e-HIGHWAY 2050

Modular Development Plan of the Pan-European Transmission System 2050

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WP 1	Setting the boundary conditions for 2020-2050 grid planning		
D 1.1a	**Review of useful studies, policies and codes**		

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Document information

General purpose

The objective of this document as the first of two deliverables from WP1 is to collect current knowledge and expectations about future developments in Europe, as seen from the TSO side and in other relevant scenario studies. Together with the outputs from the other tasks this report will be a supplement to the final deliverable D1.2 of WP1.

This document is the public version of Deliverable D1.1 where confidential national data has been removed.

EXECUTIVE SUMMARY

This report presents expectations that the E-Highway2050 project have about a set of selected issues related to the development of the European power systems from today to 2050, and summarizes key assumptions and results from a number of relevant existing scenario studies. The e-Highway2050 consortium consists of transmission systems operators (TSO's), research institutions, universities, companies and non-governmental organisations coming from all over Europe.

The scenario studies' review will be used together with the input from the other tasks in WP1 to define the framework and the boundary conditions to be considered in the following WPs of e-Highway2050 for the preparation of the Modular Development Plan of the European Electricity Highways.

The overviews of national policies have been collected via a questionnaire to TSO's. The answers received helped to understand the different trends in each country and to cope with national specific issues, which will be most relevant when building top down scenarios.

This Deliverable is organized as follows:

- The Introduction in Chapter 1 presents the objective of the report, the methodology, the expected outcome and the foreseen impact on other WPs.
- Chapter 2 presents a review of current national energy policies in European countries. Four major parts covering the topics energy demand and efficiency, generation, storage and general frame are addressed in this chapter.
- Chapter 3 provides a review of a number of existing scenario studies which are briefly summarized in this document. The review is focusing on both technological, economical and policy related aspects as well as need for R&D. Reviewed documents are in the following categories: Global scenario studies, European scenarios studies, Regional/ national studies and other relevant studies. A recommendation for further use in e-Highway2050 is given.
- A final Chapter 4 includes the summary and a set of final remarks and possible recommendations based on the compilation of the data processed.

Based national policies review, we can see there are lots of differences among the European country.

Both in global and in European studies there are several trends related to scenarios focusing on a low carbon society in 2050 and these trends should be reflected in the further e-Highway2050 work:

- ✓ The percentage reduction of GHG compared to 1990 is in average larger in the power sector than in other sectors
- ✓ The GHG emissions from the power sector is low (less than 20%) in 2050 compared to 1990

- ✓ The electricity consumption increases in all scenarios, also in "Energy Efficiency" scenarios
- ✓ Important factors that increase the electricity consumption are electrification of the transport and the heating sector
- ✓ A combination of several efforts are necessary, e.g. increased share of RES, nuclear, CCS and energy efficiency. One of the efforts may be omitted, but at least two are always included.
- ✓ The share of RES is high compared to today
- ✓ Energy efficiency is a cost efficient contribution to reduction of GHG emissions
- ✓ According to the summarized assessment of questionnaires grid upgrades and expansions will be necessary

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1 INTRODUCTION

Work Package 1 (WP1) of the e-Highway2050 project establishes a set of boundary conditions to inform all participants of the opportunities but also necessary limitations that are required to bring about a successful transition from today's infrastructure arrangements to the next generation of infrastructure needed to support a vision of an integrated power system with an evolving mix of electricity generation driven predominantly by renewable sources in 2050.

The vision requires coordinated progress on many fronts – finance, technology, research and development, the establishment of adequate supply chains, significant changes in the generation mix and in evolving grid capability throughout Europe. It is therefore vital that the Consortium is able to agree on a set of operating and design boundaries that adequately defines the pan-European Electricity Highways visions and sets a detailed framework for the work that needs to be undertaken in order to develop a unified approach to the considerable task in hand. A significant number of independent studies have already been carried out to underscore the importance of long-term planning towards a system that can manage the increasing share of renewable generation technologies being deployed in response to the EU's decarbonization directives. Few, if any of these, have a sufficient focus on industry experience and/or national participation. Therefore, the broad involvement of national TSOs is needed to perform a proper review of national trends in this task. Moreover, important references include the work conducted in other scenario studies and in EC funded research projects of similar scope.

The objective of Deliverable D1.1 as the first of two deliverables from WP1 is to collect current knowledge and expectations about future developments in Europe as seen today in the different European countries including the visions proposed in relevant scenario studies. Together with the outputs from the other tasks in WP1, D1.1 will be a supplement to the final deliverable D1.2 of WP1 where the Boundary Conditions for e-Highway2050 are formulated.

2 NATIONAL POLICIES REVIEW

National policies have a major impact on the development of energy economics and the power system. Political requirements for instance possess the force to influence country's whole energy mix in short term as well as in long term consideration. Therefore it is essential to take these major aspects into account while identifying the boundary conditions for scenarios in 2050. To get a wide overview about national policies and about performed studies, a request in form of a dedicated questionnaire was send out to all contributing TSOs, to gather relevant information. The questionnaire was divided into four major parts covering the topics *Energy demand and efficiency*, *Generation*, *Storage* and *General framework*.

The following considerations were taken into account when filling the questionnaire:

- The TSO's were supposed to limit the answer to policies or measures that are in application today or have already been decided by the government or another legal / official authority.
- All polices dealing with the horizon from today to 2050 should be exposed.
- The idea was to capture the major dynamics/trends in each country.

2.1 General frame

The general frame is of relevance as it describes which party is defining the national energy policy and whether coordination between local and national policies exists. In the European countries the energy policies are in general defined by the national governments. Usually the energy policies at local level are coordinated with the national policy.

A. Austria

Main Policies for the energy sector: *Austria Energy strategy*

In Austria, the national government and local governments (of regions) are defining national policies. Between regions big differences of subsidies exists.

Targets:

- RES increase
- energy efficiency increase
- reduction of GHG emissions

B. Belgium

Main Policies for the energy sector:

In Belgium the federal and regional governments are defining the energy policy. The policies and related efforts are often shared among the regions.

The Federal Authority is competent for all matters which require uniform implementation on a national level due to their technical or economic indivisibility, in particular: the legislation

of the electricity sector, including the national infrastructure plan, the nuclear fuel cycle, large-scale storage infrastructures, the transmission and production of energy, tariffs.

The Federal Authority is responsible for marine spaces that are under Belgian jurisdiction pursuant to the international law of the sea. Accordingly, the renewable energy installations in the North Sea are subject to federal competence.

The competence for granting environmental permits and urban planning permits rests with the Regions in relation to their territories, and with the Federal Authority for marine spaces under Belgian competence.

Targets:

- reducing consumption of energy from fossil sources to safeguard future reserves;
- reducing greenhouse gas emissions;
- reducing the country's dependence on energy imports;
- minimizing the impact of price fluctuations for energy from other sources;
- creating employment in the framework of an innovative economy;
- diversifying the available range of energy to improve the functioning of the energy market.
- nuclear phase-out taking place between 2015-2025

C. Bosnia and Herzegovina

In Bosnia and Herzegovina's case, energy policy is defined by two Entities level: Federation B&H and Republic of Srpska. The main Energy strategy will be a sum of two entity levels.

D. Czech Republic

In the CzechRepublic, the energy policy is defined by the national government. The main policy directed at the energy sector is the *Czech Energy Policy*.

E. Denmark

Main Policies for the energy sector:

In Denmark, the energy policy is defined by the national government. The overall vision for Denmark is to be fossil-free in 2050.

Targets:

- 2020: 50% wind power in the electricity system; main measures: subsidies, regulation
- 2030: Phase out of coal used on central power plants
- 2035: Electricity and heat system fully supplied

F. France

Main Policies for the energy sector: POPE law in 2005, Grenelle Laws in 2009 and 2010

In France the energy policy is defined by the national government. The energy policies at local level are in general coordinated with national policy, but local initiatives are possible.

Targets :

- Security of energy supply
- Competitive energy supply
- Sustainable energy development
- Equal level of energy service to all territories and all citizens
- 75% reduction in CO2 emissions by 2050 and a reduction in GHG emissions in the transport sector to 1990 levels by 2020
- Decrease of final energy intensity of 2% per year till 2015 and of 2.5% per year between 2015 and 2030
- Quantitative targets per generation technology for 2010 and 2015 with priority given to carbon-free technologies to limit fossil fuel dependency

The start of a New National Energy debate with conclusions to come in 2013, may lead to new policies.

G. Germany

Main Policies for the energy sector:
EnWG (General Energy Law), EEG (Renewable Energy Law),

In Germany the energy policy is defined by the national government. The main driver in the RES-sector are the subsidies, which are defined by the EEG (Renewable Energy Law).

Targets :

- Security of energy supply
- Nuclear phase-out in 2022
- Integration of RES, especially Offshore Wind into the existing grid (35 % in 2020, 50 % in 2030, 65% in 2040, 80 % in 2050)
- Increase the cross-border Global Transfer Capacities
- Build intra-german HVDC-Lines to connect the wind farms in the north with the big demand-centres (due to high industrialisation) in the west and south of Germany

H. Greece

Main Policies for the energy sector :
The Ministry of Environment, Energy and Climate Change (YPEKA) is defining the National energy policy, while the Regulatory Authority for Energy (RAE) providing the regulatory framework.

Targets:
A target of a 20% share of renewable energy in the gross final energy consumption in 2020 to be achieved. The roadmap to achieve this target combines measures for energy efficiency as well as for the enhanced penetration of RES technologies in electricity production, heat supply and transport.

I. Italy

Main Policies for the energy sector:

In Italy the energy policy is defined by the National Government. The energy policies at local level are in general coordinated with National Policy, but Local Authorities can go beyond these and their objectives. Nuclear is not allowed in Italy after a national referendum in 2011.

