DSO), NTE (DSO), Hvaler Municipality, SINTEF Energy Research, SINTEF ICT, Smart Innovation Østfold. (In total there are 23 partners within the project.)

Project objective, topic and results

The main objective of the project is contributing to increased flexibility in the future smart distribution grid by demonstration and verification of technical and market based solutions for flexibility, on different grid levels and for different stakeholders.

This should be performed through the following sub-targets:

- Demonstrate and verify the potential for flexibility as active customers with demand, generation and/or storage of energy.
- Demonstrate and verify aggregated flexibility at several active customers.
- Demonstrate and verify how energy storage can be used/localized for largest possible benefit for both the distribution grid and the power system.
- Demonstrate and verify flexible operation of the grid through real time monitoring and control.
- Contribute to efficient handling of ICT security events related to monitoring and control in the distribution grid.
- Ensure right to privacy by increasing amount of information generated from increased monitoring and control.

Demonstration activities are important within the FlexNet project, and these will be performed within the grid areas of both BKK (Bergen) and NTE (Steinkjer), and at Hvaler. The demonstration concepts to be tested are related to the future MV/LV substation and automated grid operation, prosumers in weak distribution grid and flexibility at prosumers.

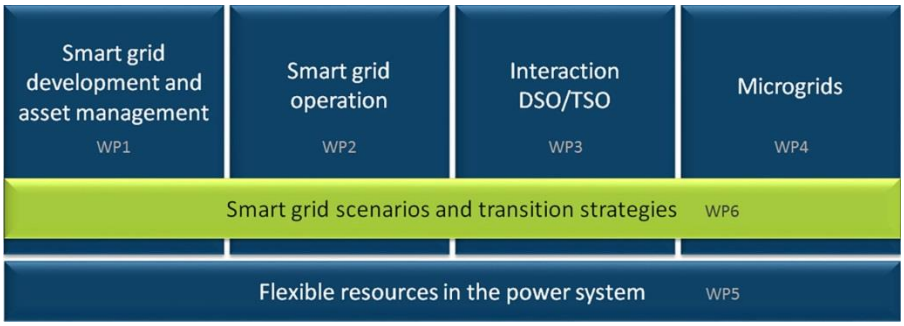
The activities within the FlexNet project are divided in the three thematic areas, and several research questions are defined for the thematic areas.

	Customer focus <----------> Grid focus		
Demo location	**Flexibility prosumers**	**Flexibility prosumers and consequences for the grid**	**Flexible grid operation**
BKK (Bergen)		X	X
NTE (Steinkjer)	X	X	
Hvaler	X		

Topics addressed in SET Plan Integrated Roadmap

Theme 1: Engaging consumers through better understanding, information and market Transformation
Theme 2: Activating consumers through innovative technologies, products and services
Theme 7: Unlocking the potential of energy storage and conversion of electricity to other energy carriers
Theme 8: Providing the energy system with flexibility, security and cost-effectiveness

	Norway
	Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level Monitoring and control for more flexible operation of the distribution grid.
2	**R&D PROJECT TITLE: Spesnett – Power (Finished)** ***Funding Frame / Funding Agency / Contract number / Project Duration:*** National innovation/research project within the ENERGIX program of the Norwegian Research Council / Additional funding from Energy Norway (association of DSOs) Project period: 2013-2016 ***Total Budget (M€) / Involved Partners*** The total budget is app. 1 mil Euro Involved partners: SINTEF Energy Research, Luleå University of Technology and several DSOs in Norway ***Project objective, topic and results*** The project's main idea is that "smarter" management, planning, measurement and control of power quality will reduce the need for extensive and very costly reinforcements of network in Norway. This will save utility companies and thus network customers large amounts in years ahead and also make new energy-efficient technologies more cost effective to use. The project will contribute to both rationalize the voltage quality and reduce costs of grid reinforcement due to challenging electrical equipment and appliances installed at end-users. ***Topics addressed in SET Plan Integrated Roadmap*** Theme 6: Modernising the European electricity grid and establishing synergies between the various energy networks Theme 8: Providing the energy system with flexibility, security and cost-effectiveness ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The following workpackages in Spesnett are the most relevant for ELECTRA IRP: WP 4: Smarte Grids and Power Quality WP 5: Distributed generation in LV-net
3	**R&D PROJECT TITLE: Centre for Intelligent Electricity Distribution (CINELDI)** ***Funding Frame / Funding Agency / Contract number / Project Duration:*** Specific financing scheme called Centres for Environment-friendly Energy Research (FME) is operated by The Research Council of Norway and covers all together 11 centres and app. 130 mil Euro. CINELDI has duration eight years. ***Total Budget (M€) / Involved Partners*** App. 40 mil Euros SINTEF Energy Research, Norwegian University of Science and Technology (NTNU) and 29 industrial partners. ***Project objective, topic and results*** CINELDI targets innovation on the system level of the cyber-physical distribution system of 2030-2040. The main topics of research are smart grid development, asset management and operation, interaction between the distribution system operators and the transmission system operator, microgrids and utilization of flexible resources in the system. Altogether, this will provide input to smart grid scenarios

	Norway
	and transition strategies for the Norwegian distribution system.  ***Topics addressed in SET Plan Integrated Roadmap*** Theme 8: Providing the energy system with flexibility, demand response, security and cost-effectiveness ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** WP2 Smart Grid Operation and WP3 Interaction TO/DSO are the most relevant for ELECTRA. Several Use Cases from ELECTRA have been studied within CINELDI and in particular PVC/PPVC.

	Poland
1	**R&D PROJECT TITLE: Local Balancing Area as element increase the safety and efficiency of the distribution system operation - ENERGA LOB** ***Funding Frame / Funding Agency / Contract number / Project Duration*** National Centre for Research and Development (NCBR) and National Fund for Environmental Protection and Water Management (NFOŚiGW) Project reference: GEKON1/O2/213880/30/2015 – ENERGA LOB Funded under: GEKON Programme – Generator of Ecological Concepts From 2016-01-01 to 2017-12-31, 24 months, ongoing project. ***Total Budget (M€) / Involved Partners*** Total Budget EUR 4 723 510 Involved Partners: 1. ENERGA OPERATOR SA, Poland 2. INSTYTUT ENERGETYKI, Poland 3. UNIWERSYTET ZIELONOGORSKI, Poland ***Project objective, topic and results*** The project aims to demonstrate an ability of a part of a power system to locally balance its load by distributed energy resources with an assistance of storage. An important feature of the demonstration is that the distinguished part of the power system can remain connected to the rest of the power system, which is in contrast to a typical microgrid demonstration, where the system under test is isolated from the main power system. This is in line with the Web-of-Cell concept, where all cells stay interconnected to each other and operate synchronously. The project is a real life demonstrator encompassing an area with a total demand of 1,2 MW supplied by several wind turbines and balanced by 0,75 MW battery storage system. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3: Theme 7, Theme 8, Theme 9 ***Added value expected by the proposed cross-European cooperation***: This is a national project, i.e. no international cooperation was involved. However, it serves a role of a demonstration and experience exchange platform for international collaborators of the Polish project partners.
2	**R&D PROJECT TITLE: Using real-time measurements for monitoring and management of power transmission dynamics for the Smart Grid - REAL-SMART** ***Funding Frame / Funding Agency / Contract number / Project Duration*** FP7 /European Commission, Directorate-General for Research & Innovation Project reference: 251304 - REAL-SMART Funded under: FP7-PEOPLE From 2010-09-01 to 2014-08-31, closed project. ***Total Budget (M€) / Involved Partners*** Total Budget EUR 1 085 754 Involved Partners: 1. IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE, United Kingdom 2. ABB SCHWEIZ AG, Switzerland 3. ABB AS, Norway 4. ABB SPZOO, Poland 5. FINGRID OYJ, Finland

	Poland
	6. GENERAL ELECTRIC DEUTSCHLAND HOLDING GMBH, Germany 7. TECHNISCHE UNIVERSITAET GRAZ, Austria 8. NATIONAL GRID ELECTRICITY TRANSMISSION PLC, United Kingdom 9. STATNETT SF, Norway 10. AALTO-KORKEAKOULUSAATIO, Finland ***Project objective, topic and results*** Project addresses the topic of observability of the power system, particularly on the transmission level. It focuses on the employment of WAMS systems for early detection of stability problems also including the impact of large wind farms as well as industrial loads. On the outcomes the project supports control actions and decision making on the short term and advanced grid planning and operation on the long term. These actions support activities undertaken in ELECTRA project in particular in WP5 Increased Observability. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3: Theme 7 ***Added value expected by the proposed cross-European cooperation***: Project results are likely to influence the current operational practice at the transmission level, since one of the partners is a TSO. These results may also be used as an input in other EU projects related to grid operation planning, such as the INTERPLAN project.

	Portugal
1	**R&D PROJECT TITLE: ESGRIDS – Enhancing Smart Grids for Sustainability** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Portugal2020 Programme, Portuguese Foundation for Science and Technology (FCT), reference 03/SAICT/2015, 3 years ***Total Budget (M€) / Involved Partners*** 2.1 M€ / INESC TEC, UBI, Univ. Coimbra ***Project objective, topic and results*** Develop new scientific methodologies and solutions, using a multidisciplinary approach that involves the main actors of the smart grid, to meet the challenges of the future electrical power system. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 1 (theme 1 and 2), Challenge 2 (theme 3), Challenge 3 (theme 8), Challenge 4 (theme 10) ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Part of the work in ESGRIDS is dedicated to providing the energy system with flexibility, which is a crucial aspect for the Web-of-Cells concept. Thus, the methodologies developed in ESGRIDS can be very useful for the future development of the concepts addressed in ELECTRA.
2	**R&D PROJECT TITLE: SmartGuide – Defining Planning and Operation Guidelines for European Smart Distribution Systems** ***Funding Frame / Funding Agency / Contract number / Project Duration*** ERA-Net Smart Grid Plus Framework Program, Portuguese Foundation for Science and Technology (FCT), reference SmartGP/0002/2015, 3 years ***Total Budget (M€) / Involved Partners*** 0.2 M€ / INESC TEC ***Project objective, topic and results*** This project focuses on the development of improved planning and operating guidelines for European Smart Grids, considering renewable energy sources and the demand that arise from smart market applications (e.g. demand response, frequency control and reserves management) ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 3 (theme 6 and 8) ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Part of the work in SmartGuide is dedicated to optimizing the flexibility provided DER, which is a crucial aspect for the Web-of-Cells concept. Additionally, SmartGuide seeks to optimize network reinforcement and expansion by considering the optimal operation of flexible resources. Thus, the methodologies developed in SmartGuide can be very useful for the future development of the concepts addressed in ELECTRA.