National Legislative Framework indicating strategies, priorities and qualitative objectives is converted in National policies and quantitative targets through Planning. Main sector Plans here referred:

- Development Transmission Plan 2012 of TERNA (PdS)1
- National Action Plan for renewable energy in Italy 2010 (PAN)
- Italian National Action Plan for Energy Efficiency 2011 (PAEE)

Targets:

- security of energy supply
- competitive energy supply,
- sustainable energy development,
- increase of energy efficiency,
- maximization of RES penetration.
- Reductions in final energy consumption expected 2020 about 14%
- increasing the target of RES to reach 43,8 GW in 2020

In 2012, the debate on the National Energy Strategy has been started.

J. Lithuania

Main Policies for the energy sector:

In Lithuania the energy policy is defined by the national government and the Ministry of Energy of the Republic of Lithuania. Energy policies at local level are coordinated with national policy.

The National energy Independence Strategy of the Republic of Lithuania is based on three essential and interconnected principles: Energy independence, Competitiveness, Sustainability.

The implementation of strategic projects will ensure that in 2020 more than 80 % of energy-mix, which is currently being imported from the single supplier, is replaced with a well-balanced structure of energy resources. In 2020, at least half of the required energy will be generated locally (with the focus on nuclear power and renewable energy sources), while the rest of energy will be imported from different sources.

Targets:

- Energy independence (to 2020)

[1]Currently under consideration by the competent Authorities.

- enhancing competitive local energy generation, including the implementation of the new regional nuclear power plant project (regional nuclear power plant in Visaginas)
- providing alternative supply of energy sources
- promoting the development of renewable energy sources and enhancing energy efficiency
- electricity links to Sweden (NordBalt) and Poland (LitPol Link 1)
- a functional regional electricity market
- a synchronous interconnection with the European Continental Network of ENTSO-E

K. FYR of Macedonia

Main Policies for the energy sector:

In Macedonia, the energy policy is defined by the national government. The energy policies at local level are coordinated with the national policy. Main policies include:

- Securing reliable, safe and quality energy and energy fuel supply to consumers;
- Establishment of an efficient, competitive and financially sustainable energy sector;
- Encouraging competition on energy markets with respect for the principles of non-discrimination, objectivity and transparency;

Targets

- Integration of Republic of Macedonia's energy markets into the regional and international energy markets, pursuant to the commitments assumed under the ratified international treaties;
- Increasing energy efficiency by 2020 (Energy Efficiency Action Plan)
- Promotion of the use of energy from renewable sources by 2020 (RES Strategy) and cogeneration plants
- Environmental protection from the adverse effects of particular activities in the energy *field.*

L. Norway

Main Policies for the energy sector:

67,5% renewable electricity in the total energy mix

In Norway the energy policy is defined by the national government. The energy policies at local level are coordinated with the national policy.

Quantitative Targets:

13,6 TWH of new RES production in 2020

M. Poland

Main Policies and Targets for the energy sector:

In Poland, the energy policy is defined by the national government. The energy policies at local level are coordinated with the national policy.

- **Energy Law Act:** provide energy security, economical and rational use of fuels and energy, development of competition, the negative effects of natural monopolies, integrating environmental protection requirements, obligations under contracts. The project of new Energy Law Act is in the process of legislation. Estimated time of entry into force: 2013
- **Gas Law:** The purpose of the Act is to create conditions to ensure safety of supply of natural gas and technical safety gas systems. Estimated time of entry into force: 2013
- **Nuclear** Law**:** ACT for the preparation and implementation of investment in nuclear power facilities and associated investment.
- **Law on Energy Efficiency:** To improve energy efficiency. Sets a national target for energy efficient management to get final energy saving in the amount of not less than 9% of the national average energy consumption per year (averaging years 2001-2005). Time frame: 2016

N. Portugal

Main Policies for the energy sector:

National Renewable Energy Action Plan (NREAP) and National Energy Efficiency Action Plan (NEEAP), both under revision process.

In Portugal the energy policy is defined by National government through Portugese Directorate-General for Energy and Geology.

Targets:

- To develop mature RES (NREAP: 34.8% of final gross energy consumption in 2020 supplied by RES)
- to produce biofuels based on waste and biomass, as well as on dedicated crops
- to explore biogas to be stored and transported in natural gas grid
- to develop solar (thermal), biomass, heat pumps and geothermal technologies for heating and cooling purposes.
- 20% reduction in energy consumption in 2020 (same as EU2020 target).

O. Romania

Main Policies for the energy sector:

In Romania the energy policy is defining by the national government through Ministry of Economy, Trade and Business Environment. The energy policies at local level are coordinated with the national policy.

The main objectives in energy sector are:

- energy security,
- sustainable development,
- competitive market development,
- further restructuring
- privatization *of the energy sector.*

P. Serbia

Main Policies for the energy sector:

In Serbia, the energy policy is defined by the national government. The energy policies at local level are coordinated with the national policy.

Main polices are directed toward increasing of energy efficiency measures, implementation of RES in the power system, and to enabling energy independency of Republic of Serbia in the future.

Targets:

The general target is to achieve efficiency improvements in all sectors and energy savings.

Q. Spain

Main Policies for the energy sector:

The broad vision is to fulfill the EU 2020 energy & climate objectives while reducing energy dependence, improving security of supply and fostering competition

Targets:

- Increase the interconnection capacity with Central Europe
- Fostering the integration of RES production into the power system
- 20% share of energy from renewable sources in the Spanish gross final consumption of energy by 2020
- 20% cut in annual primary energy consumption by 2020

R. Sweden

Main policies for the energy sectors and targets

In Sweden, the energy policy is defined by the national government. The vision for Sweden 2050 is to be fossil-free.

The government has set the following goals for 2020:

- 40 % reduction of GHG emissions (compared to 1990 level)
- 50 % of the Swedish energy supply should come from renewable energy.
- 20 % increase in energy efficiency (compared to 2008)
- Minimum 10 % renewable fuels in the transport sector

S. Switzerland

Main Policies for the energy sector:

Energy strategy and energy perspectives 2050, published in 2012 by the Swiss Federal office of energy (BFE). The corresponding legal framework has not yet been adopted by parliament.

In Switzerland there is a national energy policy (Energiestrategie 2050) as well as cantonal energy policies. The cantonal (and local) policies must be in line with the national policy but can go beyond its scope and objectives.

Targets:

- Nuclear phase out,
- Grid extensions (incl. Cross-border) and
- Promotion of RES, plus 24 TWh of RES (without hydropower),
- Increase of energy efficiency

T. United Kingdom

Main Policies for the energy sector:

In the United Kingdom, the energy policy is defined by the national government (devolved Administrations of Scotland, Wales and Northern Ireland). Energy policy is set at a national level, with co-ordination taking place wherever appropriated.

Main policies are dealing with:

- Electricity Market Reform,
- Gas Generation Strategy, Energy Security,
- Action on Climate Change,
- Renewable Heat Incentive,
- Green Deal and Energy Company Obligation,
- Carbon Emissions Reduction Target,
- Affordability whilst supporting growth

Targets:

- Energy security: to ensure that UK businesses and consumers have secure supplies of energy, for light and power, heat and transport;
- deliver secure, low-carbon energy at least cost to consumers (at least 80% of 1990 levels by 2050), taxpayers, and the economy as a whole;
- deliver our policies in a way that maximises the benefits to the economy in terms of jobs, growth and investment
- 15% of energy from renewable sources by 2020

2.2 Energy Demand and Efficiency

In this part the national trends and policies that are going to have a strong impact on demand are presented. Most trends or efforts for achieving a higher degree on energy efficiency are discussed. In detail, the main policies affecting

- *thermal insulation of buildings,*
- *restrictions or encouragement concerning space heating or other electrical devices,*
- *the promotion of electrical vehicles,*
- *restrictions or encouragement concerning other electrical devices, and*
- *demand side management*

are regarded.

2.2.1 National policies on demand and energy efficiency

A. Austria:

Main general policies in favour of energy efficiency:
The Austrian Energy Efficiency Act Statutory includes regulations to increase energy efficiency.

Main policies in favour of thermal insulation in buildings:
There are Technical rules in the building code of state governments addressing Promotion of renewable energy systems in the building sector. Further development of building and energy-related rules, renovation obligations as well as minimum requirements for the construction and renovation of public buildings is another expected result.

Main policies in favor of electric vehicles:
There is a financial measure in the Austrian Action Programme for Mobility Management (klima: active) addressing the Promotion of vehicles with low-emission and energyefficient fleets by companies and local authorities as well as private vehicle owners.

Main policies, restriction or encouragement concerning electric space heating devices:
This policy measure is linked to housing support and further initiatives at regional and local levels.

Main policies, restriction or encouragement concerning Demand Side Management:
There are R&D programs on smart grids, networks and metering.

B. Belgium:

Main policies in favour of thermal insulation in buildings:

- (pre-)feasibility study for new buildings (>1.000 m2) and for fundamental renovations of buildings >5.000 m2.
- Subsidies for the realisation of particularly innovative and exemplary buildings.

Main policies, restriction or encouragement concerning electric space heating devices:
Tax reductions

Main policies in favor of electric vehicles:
Tax reductions and premiums for electric vehicles and charging stations.

Main policies, restriction or encouragement concerning other electric devices:
Strengthening household appliance energy efficiency standards. Broadening, strengthening and reviewing the labeling system for electric appliances (including industrial appliances and electric motors).

Main policies, restriction or encouragement concerning Demand Side Management:
R&D programs on smart grids, networks and meters.

C. Bosnia and Herzegovina

In Bosnia and Herzegovina some improvements have been suggested within the Energy Community regarding energy efficiency, but have not been adopted.

D. Czech Republic

Main general policies in favour of energy efficiency:

- Efficient appliances and products.
- Efficient energy conversion
- Smart grids. Civil engineering.

Main policies in favour of thermal insulation in buildings:
From 2020, low energy standard or near zero energy requirements of buildings to be set-up.

Main policies, restriction or encouragement concerning electric space heating devices: Conversion to heating pumps replacing local coal and convector heating.

Main policies in favor of electric vehicles:
Support of R&D.

Main policies, restriction or encouragement concerning other electric devices:
Labeling, advertisement of efficient use.

Main policies, restriction or encouragement concerning Demand Side Management:
support of smart metering and smart grids.

E. Denmark

Main general policies in favour of energy efficiency:
The focus areas are energy efficiency in buildings and energy efficiency in transport. Main measures are: Subsidies, taxes and regulations.

Main policies in favour of thermal insulation in buildings:
There are strict requirements to new buildings regarding insulation. Further money has been allocated to energy renovation of existing buildings. Main measures are: Subsidies, taxes and regulations.

Main policies, restriction or encouragement concerning electric space heating devices:
Oil fired burners are to be phase out by 2030 and should be replaced by district heating, heat pumps or other RE heating solutions. Main measures are: Subsidies.

Main policies in favor of electric vehicles:
Electric vehicles are supported by spreading programmes and have a tax exemption until 2015.

Main policies, restriction or encouragement concerning other electric devices:

Electric heat pumps are prioritized in the heating system both in households and in connection to CHP plants. Main measures are: Subsidies.

Main policies, restriction or encouragement concerning Demand Side Management:
There is a focus on installation of smart meters in all households allowing for hourly electricity prices for the customers. In the moment a national strategy for Smart Grids is under preparation. Main measures are: Regulation

F. <u>France</u>

Main general policies in favour of energy efficiency:
POPE law in 2005 and two "Grenelle laws" in 2009 and 2010.
Start of a New National Energy debate with conclusions to come in 2013 that may lead to new policies.

- ***Targets:***
  - To combat climate change and to improve energy performance;
  - Target for obligation mechanism (cumulated discounted savings) for second phase (2011-2013): 345 TWh.
- ***Main measures:***
  - Regulation, incentives, obligation mechanism through energy saving certificates (white certificates).

Main policies in favour of thermal insulation in buildings:
Grenelle Laws in 2009 and 2010, Thermal Regulation (Building Energy Regulation) RT 2012 in 2010, French Finance Acts.

- ***Targets:***
  - A 38% reduction of energy consumption in older buildings. In new building, primary energy consumption limited to 50 kWh/m^2*year on average (depending on the home) for heating, sanitary hot water, lighting, air conditioning and ventilation
  - a comprehensive renovation of 400,000 buildings every year from 2013 and 180,000 low-income housing units renovated in the National Agency for Urban Renewal area
- ***Main measures:***
  - Application of the "low energy building" standard (Bâtiment Basse Consommation – BBC) to all new buildings since end-2012, and construction of energy positive buildings starting at the end of 2020
  - Incentives (advantageous tax credit, tax reduction rates, zero-interest + eco-loan) for a better insulation in existing buildings. For existing buildings, a decree is expected on energy renovation requirements for tertiary buildings.

Main policies, restriction or encouragement concerning electric space heating devices:
Thermal Regulation (Building Energy Regulation) RT 2012 in 2010, French Finance Acts.

- ***Targets:***
  - The reference to primary energy in the thermal regulation 2012 should very strongly reduce the development of Joule effect space heating.

  - Installation of heat pumps in 2 million homes and revival of geothermal energy operation.
- ***Main measures:***
  - Regulation, Subventions ("sustainable development tax credit") for the installation of a heat pump until 2014

Main policies in favor of electric vehicles:
National plans in 2009 and 2012.
- ***Target:*** 2 million electric and plug-in hybrid electric vehicles in 2020.
- ***Main measures****:*
  Promoting the development of electric and plug-in hybrid electric vehicles by fostering the development and maintenance of recharging infrastructure and by giving incentives to encourage their purchase.

Main policies, restriction or encouragement concerning other electric devices:
POPE law in 2005.
- ***Target*****:** 345 TWh of savings during the second phase (2011-2013) of the obligation mechanism
- ***Main measure:*** Obligation mechanism through energy saving certificates

Main policies, restriction or encouragement concerning Demand Side Management:
Withdrawal tariff options still included in regulated tariffs, bilateral contracts between consumers and their electricity suppliers with demand response clauses, distributed load shedding on the Balancing Mechanism.

G. Germany

Main general policies in favor of energy efficiency:
Subsidies for energy efficiency, thermal insulation of buildings, electrical vehicles and Demand Side Management.

H. Greece

The main general policy in favor of energy efficiency is the rationalism of the usage of end-user's electrical and thermal energy. Currently, the main policies in favor of thermal insulation in buildings and space heating are gathered in the new "Energy Performance of Buildings" Regulation (KENAK), aiming to achieve significant energy savings in urban domain.

Electrical vehicles are going to be supported. Relevant measures have not been announced yet. In 2011, there were 3 charging points in Greece while the target for 2020 is 13000. A pilot project is ongoing in the city of Kozani.

I. Italy

Main general policies in favor of energy efficiency:

Subsidies for energy efficiency, thermal insulation of buildings,electric space heating devices, electric vehicles and Demand Side Management. Existing operational mesures are in particular taken in Italy for thermal insulation in buildings.

J. Lithuania

Main general policies in favor of energy efficiency:

Increase energy efficiency in all areas of the final energy consumption.

- ***Target:*** To achieve 1.5 % annual savings of the total final energy consumption.
- ***Main measures:*** Energy efficiency of the transport sector will be improved by measures to promote the renewal of car fleet in the country, a shift towards modern and environmentally-friendly public transport, optimizing transport infrastructure and promoting investments into environmentally-friendly means of transport.
- ***Time frame****:* Until 2020.

Main policies in favor of thermal insulation in buildings:

- ***Targets:*** 220 ktoe annual energy savings from efficient heating and 70 ktoe savings from efficiency and greater use of more efficient appliances. By 2020, reduction of the heat consumption by 30–40 % in buildings (the majority will have been insulated)
- ***Main measures:*** Promotion of residential and public buildings modernization (at least 3% renovated per year).
- ***Time frame****:* Until 2020.

Main policies, restriction or encouragement concerning electric space heating devices, electric vehicles and other electric devices:

Modernization of the electricity grid thanks to EU funds and implementation of smart grids concept. This would allow better use of the various generation sources (as well as producing green electricity) and would create favorable conditions for the economic development of electric vehicles, heat pumps and other energy production and consumption in regulating the use of facilities.EU funds will be used to modernize the electricity grid implementation of smart grid concepts, which would allow better use of the various generation sources (as well as producing green electricity) and would create favorable conditions for the economic development of electric vehicles, heat pumps and other energy production and consumption in regulating the use of facilities.

K. FYR of Macedonia

Main general policies in favor of energy efficiency:

- Measures and activities on energy end-use efficiency, adoption and implementation of programs, plans on energy efficiency improvement and promotion.
- Performance of energy efficiency services and energy audits, as well as fulfillment of obligations assumed by the public sector and big consumers as regards energy efficiency and energy savings.

The energy efficiency policy shall enable attainment of sustainable energy development objectives, reduction of adverse environmental effects from energy activities performance

and energy consumption, improved reliability of energy supply, as well as fulfillment of the commitments assumed by the FYR of Macedonia as regards the greenhouse gas emission reduction.

- ***Targets:***
  Improvement of security of energy supply, sustainable economic development and competitively of the economy. To achieve national indicative energy savings target of at least 9% energy savings by 2018.
- ***Main measures:***
  - *EE Strategy,*
  - *First EEAP,*
  - *Decree on indicative energy savings targets in the Republic of Macedonia,*
  - *Decree on eco design of products,*
  - *Rulebook on the indication by labeling of the consumption of energy and other resources by energy-related products,*
  - *Rulebook on high efficiency heat and power plants.*

Main policies in favor of thermal insulation in buildings:
A Rulebook on energy performance of buildings, the basis for which is given in the Energy law is in draft and it is not adopted yet. This will prescribe:

1) methodology on setting building or building unit energy performance;
2) minimum energy efficiency requirements for new and reconstructed buildings and building units, as well as for buildings and building units subjected to major renovations;
3) supervision method for determining the compliance of buildings, building units, devices and plants with the provisions contained in the Rulebook;
4) terms and conditions on project design development for construction of new and major renovations of existing buildings and building units in terms of energy efficiency;
5) manner and dynamics of supervision for building air-conditioning systems with effective rated output exceeding 20 kW;
6) manner and dynamics of supervision for building air-conditioning systems with effective rated output exceeding 12 kW;
7) building and building unit types owned by public sector entities that would be subject to mandatory installation of solar collectors for hot water, as part of construction of new and reconstruction of existing buildings;
8) labeling of buildings and building units, as regards their energy performance;
9) template and contents of the statement on the basic construction or reconstruction project's compliance with the minimum requirements stipulated in the Rulebook;
10) template, contents and validity period of building energy certificates;
11) the minimum total useful floor area of buildings or building units for which there is obligation for obtaining and displaying the building energy certificate; and

12) control over the issued certificates for energy performance of buildings and prepared reports on the control over the systems for space heating with boilers with on effective rated output of more than 20 kW and air-conditioning systems with on effective rated output of more than 12 kW

Main policies, restriction or encouragement concerning electric space heating devices:
EE Strategy and first EEAP have proposed measures such as: greater use of geothermal heat pumps in households and service sector; carrying out of educational and promotional activities to improve the EE for household and service sector. The aim of the first measure is to encourage greater exploitation of renewable energy sources for households and service sector and the second one aims to educate people and to raise awareness for EE and energy savings. There are no restrictions for use of electric devices for space heating purposes.

- ***Targets:***
  The aim of the first measure is to encore greater exploitation of renewable energy sources for energy supply in households and service sector and the second one aims to educate people and to raise awareness for EE and energy savings.
- ***Main measures:*** EE Strategy, first EEAP.

Main policies in favor of electric vehicles:
There are no special policies for use of electric vehicles by the aspect of EE. There are measures in the first EEAP named "Renewal of the national road fleet" and "Promotion of sustainable urban transport systems" which could covers using of electrical vehicles. The second measure contains one sub-measure named "Introduction of tramway in the City of Skopje". Also, there are measures in the first EEAP named "Promotion of the use of railway in the intercity transport". The main measures are EE Strategy, first EEAP.