3	**R&D PROJECT TITLE: GReSBAS – Grid Responsive Society Through Building Automation Systems** ***Funding Frame / Funding Agency / Contract number / Project Duration*** ERA-Net Smart Grid Plus Framework Program, Portuguese Foundation for Science and Technology (FCT), reference SmartGP/0001/2015, 3 years ***Total Budget (M€) / Involved Partners*** 0.4 M€ / INESC TEC ***Project objective, topic and results*** The main objective of the GReSBAS project is to implement and demonstrate an innovative gamification system for promoting Demand Response (DR) actions in buildings. This system will use building automation technologies and advanced gamification techniques for end-user engagement in order to enable the active participation of building occupants/owners in DR schemes. An important emphasis will be given to DR programs capable of supporting and improving the operation of distribution grids, namely for the purpose of peak shaving and congestion management. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 1 (themes 1 and 2), Challenge 2 (themes 3, 4 and 5) ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The work developed in GReSBAS will contribute to engage consumers in demand response schemes and to promote consumers' behavioural change towards more energy efficient behaviours. Furthermore, through demand response techniques, it will contribute to increase load flexibility in buildings. This flexibility is a very important aspect to operate the cells of the ELECTRA project in a more efficient and reliable way.
4	**R&D PROJECT TITLE: SusCity: Urban data driven models for creative and resourceful urban transitions** ***Funding Frame / Funding Agency / Contract number / Project Duration*** MIT|Portugal Programme, Portuguese Foundation for Science and Technology (FCT), reference MITP-TB/CS/0026/2013, 3.5 years ***Total Budget (M€) / Involved Partners*** 1.2 M€ / INESC TEC, Univ. Minho, Univ. Coimbra, IST, Nester, EDP Distribuição ***Project objective, topic and results*** This project aims at advancing the science of urban systems modelling and data representation supported by urban "big data" collection and processing, with the double objective of enabling and demonstrating a suite of new services that explore economic opportunities associated with the transition to sustainable urban systems. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 1 (themes 1 and 2), Challenge 3 (theme 9)

	Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level The work developed in SusCity, through demand response techniques, will contribute to increase load flexibility in buildings and cities. This flexibility is a very important aspect to operate the cells of the ELECTRA project in a more efficient and reliable way.
5	**R&D PROJECT TITLE:Best Case – Better Science Through Cooperative Advanced Synergetic Efforts** ***Funding Frame / Funding Agency / Contract number / Project Duration*** North Region Operational Program / ON.2 / SAESCTN-PIIC&DT/1/2011 / 2.5 years ***Total Budget (M€) / Involved Partners*** 7 M€ / INESC TEC ***Project objective, topic and results*** This project envisages a two level synergistic approach: 1) Strengthening the expertise in a set of core technologies within the electric energy system area and 2) Broadening the research scope to a set of enabling technologies from the Information and Communication Technologies (ICT) field. By embedding ICT with e energy system's core technologies, this project will leverage the development of a solid and mature Smart Grid concept with innovative solutions. ***Topics addressed in SET Plan Integrated Roadmap*** Challenge 1 (theme 1 and 2) ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The work developed in Best Case, namely the user engagement through ICT technologies, will contribute to increase load flexibility in distribution networks. This flexibility is a very important aspect to operate the cells of the ELECTRA project in a more efficient and reliable way.

	Spain
1	**R&D PROJECT TITLE: OSIRIS-Optimización de la Supervisión Inteligente de la Red de Distribución (Intelligent Supervision Optimization of the Distribution Network)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** RETOS-COLABORACIÓN 2014 / Ministry of Economy and Competitiveness (MINECO) / RTC-2014-1556-3 / 3 years ***Total Budget (M€) / Involved Partners*** 6.6 M€ Unión Fenosa Distribución, University Carlos III, ORBIS, NEORIS, ZIV Metering Solutions, STM, TECNALIA ***Project objective, topic and results*** Project objective is to develop tools and equipment to optimize the supervision of the smart grid under deployment. The main aim is to guarantee the proper operation of the AMI infrastructure from the communication point of view, which will allow knowing approximately the state of the grid since the communication technology uses the electrical infrastructure (PLC). The project proposes to monitor the MV and LV network by means of a recurrent communication with a reduced number of devices, complementing this information with a state estimator based on the historic data of a massive number of deployed devices (mainly smart meters and data concentrators). If in some grid points there is no communication, using complex analysis algorithms it is possible to conclude that there is an electrical supply problem at those points. The diagnosis can be extended with the analysis of losses, unbalance, etc. Going further, the project will try to study the possibility of a proactive mode, where the field devices can send their own diagnosis of the communication incident to a central platform. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 6 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The new control schemes to be developed in ELECTRA will largely rely on an increasing network observability. This is precisely the topic analysed in OSIRIS, for which network controllability is out of the scope. Concrete topics for interaction are state estimation algorithms and the use of historical network data for grid state diagnosis. Deeper analysis would be necessary to see if OSIRIS can apply and benefit using the ELECTRA observables.
2	**R&D PROJECT TITLE: FUTURE GRIDS-Nueva oferta tecnológica para las redes eléctricas inteligentes del 2020 (New technology offer for the 2020 Smart Grids)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** ETORTEK 2014 / Basque Government (Economic Development and Competitiveness Department) / IE14-389 / 2 years ***Total Budget (M€) / Involved Partners*** 1.7 M€ TECNALIA, BCAM (Basque Center for Applied Mathematics), University of the Basque Country ***Project objective, topic and results*** The general objective of FUTURE GRIDS is to investigate on the electrical networks research strategic lines as defined by the Basque Government and therefore contribute to increase the technological offer of the Basque industries in the electric power sector. FUTURE GRIDS is project that combines different so-called technological lines dealing with different

	Spain
	issues under the Smart Grids umbrella. Among them, the relevant sub-projects for ELECTRA are the following: - Technological Line 2: "Advanced operation of LV networks", which has two main objectives: (1) development of tools for disaggregation of loads from smart meter data, and (2) determination of the LV topology from smart meter data. Main results in this activity are related to load monitoring, modelling and simulation, including tools for load disaggregation at domestic level, eliminating the need of sub-metering applications. In addition, algorithms for identifying the LV grid topology with some restrictions have been developed. - Technological Line 3: "Design of a PHIL system for smart grid applications", which is organised around 4 objectives: (1) PHIL system analysis in the scope of Smart Grids, (2) revision of applications of Smart Grids using PHIL, (3) analysis of the power interface problems in PHIL systems, and (4) specification and design of a PHIL platform in the Smart Grids Laboratory of TECNALIA. Main result of this activity is the specification and conceptual design of a PHIL platform adapted to the equipment and applications currently running in the Smart Grid Laboratory of TECNALIA. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 1: Theme 1 and Theme 2. Integrated Challenge 3: Theme 6 and Theme 8. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** In a similar way to OSIRIS, the issue of increasing the grid observability is one of the corner stones of ELECTRA and clearly any development in this field can benefit the ELECTRA proposals and save a lot of effort which can be oriented to grid controllability. To be more precise, Technological Line 1 can be of interest for ELECTRA from the point of view of the network observability in the LV level: LV distribution network is no longer blind for the operators; smart meters will play an important role as the main electrical sensors in the LV grid, far beyond the billing process. Even when it is not "the core of ELECTRA" (since it is more an "instrumental issue" to reach the objectives), Technological Line 2 is relevant for ELECTRA since PHIL infrastructures will be used in ELECTRA for validation purposes (WP7). Any development in this type of platforms will be exploited in ELECTRA/WP7.