Main policies, restriction or encouragement concerning other electric devices:
Decree on eco design of products fit the conditions which the products have to fulfill when they are producing or in order to be out on the market. The Decree prescribes:

1) General terms and conditions on product eco-design;
2) methods on setting the generic and specific requirements for eco-design;
3) generic and specific requirements for the eco-design of particular types of products or product groups;
4) internal control of eco-design;
5) management system for compliance assessment;
6) dynamics and deadline for application of terms and conditions and requirements from the Act concerning particular types of products;
7) other terms and conditions that should ensure that the energy-using products or products impacting the e*nergy consumption meet the eco-design requirements.*

The Decree on eco design of products relates to: simple set-top boxes; household lamps; standby and off mode electric power consumption of electrical and electronic household and office equipment; no-load condition electric power consumption and average active

efficiency of external power supplies; electric motors; glandless standalone circulators and glandless circulators integrated in products; televisions; household refrigerating appliances; washing machines; and dishwashers.

Rulebook on the indication by labeling of the consumption of energy and other resources by energy-related products prescribes:

1) the products to be labeled;
2) the manner of product labeling;
3) the manner of determining product characteristics;
4) the label's form and contents;
5) the manner of supervision over labeling.

The Rulebook covers the following products: household refrigerating appliances (electric refrigerators, freezers and their combinations); televisions; household dishwashers; household washing machines (tumble driers and combined washer-driers); electric ovens; air-conditioners, and lamps.

- ***Targets:***
  The energy-related produces fulfilling prescribed criteria /conditions according to the Decree on eco design of products can be put on the market. Also, energy-related products which are labeled according to the Rulebook on the indication by labeling of the consumption of energy and other resources by energy-related products can be put on the market.
- ***Main measures:***
  - Decree on eco design of products,
  - Rulebook on the indication by labeling of the consumption of energy and other resources by energy-related products.

Main policies, restriction or encouragement concerning Demand Side Management:
The Energy Law requests by public sector entities to implement energy efficiency measures including annual energy consumption analyses and monitoring of energy consumption. In addition, an amendment to the Energy Law is in progress which will regulate in detail monitoring and management of the energy consumption in public buildings and street lighting systems. After adoption of this amendment, a separate Rulebook on information system for monitoring and management of the energy consumption of the public sector entities will be adopted.

- ***Main measures:*** Energy Law, Draft Amendment to the Energy Law.

L. Norway

Main general policies in favor of energy efficiency:
Positive policy toward energy efficiency.

- ***Main measure:*** Support handled thru state owned Enova SF which promotes energy efficiency financing and active advice.

Main policies in favor of thermal insulation in buildings:
New building regulations.

- ***Main measure:*** Improved insulation.

Main policies, restriction or encouragement concerning electric space heating devices:
No residential restrictions, Office and industrial encouraged to central heating.

- ***Main measures:*** Heat pumps are recommended, Oil heating will be prohibited.

Main policies in favor of electric vehicles:
Positive political support for electrical vehicles.

- ***Main measures:*** Reduced tax on e-vehicles, free parking,free tollrads and may use bus and taxi lanes.

Main policies, restriction or encouragement concerning other electric devices:
Automatic metering systems, AMS, to be implemented. by 2015.

Main policies, restriction or encouragement concerning Demand Side Management:
AMS and coming smart grids.

M. Poland

Main general policies in favor of energy efficiency:
Act of 15 April 2011 (Journal of Laws No 94, item. 551) on energy efficiency

- ***Targets:***
  - Energy Efficiency Act of 15 April 2011 (Journal of Laws No. 94, item. 551), defines the purpose of energy saving, including the leading role of the public sector, establish mechanisms to support and monitor the system and collect the necessary data. The Act will also ensure the full implementation of European directives on energy efficiency, including in particular the provisions of Directive 2006/32/EC on energy end-use efficiency and energy services.
  - Energy Efficiency Act implements into Polish law Directive 2006/32/EC of European Parliament and the Council of 5 April 2006 on energy end-use efficiency services and adopted the European Council in March 2007 decision establishing a target of 20 % reduction in energy consumption in the European Union by 2020.
  - The Energy Efficiency Act put into effect a system of energy efficiency certificate, so-called "white certificates". This is mechanism of stimulation and forcing savings behavior. "White certificates" will be available only for projects with the highest economic efficiency. "White certificates" based on the existing systems support cogeneration and renewable energy sources (so-called red and green certificates). For companies selling electricity, natural gas or heat applied to end-users will be required to obtain a certain number of certificates. The authority which issues certificates of energy efficiency is the President of Energy Regulatory Office.

  - National energy efficient management to get final energy saving in the amount of not less than 9% of the national average energy consumption per year (averaging years 2001-2005). "White certificates" will be issued to those who successfully completed the tender procedure.

- ***Main measures:***
  - Methods of energy efficiency for public sector:
  - "White certificates" - market mechanism to achieve measurable energy savings in 3 areas:increase energy savings by end users, increase energy savings by the device's own needs as a team of auxiliary facilities or installations for generating electricity or heat,reduce the loss of electricity, heat and natural gas transmission and distribution.
  - 80% of "white certificates" will increase energy savings by end-users. The rest will be able to get the manufactures to increase their saving and reduce losses in transmission and distribution. End-users, which in the year preceding the certification consumed more than 400 GWh of energy and for which the share of energy costs is more than 15% in the value of its production and that improved energy efficiency, will be included in the “white certificates” program.
- ***Time frame****:* National target to 2016

Main policies in favor of thermal insulation in buildings:
Act of 7 July 1994 (Construction Law No 89, itm. 414) Regulation of the Minister of Infrastructure dated 12 April 2002 on the technical conditions to buildings and their location. Act of 21 November 2008 to support thermo-modernization and renovation

- ***Targets:***
  1. For buildings law prescribes preparing energy characteristic as certificates. The certificates are valid for 10 years.
  2. The Regulation sets technical conditions, which should respond buildings and devices associates with them (compatible with Construction Law).
  3. The Act sets out the financial aspects from Thermo-modernization and Repairs Capital cost of modernization and repairs projects. Act provides important grants to investments in the following areas:
     - *thermo-modernization buildings,*
     - *thermo-modernization local heating networks,*
     - *thermo-modernization heat sources*
     - *use of renewable and alternative energy sources.*
- ***Quantitative Targets:***
  1. The size of energy to be used of the buildings (kWh/m2*year).
  2. Thermal insulation water heating should correspond to the requirements of Polish Standard. The facade of buildings at the height over 25 m (from the land) should have mechanical attachment and thermal insulations should be made of non-combustible material.
  3. Subsidies for those who decrease building energy consumption at least:

- *10% for the buildings in which only upgrading the heating system,*
- *15% for the buildings in which the year 1984 was carried out modernization of the heating system,*
- *25% for other buildings.*

Main policies in favor of electric vehicles:
The Polish Goverment is preparing regulation on purchase of new vehicles with reduced carbon emissions and electric cars. The Main measures aretax relief and incentives on the purchase of electric vehicles.

Main policies, restriction or encouragement concerning Demand Side Management:
The second National Action Plan Energy Efficiency for Polish 2011 entered new efficiency improvement measures target.

- ***Targets:***
  The following measures to improve efficiency (5 examples):
  1. In the residential sector (households) - thermo and maintenance fund (continued). *Expected energy savings in 2016 = 8121 GWh.*
  2. The service sector (including the public sector)- the green investment energy management in publicbuildings. *Expected energy savings in 2016 = 1950 GWh.*
  3. Overview of the planned measures in the public sector - the program "saving energy and promoting renewable energy sources".*The program is currently under preparation.*
  4. Overview of the planned measures in the public sector- operational Program Infrastructure and Environment –thermo-modernization of public buildings. *Expected energy savings in 2016 = 320 GWh.*
  5. The system of "white certificates".*Expected energy savings in 2016 = 25586 GWh.*

- ***Main measures:***
  1. A thermo-modernization, which aims to:
     - reduce the consumption of energy for heating and hot water residential, collective residence and buildings which are owned by local governments,
     - which are used to perform their public duties,
     - reduce the costs of heat supplied to the building - by implementation of the technical connection to the centralized heat source,
     - reduce primary energy loss in local and district heating networks.
  2. Number of objects included in thermo-modernization
     - about 3000 pcs,
     - grants may be awarded to implementation of projects in buildings public,
     - thermo-modernization of public buildings, including changes in equipment with the highest reasonable energy-related standards, in particular:
       a) warming facility,
       b) replacement windows,
       c) replacement of exterior doors,

d) reconstruction of heating systems (including heat exchange),
e) replacement of air conditioning and ventilation systems,
f) the preparation of technical documentation for projects,
g) energy management systems in buildings,
h) the use of renewable energy technologies .
i) replacing the interior light

3. The program is currently under preparation. The Scope:
   - local projects aimed at improving the energy efficiency of buildings, including thermo-modernization of public utility buildings for the needs of education, health care, environmental and social buildings and local government;
   - projects to replace obsolete heat power of 0.2 MW to 3 MW modern, energy-saving eco- sources of energy in public buildings,
   - modernization of district heating systems,
   - promote the use of renewable energy sources (including solar, photovoltaic systems, biogas, geothermal, etc.)
4. Thermo-modernization of public utilities and replacement of equipment buildings for energy saving associated with:
   - warming facility
   - replacement windows, exterior doors and energy-efficient lighting,
   - reconstruction of heating systems (including heat exchange), ventilation and air conditioning systems,
   - preparation of technical documentation for the project.

   Projects not eligible for support are public buildings, in which more than 15% of the total area of the building is business activity or purpose housing.
5. The system of white certificates supports energy saving projects, such as the modernization of district heating networks and heat sources buildings, lighting, appliances, energy recovery and modernization of industrial equipment and installations. The President of the Energy Regulatory Office is authorized toissue white certificates.

- ***Time frame****:*
  1. Start - 2011; end - 2014
  2. Start - 2010; end - 2015
  3. Start - 2012; end - 2017
  4. Start - 2007; end - 2015
  5. Start - 2013; end - 2016.

N. <u>Portugal</u>

For Portugal the main policies regarding demand and energy efficiency is the Revised National Energy Efficiency Action Plan (NEEAP) which is not published yet.

O. Romania

Main general policies in favor of energy efficiency:

The main policies are in the "National Action Plan for Energy Efficiency". The first "NAPEE" foresees development of economy aiming to reduce the share of energy-intensive activities. The second one foresees promoting production of renewable electricity, high efficiency cogeneration, energy retrofitting groups on coal plants and installing new units, plus reducing losses in transmission and distribution networks which will have a favorable impact in reducing primary energy, thereby contributing to the EU target for EU "20-20-20" .

- ***Targets and measures :***
  - First NAPEE (2007, written in accordance with with Directive 2006/32/EC) : reduction of the final energy consumption by 1.5% annually during 2008-2016
  - Second NAPEE (2011, in light of developments in sustainable development policies and targets EU "20-20-20"): quantitative measures of energy saving.
  - Elimination in the relatively near future subsidies to households supplied heat through district heating systems, energy enforcement of social benefits only to those who need it and for as long as they need (based on strict criteria set).

Main policies in favor of thermal insulation in buildings:

Ministry of Regional Development and Housing initiate a "National Program for thermal insulation" (GEO no. 18/2009) in order to increase the energy performance of buildings built after projects developed in the period 1950-1990.

- ***Targets:***
  Reduction of heating and hot water bill by 40-60%; improving hygiene and thermal comfort inside; replacing old heating installations and domestic hot water in basement (waste reduction)
- ***Main measures:***
  Financing the execution of repair works:50% of allocations from the state budget within the funds approved for this purpose in the annual budget of the Ministry of Regional Development and Housing; 30% of annual funds approved for this purpose in the local and / or in other legally; 20% of the repair of the owners' association and / or in other legally constituted.

Main policies in favor of electric vehicles:

Ministry of Environment and Forests encourages people to participate in the Program to Dispose of Waste Cars "RABLA" which gives them subsidies. Government will subsidize from "Environmental Fund", the necessary infrastructure for electric and hybrid cars.

Government will provide individuals or businesses a subsidy of 20% of the purchase price of an electric car, but no more than 3,700 € or 10% of the price, but not less than 1,800 € for a hybrid car.

P. Serbia

Main general policies in favor of energy efficiency:

Main policy for energy efficiency is related to decreasing average energy consumption in public and civil buildings, and making new energy efficient objects which will have to receive so called "green passport", which confirms that the level of consumption of electrical energy for heating and cooling purposes is at the same level as in EU.

- ***Target:*** *Limit in consumption of electrical energy in new buildings will be 65 kWh/m^2.*

Main policies in favor of thermal insulation in buildings:

Our energy efficiency agency has published several documents regarding thermal insulation in buildings. For electric space heating devices, electric vehicles, other electric devices and Demand Side Management no strategies exists.

Q. Spain

In Spain there are several politics to foster the energy efficiency and savings of energy in all main sectors:

- Industry in general: Energy audits, energy managements systems
- Transport sector: Fleet renovation, rationalization of use, modal shift
- Building sector: Thermal insulation, lighting and heating efficiency, insulation of buildings in order to limit the energy demand needed to reach thermal comfort and enhancement of performance in thermal installations.
- Public Buildings: Enhancement of Public lighting
- Agriculture: Energy efficiency enhancement of watering installations
- Fostering of high-efficiency cogeneration
- Households: RENOVE plan for the renovation of household electrical appliance(s) to improve the efficiency of these devices

Other politics:

MOVELE project: Promotion of electric vehicle: demonstration project of viability of electric vehicles. The objective of this project is the demonstration of technical and economic viability, identification of incentivizing regulations, development of infrastructure and to allow the participation of private companies. The objective is to reach 250,000 electric vehicles in circulation in 2014. Presently there are 800 recharging points in operation.

Incentivize a change in consumers´ behavior: Change consumers´ behavior so as to:

- facilitate the integration of renewable energies
- improve the efficiency of the whole power system

The main objective is flattening of the electricity demand curve or even better, move the demand from the hours in which RES production is low to the hours in which RES production is high. The regulatory instruments are mainly two:

(i) Time-differentiated access tariffs for some consumers

(ii) Contracts with large consumers willing to flatten their load curve and allowing interrupting their power supply in specific circumstances in exchange for a payment (which can be seen as a reduction of their corresponding access tariff). This kind of contracts is addressed to incentivize in particular the consumers who have the largest potential of changing their behavior.

Source: National Plan for energy savings and efficiency 2011-2020

R. Sweden

Main general policies in favour of energy efficiency:
Measures in building sector and in industry for increased energy efficiency. Main measures are tax reliefs.

Main policies in favour of thermal insulation in buildings:
Strict requirements for energy usage in new houses. (Maximum heat consumption of 55-95 kWh/(m^2*year) (depending on geographical location) for houses with direct electrical heating and 90-130 kWh/(m^2*year) if other heating)

Main policies, restriction or encouragement concerning electric space heating devices:
Currently none, but a subsidy programme for conversion of direct electric heating has recently been ended.

Main policies in favor of electric vehicles:
Electric vehicles are promoted as environmental and owners pay no vehicle tax for the first five years.

Main policies, restriction or encouragement concerning other electric devices:
Energy labeling.

Main policies, restriction or encouragement concerning Demand Side Management:
Since 1 October 2012, end consumers can choose hourly balancing. The possibilities for net debiting of end consumers are currently being investigated. A national council for Smart Grids have been set up.

S. Switzerland

Main general policies in favor of energy efficiency:
Measures in the building sector, regulations on vehicle emissions, and minimal efficiency standards for electrical appliances

- ***Targets:***
  Improvement of building efficiency standards, reduction of CO2 Emissions, reduction of electricity demand per appliance.
- ***Time frame:*** *2050*

Main policies in favor of thermal insulation in buildings:
More stringent requirements for new and renovated buildings. The main hindrance of such measures has so far been slow renovation rates. Cantonal policies are of particular significance in the building sector as the relevant national policies must be incorporated into -and implemented by way of - cantonal regulations.

- ***Targets:***
  Increasing renovation rates, compulsory building energy efficiency certificate for new or renovated buildings. Reducing building energy consumption by 28 TWh (of which 12 TWh electricity) compared to Business-as-usual.
- ***Main measures:***
  More stringent cantonal regulations, funding via CO2 taxes (currently only on fuel for heating but not fuel for transportation), favorable tax reductions for complete building renovations (current regulations favor step-wise and as such often poorly coordinated renovations), energy certificates (primarily for information purposes).
- ***Time frame****:* 2050

Main policies, restriction or encouragement concerning electric space heating devices:
Policy to forbid electric heaters and boilers. Fossil fueled heating systems (in particular oil) are to be replaced by RES. An inspection of buildings energy systems every 10 years is to be made compulsory. The main restriction of such measures is public acceptance (e.g. the new energy policy to forbid the future installation of electric heaters was rejected last autumn in one canton by its population).

- ***Targets:***
  From 2020 onwards, new buildings are largely net autonomous concerning yearly heat production, and can also cover some of their electricity requirements. New buildings shall not require more than 60 kWh/(m^2*year) for heating (minimal standard).
- ***Main measures:***Regulations.
- ***Time frame****:* 2050

Main policies in favor of electric vehicles:
No direct policies promoting electric vehicles but measures to improve the general efficiency of transportation. A shift towards e-vehicles may occur depending on development path and thus increase electricity demand. No concrete scenarios exist at present concerning the magnitude of this effect (see 'other relevant trends' below).

- ***Targets:***
  Reduction of CO2 emissions: By 2015, the average CO2 emissions per vehicle shall not exceed 130 g CO2/km and by 2020 the value will be at 95g CO2/km.
- ***Main measures:***Regulation, certificates (for information purposes).
- ***Time frame****:*2020; follow up targets not (yet) defined.

Main policies, restriction or encouragement concerning other electric devices:
Minimal efficiency standards for electric appliances as well as information campaigns concerning such devices. On the cantonal and local level time-limited campaigns offering partial refunds of the costs of very efficient machines (refrigerators, tumble dryers, washing machines) have been carried out in recent years.

- ***Targets:*** The estimated efficiency improvement potential of best-available-technologies compared to present technologies is 25-30%.
- ***Main measures:*** Regulations, information campaigns, promotions and energy labels.
- ***Time frame****:* 2050, with concrete targets to be reevaluated every few years.

Main policies, restriction or encouragement concerning Demand Side Management: Promotion of smart metering

- ***Targets:*** At present no concrete targets defined. Energy utilities have, or are conducting smart metering pilot projects.
- ***Main measures:*** Regulations (to be developed).
- ***Time frame****:* 2050

Other relevant trends: Depending on the pursued energy strategy, electricity demand of transportation may increase considerably.At present, transportation represents 5% of total electricity demand. Most of this can be attributed to rail transport. By 2050, this share (incl. all forms of transportation) is expected to increase to 10-20%.

T. United Kingdom

Main general policies in favor of energy efficiency:
EU ETS, Climate Change Levy, Carbon Emissions Reduction Target (CERT), Community Energy Savings Programme (CESP), Carbon Reduction Commitment (CRC), Building Regulations, Code for Sustainable Homes.

- ***Target:*** CRC mandatory carbon reductions for business based on peer performance.
- ***Main measures:*** Taxes, obligations, levies, supplier obligations for whole house solutions for low income families, Building design standards.

Main policies in favor of thermal insulation in buildings:
Green Deal, ECO.

- ***Target:*** Reduce CO2 targets by 0.5M ton/year by 2015.
- ***Main measures:*** Loan to buy energy efficiency device paid by savings in energy bill.

Main policies, restriction or encouragement concerning space heating electric devices:
Renewable Heat Incentive

- ***Target:*** There is a funding cap for each year.
- ***Main measure:*** Subsidy**:** RHI tariff lifetime 20 years

Main policies in favor of electric vehicles:

Office of Low Emission Vehicles, Tax exemption and Congestion Charge exemption. £5,000 grant against vehicle purchase.