	Turkey
1	**R&D PROJECT TITLE: Smart Grid Controller for PV Network** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Approved joint project at Ministerial level between TUBITAK and KACST (King Abdulaziz City for Science and Technology) with KACST funding. The duration is five years. ***Budget/Partners*** Total Budget & funding 2011-2016: 1.5 M$. Partners: TUBITAK and KACST. ***Project objective, topic and results*** The purpose of this project is to develop a smart grid photovoltaic network controller that optimizes the operation of the Hybrid PV integrated LV distribution system in Saudi Arabia LV distribution network. The whole research is divided into several phases. The first phase which is the scope of this project focuses on the development of hardware and software of a smart grid PV network controller with its communication infrastructure performing mainly the energy management of the PV Hybrid generating units in the controlled system. The following phases could also be coordinated focusing on system improvement with protection, islanding, power quality, etc. In the Smart Grid Concept, training subjects were defined and taught to KACST staff such as protection, distribution, smart grid, MathLab, PLC, E-Plan, etc. In the scope of the "Smart Grid Controller for LV PV Network" project, a prototype system is designed considering scalability and interoperability which controls, monitors, tracks and self-heals PV power plants that are connected to the electrical grid on LV side as Distributed Energy Resources (DER). The scalability property makes the system open for expanding easily to integrate dispersed PV generation to the grid with central control which is significant considering the increasing interest and growing rate of PV power plants in Saudi Arabia. By the help of the scalability property of the designed system, it is observed that, the system can act as central management and integration interface for DERs especially for PV power plants since the system has both protection and communication layers that are configured considering power quality characteristics of Saudi Arabia Electricity Grid and the selected inverters. The designed system has interoperability property on both selected communication protocols and hardware configuration. The system has MODBUS/TCP support which is the industrial wide protocol for communicating with field devices such as input-output modules, protection relays, sensors, communication interfaces of PV inverters and so on. Therefore, any device from any brand that is needed for implementation of PV power plant can easily be integrated to the communication interface of the designed system. The system has also support for IEC61850 communication protocol which is the state of the art substation automation protocol that is used by system operators for this century. And by the help of supporting IEC 61850 protocol, the system can also be integrated to existing control system or mechanism of system operators and can act as the part for managing DERs considering PV power plants. Having interoperability on hardware configuration on the designed system enables changing the design for desired places and configuration and adding additional devices for extra functionalities. As an overview, a prototype controller system for LV PV Network is developed considering the necessities and functionalities of smart grid concept. As a result, the developed system is realized considering being capable of adding "Demand Response", "Reactive Power Control" and "Smart Home" properties since the system has full control and communication support for PV inverters. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The main topics for interaction with ELECTRA include: supporting reactive power generation from

	Turkey
	renewable energy sources, being capable of implementing demand response, optimal management of flexible resources, load and PV generation data archiving in order to utilize the data on decision making process about PV energy; standard data model, protocols for information exchange and interoperability, models, simulation environments and test infrastructures. The relationship between the national project and ELECTRA activities about the use cases which are related with the voltage and frequency controls. The expected added values are: Developing new control and communication structure for designing novel control schemes for ELECTRA Project since the national project paves the way developing new control algorithms by having full control and test possibility that can be done on PV inverters and MV-LV grid.
2	**R&D PROJECT TITLE: Protection of Power Electronically Interfaced LV Distributed Generation Networks (PRO-NET)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** European Commission 7. Framework – ERA-NET Project 2. Call at 2011. Duration: 2013-2016 ***Total Budget (M€) / Involved Partners*** Budget: 1 M€. Partners: TUBITAK MRC Energy Institute, YILDIZ Technical University (Turkey), AALBORG University (Denmark), SIMULA Research Laboratory (Norway) ***Project objective, topic and results*** The objective is to develop intelligent and adaptive control and protection strategies based on the communication technology to response to the system condition variations, such as; the characteristics of the DG generation units in on-line operation, to effectively protect the system, to improve system stability during power system faults and performing stable operation of an island microgrid and conduce resynchronization of the islanded microgrid after a fault. In this study, an adaptive relay coordination strategy is proposed and protection recommendations related to analysis of the various fault scenarios for DG based distribution systems are given. The contribution of the study is to combine the impacts of availability scenarios for multiple DG units with protection schemes in a dynamic structure, which is ignored in previous studies that consider static structures without possible operating modes related to DG unit's availability issue. Besides, the proposed methodology offers relay coordination in such different operating modes, and fast fault isolation compared to conventional protection scheme considering different DG units' online/offline condition scenarios and fault conditions. The algorithm is tested on the IEEE 4-node system and case studies including the possible DG units in several locations within the grid structure are evaluated for different fault locations. Also an adaptive protection strategy for a distribution system with DG integration is proposed. The proposed strategy considers both grid-connected and islanded operating modes while the adaptive operation of the protection is dynamically realized considering the availability of DG power production (related to faults or meteorological conditions) in each time step. Besides, the modular structure and fast response of the proposed strategy is validated via simulations conducted on the IEEE 13-Node Test System. The developed algorithm is performed in a Hardware In the Loop (HIL) test system in order to maintain the performance of the output of the project which deals with deeply adaptive protection scheme. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 9