Main policies, restriction or encouragement concerning other electric devices:
Legislation to prevent incandescent light bulbs, energy efficiency labeling.

2.2.2 Summary of national policies on demand and energy efficiency

In the following table and figures, we provide an overview of countries having policies and/or measures with a specific focus on demand and energy efficiency. This summary reflects the current policies in Europe. Previous polices may have been different and future policies will certainly be. Thus the answers here do not reflect the *development of the topic* (for example the electric vehicles in the country) but the *existence of a policy on that topic*.

Table 2.1 Summary of national policies on energy efficiency and demand side management

Blank : no policy or no answer

++ : existing operational measure(s)

+ : existing policy or politically desired

	Energy efficiency	Thermal insulation in buildings	Electric space heating devices	Electric vehicles	Other electric devices	Demand Side Management
Austria	++	++	++	++	++	++
Belgium	++	++	++	++	++	++
Bosnia and Herzegovina	+					
Bulgaria						
Croatia						
Cyprus						
Czech Republic	+	++	++	++	++	++
Denmark	++	++	++	++	++	++
Estonia						
Finland						
France	++	++	++	++	++	++
Germany	++	++		++		++
Greece	++	++		++	++	+
Hungary						
Iceland						
Ireland						
Italy	+	++	+	+	+	+
Latvia						
Lithuania	+	+				++
Luxembourg						
FYR Macedonia	+	+			++	
Montenegro						
Netherlands						
Norway	++	++	++	++	++	++
Poland	++	++				++
Portugal	++	+	+		++	++
Romania	+	+	+	++	+	++
Serbia	+	+				
Slovak Republic						
Slovenia						
Spain	++	++	+		++	++
Sweden	++	++	+	++	++	++
Switzerland	++	++	++	+	+	+
United Kingdom	++	++	++	++	++	