	Turkey
	Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level Since as a result of the project, an intelligent and adaptive control and protection strategies based on the communication technology is developed, the gained knowledge and experience from this project will pave the way reaching the objectives that are defined in the WP6 - Control schemes for the use of flexibility and the T7.1: Requirements and KPIs for the evaluation and validation of future integrated frequency and voltage control algorithms in WP7.
3	**R&D PROJECT TITLE: Feeder Automation for Istanbul European Side MV Distribution System (TUDOSIS)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Project Client /funding agency: Istanbul Bogazici Electricity Distribution Company (BEDAS), Project Duration: 1996 – 2006 ***Total Budget (M€) / Involved Partners*** Budget: 6 M$. Project Developer: TUBITAK Marmara Research Center Energy Institute – TURKEY, Project Client: Bogazici Electricity Distribution Company (BEDAS) ***Project objective, topic and results*** The topic is developing feeder automation for Istanbul European Side MV Distribution System by updating to the single MV (34.5kV) level in big cities which consists of having less MV/MV transformer substations, less MV feeders, requirement of easy and practical operation of the network, and requires a Distribution Automation System (DAS) for substations and MV feeders. Considering the topic, the objectives of the project are minimizing the duration of electricity cut off because of problems in MV feeders, improving operational performance through centralized monitoring and control and preventing equipment breakdown and prolong system lifetime. In the scope of TUDOSIS project, a DAS is developed which has major functions such as monitoring and data acquisition, remote control, automatic fault detection, Isolation and service restoration. What is more, a MV transformer center equipped with TUDOSIS and Remote Terminal Units (RTUs) of TUDOSIS which consists of DTTU (Distribution Transformer Terminal Unit): used in Distribution Stations, LETU (Line End Terminal Unit): used in Switching Stations, STU (Substation Terminal Unit): Substation's remote terminal units and CCTU (Control Centre Terminal Unit): Used in Control Centre. The project was performed at the BEDAS MV distribution network for 400 distribution transformer and 3 regional control centers. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 8 and Action 9 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Since in the scope of the TUDOSIS project a feeder automation system is developed, the gained know-how and the experience paves the way catching the targets that are defined in WP 5 - Increased Observability, WP 6 - Control schemes for the use of flexibility and WP 8 - Future control room functionality (especially for T8.3: Development and demonstration of decision support prototypes for system operator control room functions and T8.4: Consolidation of Experiences from decision support prototypes experiments and interactions with DSOs and TSOs).

	Turkey
4	**R&D PROJECT TITLE: Monitoring and Forecasting System Development for Wind Generated Electrical Power in Turkey (RITM)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Project Client /funding agency: A Ministerial supported project which has been developed by TUBITAK MRC Energy Institute, Project Duration: 2010 – 2017 ***Total Budget (M€) / Involved Partners*** Budget: 3.5M$. Project Developer: TUBITAK Marmara Research Center Energy Institute – TURKEY, Project Client: The Ministry of Energy and Natural Resources ***Project objective, topic and results*** With this project, it is aimed to provide large-scale integration of Wind Power Plants (WPPs) to Turkey Electricity System. In this context, a wind power system monitoring and forecasting system will be developed and disseminated throughout Turkey. In the project, which is designed for the generation of a large-scale electricity from wind resource and determination of the necessary measures for the integration of wind power plants (WPPs) with electrical systems, monitoring and forecasting system basically consists of five sub-system which can be given as; WPP Measurement Sub-System, Wind Forecast Sub-System, Forecast Subsystem of Electrical Power That Will Be Produced From The Wind, Monitoring and Prediction Center Sub-System, User Sub-System. As a result of the project, a secure and reliable system located at General Directorate of Renewable Energy under The Ministry of Energy and Natural Resources which have the following properties; Data Storage, Wind data from wind masts, Power data from monitoring equipment, Turbine status data from SCADA, Mesoscale forecasts and Data processing- forecasting with providing requested data through the client software. ***Topics addressed in SET Plan Integrated Roadmap*** Integrated Challenge 3: Action 9 ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Since in the scope of the RITM project a Monitoring and Forecasting System for wind generated electrical power is developed, the gained know-how and the experience paves the way catching the targets that are defined in WP 5 - Increased Observability (especially for T5.1: Adaptive assessment of future scenarios and mapping of observability needs and T5.2: Observables for Distributed Local Control Schemes).

	UK
1	**R&D PROJECT TITLE: Consortium for Modelling and Analysis of Decentralised Energy Storage** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EPSRC (EP/N001745/1) / Duration: 01/10/15 – 30/09/18 ***Total Budget (M€) / Involved Partners*** £1,136,810 / Partners: **University of Leeds**, Birmingham City Council, Department for Energy and Climate Change (DECC), EDF Energy, GDF Suez (UK), Highview Power Storage, Hubbard Products Ltd, Leeds City Council, Leeds City Region Enterprise Partnership, Moixa Energy Holdings Ltd (group), Scottish and Southern Energy (SSE), Tata Steel, UK Power Networks ***Project objective, topic and results*** This project will use a variety of tools and methods, including technology validation, techno-economic modelling, innovation studies and public attitude surveys, to address specific barriers to the deployment of city-scale energy storage and demonstrate these methods and tools through a number of case studies analysing opportunities for energy storage deployment in the cities of Birmingham and Leeds. Techno-economic modelling will consider specific (rather than generic) distributed energy storage technologies based on validated data from laboratory and field trials and not idealised data from the literature; project team members previous work on policy, regulatory and business models will draw on the real-world experience of the project partners in trying to make a business from operating distributed energy storage in current and likely future market conditions; and the project team members work on public attitudes will be the first study of its kind in the UK to examine distributed energy storage.[28] ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1**: Theme 1, Theme 2. **Challenge 3**: Theme 7, Theme 9. **Challenge 4**: Theme 11. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** This project will increase the overall competitiveness of the electricity market in the context of storage as a service. The level of decentralised control investigated within the scope of this project will be novel, especially with any potential trials of decentralised storage with the participating DNOs. This UK focused project will consider techno-economic modelling suited to UK situation, while a broader engagement will support an assessessment of its general applicability to different regulatory, economic and technical grid characteristics.
2	**R&D PROJECT TITLE: Stability and Control of Power Networks with Energy Storage (STABLE-NET)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EPSRC (EP/L014343/1) / Duration: 30/09/14 – 29/09/17 ***Total Budget (M€) / Involved Partners*** £1,048,080 / Partners: **Imperial College London**, Alstom Grid Ltd. ***Project objective, topic and results*** This project aims to address challenges associated with energy storage, for example the uncertainty with how storage may impact system operation, namely stability. The project approach is decentralised stability monitoring, assessment and control of the network.