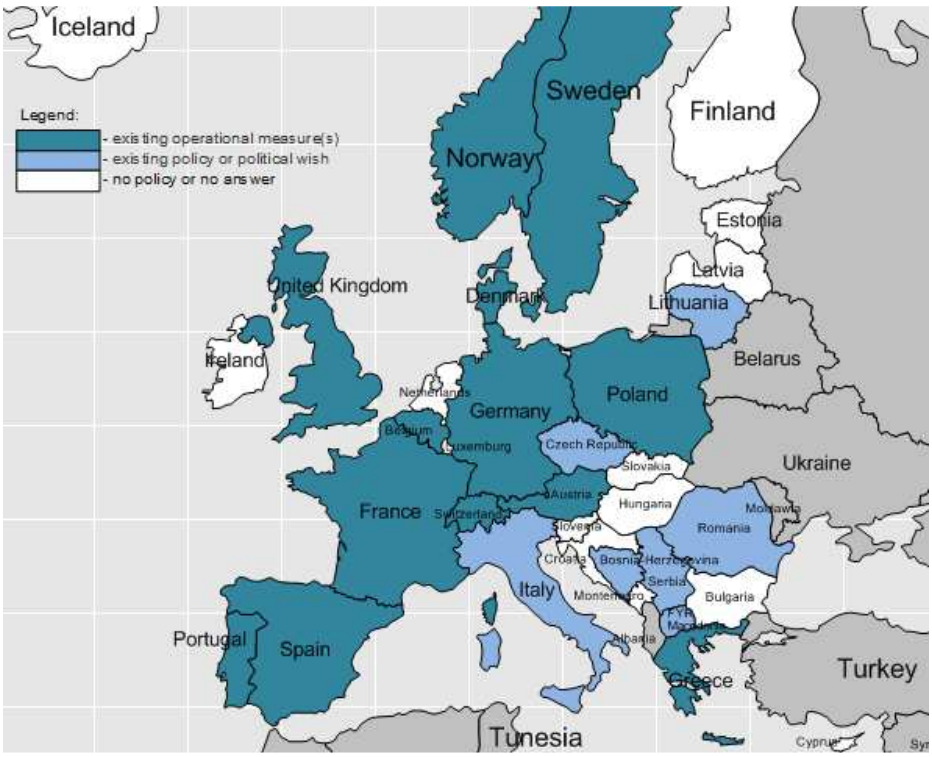

Figure 2.1 Map of national policies on energy efficiency

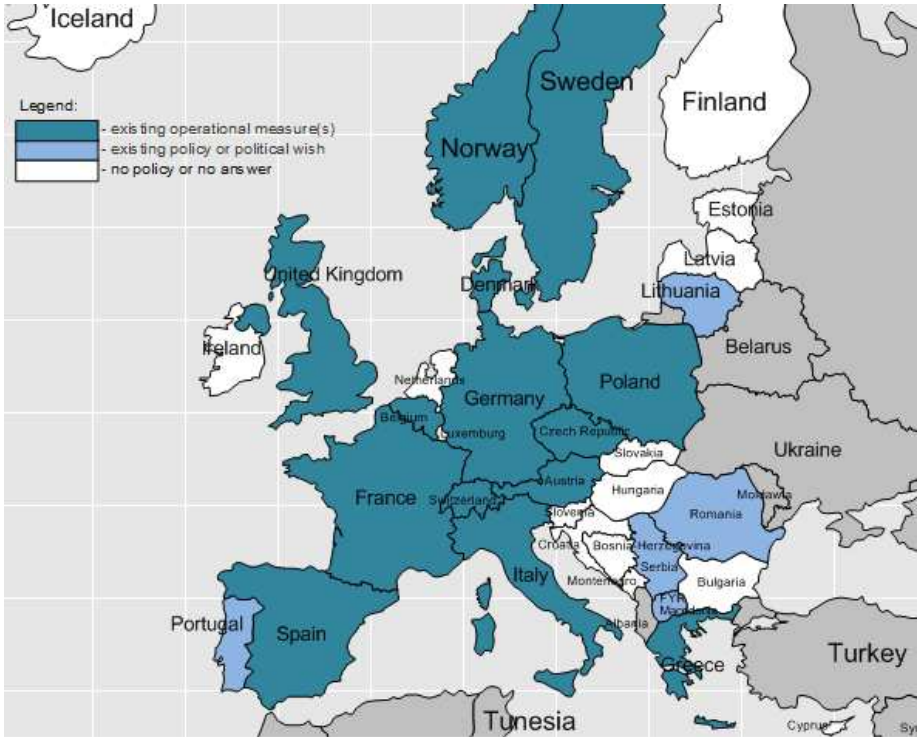

Figure 2.2 Map of national policies on thermal insulation in buildings

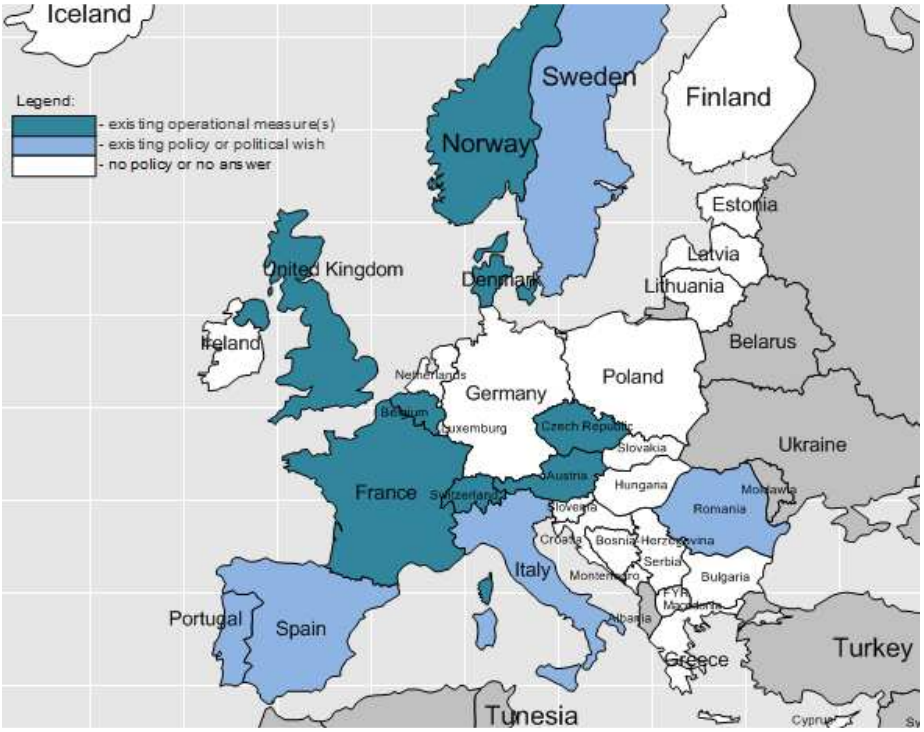

Figure 2.3 Map of national policies on electric space heating devices

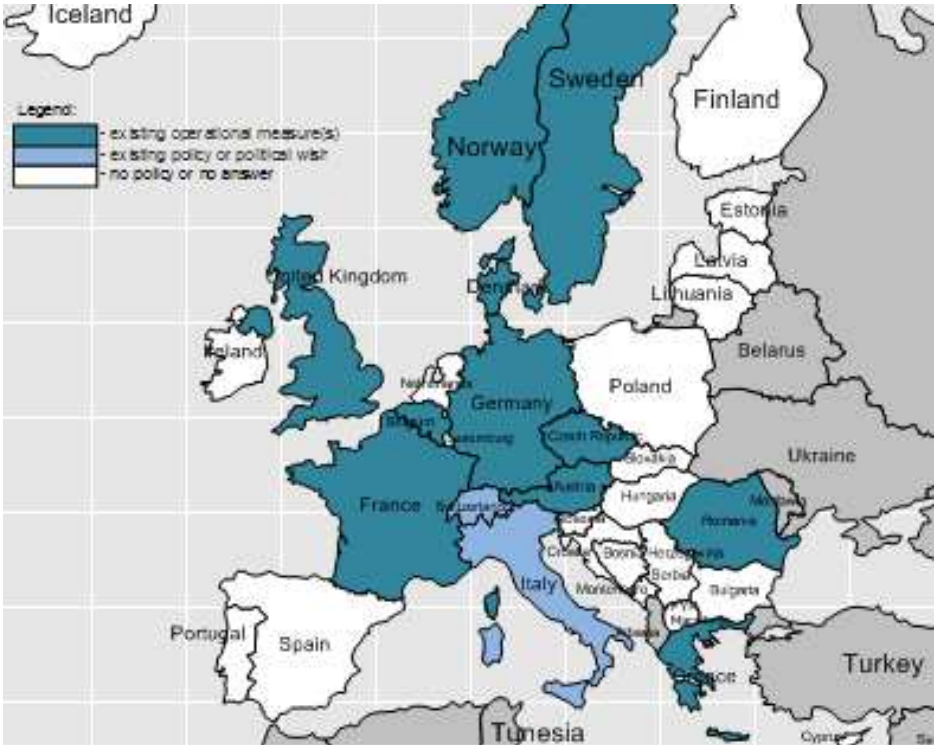

Figure 2.4 Map of national policies on electric vehicles

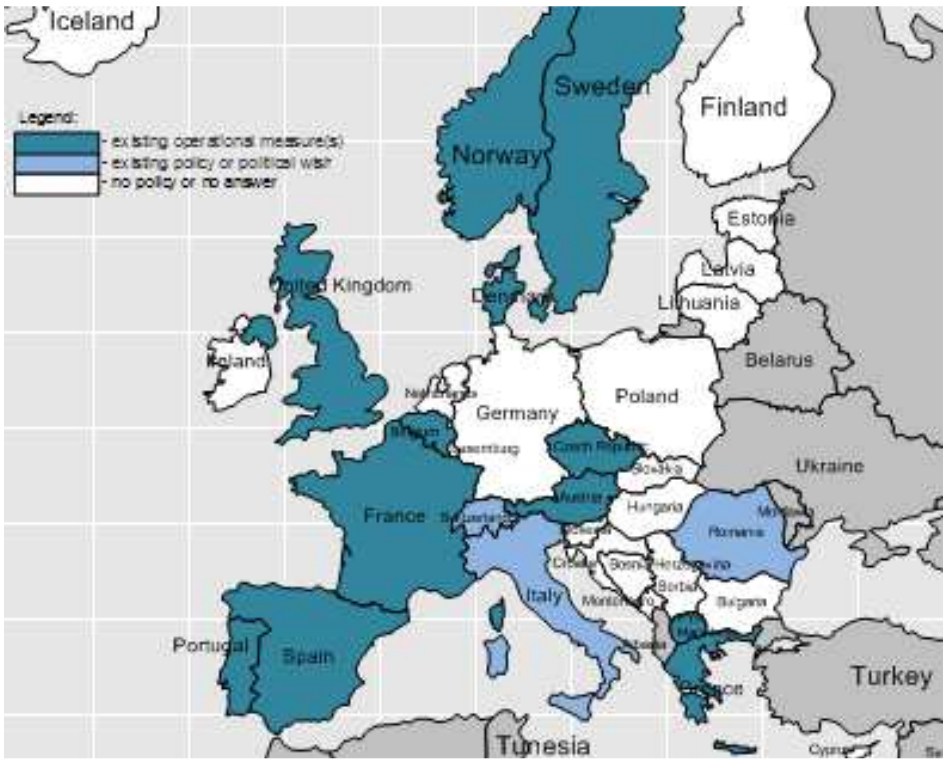

Figure 2.5 Map of national policies on other electric devices

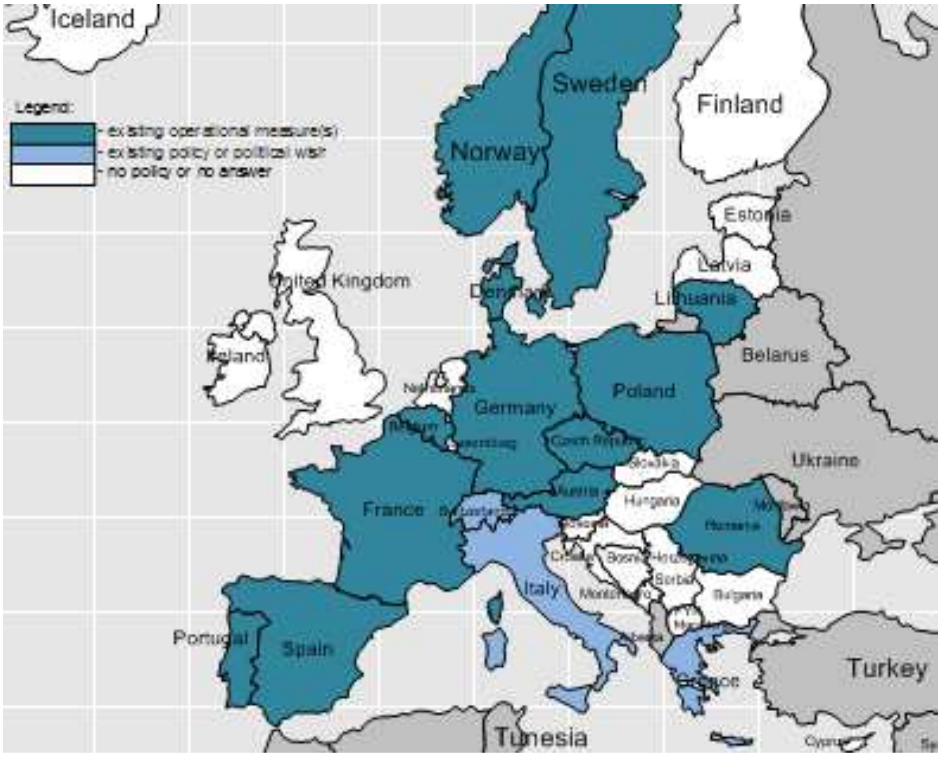

Figure 2.6 Map of national policies on DSM

Table 2.2 Summary of measures

	Energy efficiency	Thermal insulation in buildings	Electric space heating devices	Electric vehicles	Other electric devices	Demand Side Management
Austria	Statutory regulations to increase energy efficiency	Promotion of renewable energy systems in the building sector Stronger focus of housing support on thermal remediation	linked to housing support and further initiatives at regional and local levels.	Tax reduction and exemption NoVA greening – tax reduction for low CO2-emission vehicles	Strategy	Strategy
Belgium	Tax relief	Subsidies	Tax reduction	Tax reduction	Labeling system	R&D programs
Czech Republic		Low energy standards, Regulation	Heat pumps replace local coal	Support of R&D	Labelling system	Support of smartgrids
Denmark	Subsidies, taxes and regulations	Subsidies, taxes and regulations	No more oil fired burners, Subsidies	Tax reduction	Subsidies	Smart meter, Regulation
France	Regulation, incentives, energy saving certificates	Regulation, incentives for low energy building	Regulations, subventions	Promotions incentives	Energy saving certificates	Balancing mechanism
Germany	Subsidies	Subsidies		Subsidies		Subsidies
Greece		Tax incentives				
Italy		Incentive				
Lithuania		Promotion of buildings modernization				
FYR Macedonia	Decree for program plans, promotion, obligations for big consumers	Decree for program plan	Decree for program plan		Labelling,decree of eco design of products	
Norway	Financing, active advice	Recommen-dations	Tax reduction			Metering system

	Energy efficiency	Thermal insulation in buildings	Electric space heating devices	Electric vehicles	Other electric devices	Demand Side Management
Poland	White certificates	Subsidies		Tax reduction, incentives		
Romania	Subsidies	Subsidies		Purchase incentive		
Serbia	Green passport					
Spain		Program plan		Promotion		Contracts with large consumers
Sweden	Tax reduction			Tax reduction	Labeling system	Hourly balancing
Switzerland	Building efficiency standards	Regulation, tax reduction, green certificate	Regulations	Regulation, certificates	Regulations, information campaigns, promotions and energy labels.	
United Kingdom	Taxes, obligationsbuilding design standards.	Loan	Subsidy	Purchase incentive	Energy efficiency labeling	

Table 2.3 Summary of targets

	Energy efficiency	Thermal insulation in buildings	Electric space heating devices	Electric vehicles	Other electric devices	Demand Side Management
Austria	Reductions in energy consump-tion -22 % for transport, 12 % for heating and cooling, 5 % for electricity	In the part of the building code / technical rules, there are general requirements on energy savings and thermal insulation:		Applicants / tax-privileged individuals Vehicles with environmentally friendly power supply motors * maximum bonus € 500 per vehicle		
Denmark	Increase energy efficiency in buildings and in transport	strict requirements to new buildings regarding insulation reduction of energy consumption in older buildings	Oil fired burners are to be phase out by 2030 and should be replaced by district heating, heat pumps or other RE heating solutions	Promotes the use of electric Vehicles Test schemes for electric vehicles research scheme for EV DKK 53 m Green transport policy DKK 180 m		demand-side management and active demand-side participation in markets, increased DG and domestic storage (e.g. electric cars) with active management of distribution networks
France	combat climate change and improve energy perfor-mance	reduction of energy consumption in older buildings	reduce the development of Joule effect space heating	2 million electric and plug-in hybrid electric vehicles in 2020	345 TWh of savings (2011-2013)	
Lithuania	1.5 % annual savings of the total final energy consumption	reduction ofthe heat consumption by 30–40 % in buildings by 2020				
FYR Macedonia	at least 9% energy savings by 2018	greater exploitation of RES for energy supply in households and service sector			The energy-related products fulfilling prescribed criteria /conditions according to the Decree on eco	