[28] http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/N001745/1

	Topics addressed in SET Plan Integrated Roadmap **Challenge 3**: Theme 7. **Challenge 4**: Theme 11. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The project is also investigating distributed approaches to dynamic system monitoring, decentralised approaches to system wide disturbances and dynamic security assessment though a distributed energy function. Decentralised fault detection is a key area of research in within this project.[29] Added value through common themes of relevance to other European grids.
3	**R&D PROJECT TITLE: SMART Frequency Control Project (EFCC NIC) - National Grid Electricity Transmission GB** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Ofgem National Innovation Competition (NIC), NGETEN03/v2 / Duration: January 2015 – March 2018. ***Total Budget (M€) / Involved Partners*** £9,600,000 / Partners: **National Grid UK**, University of Strathclyde, Alstom-Psymetrix Ltd, Belectric Solar Ltd, Adensis GmbH, Centrica, Flexitricity, University of Manchester ***Project objective, topic and results*** This project is investigating is investigating a frequency control approach to provide faster response times, thereby improving grid stability. This will help mitigate expected increases in system rate of change of frequency (RoCoF) in the future, due to a decrease in system inertia from a high penetration of inverter based generation. Fast-frequency response challenges include the aforementioned reduced system inertia but also local control actions and their potential to degrade stability. Distributed control is being utilised by the project to increase the robustness and reliability of the proposed frequency control scheme. The approach utilises control zones. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1**: Theme 2. **Challenge 3**: Theme 6, Theme 8. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Control zones analogous to WoC and project outcomes will provide insight into operation of zonal frequency control, as well as highlight any potential issues such as conflicting control actions. Demonstration of novel frequency control with strong TSO engagement. Opportunity to link with ELECTRA WOC concepts, perhaps through combined experimental testing.
4	**R&D PROJECT TITLE: The Autonomic Power System – The University of Strathclyde** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EPSRC (EP/I031650/1) / Duration: 01/10/11 – 31/10/16 ***Total Budget (M€) / Involved Partners*** £3,429,099 / Partners: **University of Strathclyde**, Accenture, Agilent, IBM, KEMA, Mott MacDonald, PB Power, National Grid UK, SSE, University of Cambridge, Durham University, Imperial College London, Kings College London, University of Manchester, Newcastle University, University of Sussex ***Project objective, topic and results*** The Autonomic Power System project aims to move beyond the current smart grid applications and approaches. The concept is based on biological autonomic systems that set high-level goals but delegate

[29] http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/L014343/1

	the decision making on how to achieve them to the lower level intelligence. No centralised control is evident, and behaviour emerges from low-level interactions. This allows highly complex systems to achieve real-time and just-in-time optimisation of operations. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1**: Theme 2. **Challenge 3**: Theme 6, Theme 8, Theme 9. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The autonomic power system is a completely integrated and distributed control philosophy which self-manages and optimises all network operational decisions in real time. To deliver this, fundamental research is being conducted to determine the level of distributed control achievable (or the balance between distributed, centralised, and hierarchical controls) and its impact on investment decisions, resilience, risk, customer participation and control in a trans-national interconnected electricity network. Opportunity to compare and perhaps integrate different approaches within a shared architecture. Some aspects of these techniques make them eminently scalable, that could be taken from simulation into experimental testing through this cooperation with WoC.
5	**R&D PROJECT TITLE: Advanced Communication and Control for the Prevention of Blackouts (ACCEPT)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EPSRC (EP/K036173/1) Duration: 01/02/2014 – 31/01/2017 ***Total Budget (M€) / Involved Partners*** £979,507 / Partners: **University of Manchester**, University of Strathclyde, Imperial College London, IIT Delhi, IIT Kanpur, IIT Kharagpur ***Project objective, topic and results*** This project brings together a joint UK-India consortium with the skills necessary to address the potential for using Smart Grid technologies to support novel integrated protection and control tools for the prevention of blackouts. These tools would help prevent society from incurring the huge costs and discomfort associated with blackouts and increase confidence in the power system's ability to satisfy the long term needs of society and industry, as the level of uncertainty and risk in the power system increases.[30] ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 3**: Theme 6, Theme 8. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Relevant research topics include the main focus of the project, looking into the development of new PMUs to help prevent triggering blackouts from false positives caused by poor RoCoF measurements in protection PMUs. Supports the wider coordination of networks across the globe by assessing the computation, communication and control requirements to enable reliable real-time network supervision through PMU technology[31].
6	**R&D PROJECT TITLE: Northern Isles New Energy Solutions (NINES)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** DPCR5 / Ofgem / Ref: 100/11 / January 2011 – December 2016

[30] http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/K036173/1
[31] http://www.energy.manchester.ac.uk/research/energy-networks/accept/

	Total Budget (M€) / Involved Partners £34.5m / Partners: **Scottish Hydro Electric Power Distribution (SHEPD)**, University of Strathclyde, Smarter Grid Solutions (SGS), Hjaltland Housing Association, Shetland Heat Energy and Power (SHEAP) ***Project objective, topic and results*** This project involves utilising multiple smart grid approaches such as active network management (ANM), use of DG, demand side management and battery energy storage. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1:** Theme 1, Theme 2. **Challenge 2:** Theme 4, Theme 5. **Challenge 3:** Theme 7, Theme 8, Theme 9. **Challenge 4:** Theme 11. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** NINES enables efficient use of Shetland's local DG, mainly wind-based, along with storage and ANM. The power is managed within the network on Shetland but also interacts with the main grid. Lessons can be learnt from this project in how a cell can be operated, or indeed help provide insight into defining a cell or a type of cell. Furthermore, the interaction of this island with the Scottish main grid under current operation practises could help inform decisions on operational framework for the WoC concept (e.g. if Scotland is considered a cell under the ELECTRA project).
7	**R&D PROJECT TITLE: Accelerating Renewable Connections (ARC)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Low Carbon Network (LCN) Fund Second Tier CRC13.28, Ofgem / Duration: 01/11/2013 – 30/09/2016 ***Total Budget (M€) / Involved Partners*** £8.4m / Partners: **Scottish Power Energy Networks (SPEN)**, University of Strathclyde, Smarter Grid Solutions, Community Energy Scotland ***Project objective, topic and results*** The aim of the project is to accelerate the process and time for connection of renewable generation to the distribution network through Active Network Management and new and innovative commercial mechanism for linking local generation and demand through community energy schemes.[32] ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1:** Theme 1, Theme 2. **Challenge 3:** Theme 8, Theme 9. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** ARC is utilising real time control and operation of the network, using minute-by-minute network information to match electricity supply and demand to maximise efficiency of the power network for the producers and consumers within it.[33] The learning from this predominantly ANM based project can be very useful to ELECTRA due to the relevance of the focus on real time network control and supervision.
8	**R&D PROJECT TITLE: Smarter Network Storage (SNS)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** LCN Fund Tier 2, CRC13.16, CRC13.28, / Ofgem / UKPN EPN

[32] https://pure.strath.ac.uk/portal/en/projects/accelerating-renewable-connections(b9210f14-9c87-44da-b48d-fc6934e0671b).html
[33] http://www.spenergynetworks.co.uk/pages/frequently_asked_questions.asp

	Total Budget (M€) / Involved Partners £18.7m / Partners: **UK Power Networks**, KiWi Power, Imperial College London, National Grid, Durham University, Smartest Energy, Swanburton, Poyry, AMTSybex ***Project objective, topic and results*** Development of the Smart Optimisation and Control System that will schedule services for the storage and trial the commercial arrangements for shared use of energy storage. Demonstration of value streams from MW-scale network storage and the associated increase in security of supply. Participation of the storage system within National Grids short term operating reserve (STOR) market, in the context of frequency support.[34] ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1:** Theme 2. **Challenge 3:** Theme 6, Theme 7, Theme 8. **Challenge 4:** Theme 11. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** Provides insight into the role that MW-scale battery storage can play within a distributed network e.g. the SNS battery and control scheme placement next to an MV/LV primary substation. The challenges and merits of using the storage scheme as a balancing mechanism, along with scheduling and commercial arrangements e.g. cooperation between DNOs and TNOs[35] - relevant to procurement stages in ELECTRA. Lessons learnt for local control of the battery, challenges with the control and operation of the storage system, especially for frequency support.
9	**R&D PROJECT TITLE: Flexible Urban Networks Low Voltage** ***Funding Frame / Funding Agency / Contract number / Project Duration*** LCNF Tier 2 / Ofgem / UKPNT204 / Duration: 01/01/2014 – 31/12/2016 ***Total Budget (M€) / Involved Partners*** £8,860,000 / Partners: **UK Power Networks**, IGE Digital Energy, IC Consultants, PPA Energy and CGI UK Ltd ***Project objective, topic and results*** The overarching aim of this project is to explore the use of power electronics to enable the deferment of reinforcement and facilitate the connection of low carbon technologies and distributed generation in urban areas, by meshing existing networks which are not meshed, and by breaking down boundaries within existing meshed networks.[36] ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 3**: Theme 8, Theme 9. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** One of the work streams of the project looks at how large amount of data collected can be represented in a manner that is useful to control engineers and network planner. This aligns well with the objectives of WP8, future control room functionality, where visualisation for a future control room is being investigated.

[34] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/

[35] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Smarter-Network-Storage-(SNS)/Project-Documents/SDRC+9.7+Successful+Demonstrations+of+Storage+Value+Streams+LoRes+v1.pdf

[36] http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Flexible-Urban-Networks-Low-Voltage/

10	**R&D PROJECT TITLE: Assisting Communities to Connect to Electric Sustainable Sources (ACCESS)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** *Scottish Government's Local Energy Challenge Fund / Duration April 2015 – April 2017* ***Total Budget (M€) / Involved Partners*** Total budget: £1,769,000 / Partners: **Community Energy Scotland**, Mull and Iona Community Trust, SSE Energy Supply Ltd, Element Energy, VCharge, SSE Home Services, University of Strathclyde ***Project objective, topic and results*** The project aims to lay the foundations for a cost-effective platform for enabling the real time matching of local electricity generation and local electricity demand at a distribution network level. It is expected to drive the development of financially viable grid connections for smaller scale generators (especially in transmission constrained areas of the Scottish networks) by matching the supply of electricity from renewable sources to the heating needs of local consumers. ACCESS will build a framework for addressing two fundamental challenges: (1) Maximising distributed generation in Scotland using existing networks and energy storage assets. (2) Reducing fuel poverty through affordable heating services to Scottish households and businesses currently heated by oil or conventional electric storage heaters. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1:** Theme 1, Theme 2. **Challenge 2:** Theme 4. **Challenge 3:** Theme 7, Theme 8, theme 9. **Challenge 4:** Theme 11. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** The real-time localised control of generation/demand balancing in the ACCESS project aligns directly with that of ELECTRA, where the WoC concept aims to maintain active power balancing and voltage control at cell level. The ACCESS project focuses on facilitating the growth of distribution-connected renewable energy projects, which is also a key topic of interest for ELECTRA.
11	**R&D PROJECT TITLE: Smart Street** ***Funding Frame / Funding Agency / Contract number / Project Duration*** EPSRC (EP/N001745/1) / Duration: 01/01/14 – 31/12/17 ***Total Budget (M€) / Involved Partners*** £10,5M / Electricity North West Limited (lead), Kelvatek, Siemens, Impact Research, TNEI, The University of Manchester, Queen's University Belfast, The Tyndall Centre ***Project objective, topic and results*** Smart Street aims to make networks and customers' appliances perform more efficiently and make it easier to adopt low carbon technologies onto the electricity network such as solar panels, electric vehicles and heat pumps. New remote-controllable switching devices, called the WEEZAP and LYNX, developed in collaboration with project partner Kelvatek, will be integrated into the network management system. This will be the first demonstration in Great Britain of a fully centralised low voltage network management and automation system. The project involves a series of trials to test the technology on six primary substations and 38 related distribution substations, representing around 67,000 customers. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 3**: Theme 8.

	Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level The real-time control of relatively low-level LV-connected devices fits within the aims of ELECTRA – to develop an architecture to leverage massive-scale flexible distributed energy resources. The large-scale trials being conducted within this project could provide guidance and realism for the testing to be carried out within the laboratory demonstrations in ELECTRA WP7.
12	**R&D PROJECT TITLE: LV Engine** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Ofgem NIC / Duration: 01/02/2018 – 31/12/2022 ***Total Budget (M€) / Involved Partners*** £6.9m (total cost) / SP Manweb, UK Power Networks ***Project objective, topic and results*** LV Engine aims to enable increased flexibility and control in LV networks by installing Solid State Transformers (SSTs) and Vacuum Tap Changers in secondary substations. LV Engine will demonstrate the first grid trial of SSTs within the UK electricity network and provide valuable learning to other DNOs. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 3**: Theme 8. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** This project is relevant to ELECTRA because it will demonstrate increased flexibility which could be achieved, and could impact the realisation of balancing and voltage control use cases.
13	**R&D PROJECT TITLE: Low Carbon London** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Ofgem LCNF / Duration: 01/01/2011 – 31/12/2014 ***Total Budget (M€) / Involved Partners*** £28.3m (total cost) / UK Power Networks (UKPN), Imperial College, Transport for London, National Grid, EDF Energy, Flexitricity, EnerNOC, Smarter Grid Solutions, CGI, EDF Energy, Siemens, Institute for Sustainability ***Project objective, topic and results*** *Objective:* Low Carbon London (LCL) investigated and evaluated the operational impact of low carbon technologies (specifically DG, micro-generation, and EVs) on UKPN's distribution networks. This project has provided the following results: - DSR from large customers effective – demand shift enough to serve 18,000 homes at peak time - Quantified a value for EV demand on household (0.3 kW per house) - 'Wind-twinning could work in cities' - Active network management could enable up to a third more distributed energy plants to export ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 3**: Theme 9. **Challenge 4**: Theme 10.

	Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level This project demonstrates the feasibility of the use of flexibility at the scale of a large city; this is very relevant to the web-of-cells concept within ELECTRA which should enable power system control to scale effectively, despite significant growth in flexible devices/customers.
14	**R&D PROJECT TITLE: Customer Led Network Revolution** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Ofgem LCNF / Duration: Ended 31/12/2014 ***Total Budget (M€) / Involved Partners*** £31m / Northern Powergrid, British Gas, EA Technology, Durham University, Newcastle University ***Project objective, topic and results*** The project aimed to trial 'smart grid' solutions at various locations across Northern Powergrid's distribution network. It involved over 14,000 customers, with various technologies such as PV, heat pumps and EVs being assessed. 17MW of DSR trialled with I&C customers for 'large scale fast reserve'. Domestic DSR was also trialled. Active network management, battery storage, and 'enhanced automatic voltage control', as well as real-time thermal rating technologies, were used. The sheer number of different technologies used means that the project found the technologies complementing each other, in terms of operational performance. Despite this, the operator still proposes a hierarchical control/development of smart grid technology. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 1**: Theme 2. **Challenge 3**: Theme 8. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** This project relates to ELECTRA through the increased participation of customers to offer additional flexibility, particularly for voltage control.
15	**R&D PROJECT TITLE: Visualisation of Real Time System Dynamics using Enhanced Monitoring (VISOR)** ***Funding Frame / Funding Agency / Contract number / Project Duration*** Ofgem RIIO NIC / / 01/01/2014 – 31/12/2017 ***Total Budget (M€) / Involved Partners*** £6.5m/SP Energy Networks, National Grid/SPT, Psymetrix/GE Grid Solutions, University of Manchester ***Project objective, topic and results*** To develop a wide-area-monitoring using an enhanced measurement system based on phasor-measurement-units. This will enable better visibility of system dynamic behaviour, enhance network resilience, and increase network capacity. VISOR is doing this by directly investigating two main topics: real-time system dynamics (stability and security limits), and sub-synchronous oscillation monitoring. ***Topics addressed in SET Plan Integrated Roadmap*** **Challenge 3**: Theme 9. ***Relevant topics for future exchanges/interactions with ELECTRA and added value expected by cooperation at European level*** This project is directly relevant to the large-scale system monitoring and visibility envisaged within the ELECTRA project.