	Energy efficiency	Thermal insulation in buildings	Electric space heating devices	Electric vehicles	Other electric devices	Demand Side Management
					design of products put on the market	
Poland	Energy saving > 9% of the national average energy consumption per year. Use of White certificates	Preparing energy characteristic as certificates Subsidies for those who decrease building energy consumption				
Romania	Elimination subsidies to households with district heating systems	Reduction of heating and hot water bill by 40-60%				
Serbia	Limit in consumption of electrical energy in new buildings will be 65 kWh/m2.					
Switzerland	Improvement of building efficiency standards, reduction of CO2 Emissions, reduction of electricity demand per appliance.	Reducing building energy consumption by 28 TWh (of which 12 TWh electricity)	From 2020 onwards, New buildings autonomous concerning yearly heat production New buildings shall not require more than 60 kWh/(m²*year) for heating	By 2015, the average CO2 emissions per vehicle shall not exceed 130 g CO2/km and by 2020 the value will be at 95g CO2/km.	The estimated efficiency improvement potential of best-available-technologies compared to present techn is 25-30%.	
United Kingdom	CRC mandatory carbon reductions for business	reduce CO2 targets by 0.5M ton/year by 2015	funding cap for each year			

2.3 Generation

National incentives and restrictions regarding different types of generation units are analyzed. In this connection restrictions on nuclear and centralized thermal units are of major interest as well as encouragements regarding RES. These developments are important for the e-Highway 2050 – analysis, as the shift from large centralized power units to fluctuating, decentralized suppliers has an impact on the necessary future grid structure. The main policies, restrictions or encouragements concerning the following generation technologies are considered:

- Thermal units
- Nuclear units
- Photovoltaic
- Wind energy
- Biomass
- Other RES
- CHP

2.3.1 National policies on generation

A. Austria

Thermal units:
The permitting procedure (for construction) is an environmental impact assessment (EIA) (the Austrian version of the EU guideline).

- ***Targets:*** The following topics are treated: environmental impact (geology, biology, hydro, etc.), human medicine, detailed project description including constructions, energy economic use, technical alternative, etc.
- ***Main measures:*** All restrictions and guideline must be respected.

Nuclear units: There is no nuclear power in Austria.

Hydro:
Green electricity law (Ökostromgesetz) (mainly small hydro power plants);for construction EIA (see thermal),

- ***Targets:*** Encouraging the construction of hydro generation and facilitate market competition; plus 1000 MW
- ***Main measures:*** Subsidies
- ***Time frame:*** 2020

Photovoltaic:
Green electricity law (Ökostromgesetz) and local policies. For construction: EIA (see thermal) only if PV generation is big enough (not required for households);

- ***Targets:*** Encouraging the construction of PV generation and facilitate market competition; plus 1200 MW
- ***Main measures:*** Subsidies, feed-in-tariffs; Time frame: 2020

Wind energy:
Green electricity law (Ökostromgesetz) and local policies; for construction EIA (see thermal);

- ***Targets:*** Encouraging the construction of wind generation and facilitate market competition; plus 2000 MW
- ***Main measures:*** Subsidies, feed-in-tariffs, Time frame: 2020

Biomass:
Green electricity law (Ökostromgesetz) and local policies; for construction EIA (see thermal);

- ***Targets:*** Encouraging the construction of biomass generation and facilitate market competition; plus 200 MW
- ***Main measures:***Subsidies, feed-in-tariffs, Time frame: 2020

Other trends: Possible projects (especially wind) exceed the targets of the Green electricity law (Ökostromgesetz) which hasn't been adapted; therefore projects exist but might not get implemented.

B. Belgium

Thermal units:
Capacity payments (or some related mechanisms) and/or tendering processes may be considered due to SoS issues in Belgium.

Nuclear units:
Federal law on 13 January 2013 stating the nuclear phase-out in Belgium.
Taxation on the incomes from nuclear energy ("nuclear rente")

Renewables:
Off-shore RES generation: Demarcation of a reserved zone for the implementation of off-shore wind parks; Granting of area concessions; Support for electricity generated from renewable sources (green certificates). System favourable for output gaps. Contribution to the cabling costs.

On-shore RES generation: Green certificates mechanism with guaranteed minimum price; Green electricity quotas; Specific value of green certificates for photovoltaic energy (Flanders); Multiplying factor (Walloon Region); Compensation principle for systems with an output of less than 10 kVA; Granting of guaranteed origin labels; Lifting of restrictions for wind parks in agricultural zone (Flanders);Action plans for the purchase of green electricity by public authorities.

Support in investment:
- Tax reduction for investments in renewable energies (individuals);
- Tax deduction for investments in renewable energies (companies);
- Tax reduction on the interest rate payable on loans, and tax reduction on interests paid on investments in renewable energies for housing (individuals);
- Financing by third-party investor FEDESCO;
- Premiums for the installation of renewable energies infrastructure (Companies-Individuals)
- Investments in agricultural and horticultural sector;
- Intervention in connection costs for a renewable energy sources plant (Flanders);
- Supplementary support granted to local authorities; Compulsory renewable energies;

Network access: Development plans for electrical infrastructures (and PSE); Financing of BeProne platform on the grids reliability NB ADM, universities; Priority network connection for plants generating electricity from renewable energy sources; Priority network access for plants generating electricity from renewable energy sources; Technical regulations for connecting decentralised plants in parallel on the distribution network; Simple declaration for plants of less than 5 kW for single-phased connection or of less than 10 kW for three-phased connection; Development of smart grids (i.a., pilot projects); Administrative Simplification, Protection and information of consumers, R&D Studies

CHP: CHP certificates; Premiums for heating networks

Other relevant trends:
- Support mechanism for green heating;
- Procedures for granting environmental permits and urban planning permits may affect projects of new power plants.

C. Bosnia and Herzegovina

Thermal units: None

Nuclear units: So far, nuclear energy in B&H has not been discussed.

Hydro power units: Subsidies exist for small hydro plants

Photovoltaic: Subsidies exist for PV

Wind energy: Off-shore Wind parks are not an option for Bosnia and Herzegovina. Subsidies exist for Wind; 350 MW of wind by 2019, 640 MW by 2023

Other RES: None

CHP: None

D. Czech Republic

Thermal units: Support of co-generation and high efficiency of units

Nuclear units: Support of nuclear power (its share up to 50-60 % by 2040) and its use for central heating.

Hydro power units: No substantial development of hydro power but support of new Pumped Storage.

Photovoltaic: Support of roof installations only.

Wind energy: Support tailored according to economic possibilities, natural conditions and limitations in protection areas

Biomass: Special support of large units of 10 - 100 MW due to easiest compliance with emission standards

Other RES: After fulfilment of Czech RES obligations, gradually no RES subsidies; 18-25% generation share by 2040

CHP: Heat pumps preferred to classical sources. Coal is to be replaced by gas and biomass.

E. Denmark

Thermal units: Coal used as fuel on central power plants should be phased out by 2030 and replaced by biomass

Nuclear units: Nuclear units is not and has never been a part of Danish energy policy

Hydro power units: The topology in Denmark doesn't allow establishment of Hydropower in a large scale

Photovoltaic: There are no national goals on the amount of photovoltaic. However PV is supported by a PSO (Public Service Obligation) scheme

Wind energy: The goal is to have 50% wind-power in the electricity system by 2020. The new wind-production will primarily be supplied by offshore wind and only a smaller part will be supplied by onshore wind

Biomass: Biomass will replace coal in the central power plants by 2030. Further biogas is a special focus area supported by subsidies; CHPs should be using heat pumps, biomass and biogas by 2035

CHP: Electricity and heat systems should be based on RES by 2035.

F. France

Thermal units:
European directive but no transposition law in France for the moment. Around 4 GW of oil units and 3.6 GW of hard coal units will shut down between 2012 and 2015 because of this directive. A new European directive on industrial emissions will be implemented on 1st January 2016 (IED directive) to establish lower values for emission limits. The consequence for thermal units will be the closing down of several units which haven't made yet the required refurbishments. Lower limits should be implemented in 2023. New thermal units are built taking these constraints into account.

Nuclear units:
New political program / governmental announcement but no law.An announced objective is to reduce the share of nuclear in electricity production to 50% in2025.For the moment and as a consequence of Fukushima event and international debates about nuclear, the only decision actually taken in France is to shut down one nuclear unit (Fessenheim) in 2017, because of its age.

Hydro power units:
Official law concerning concessions. French government is currently leading a process to re-allocate the hydro concessions to different producers. This competition could lead to lightly increase hydro power or pumping power, but the limitations due to environmental and social reasons (water policy for wildlife or leisure activities, protection of dales and natural landscapes...) are an important limit to further development of hydro.

Photovoltaic:
Several law for the subventions; National Renewable Energy Action Plan (NREAP) targets 5.4 GW of solar for 2020; Subventions for PV (installation and feed-in-tariff)

Wind energy:
Several laws for the subventions.
National Renewable Energy Action Plan (NREAP) targets for 2020:
- On-shore wind: 19 GW
- Off-shore wind: 6 GW
Subsidies for on- and offshore wind (installation and feed-in-tariff).

Biomass:
National Renewable Energy Action Plan (NREAP) targets 3 GW of biomass for 2020

G. Germany

Thermal units: Revenues achievable in the energy market

Nuclear units: Nuclear phase-out by 2022

Photovoltaic: Subsidies

Wind energy: Subsidies

Biomass: Subsidies

CHP: Subsidies

H. Greece

Thermal units:
The main policies for the large centralized thermal units are the modernization and upgrading of existing thermal power plants along with the reinforcement of the transmission system at 400 kV voltage level.

Nuclear units: Nuclear units do not exist in Greece and are not considered for the future.

RES units:
Hydro plant development is encouraged but there are severe environmental obstacles.
Wind farms, PVs, Biomass/biogas plants, small hydros and other RES have priority in dispatch and are remunerated by a fixed Feed in Tariff (FIT).

Offshore Wind Farms do not exist yet. The FIT for offshore Wind Farms (WF) are higher compared to onshore WFs.

CHP of high efficiency (<50 MW) are treated by the existing legislation equally to RES plants.

I. Italy

Thermal units:
The permitting procedure (for construction and operation) for thermal plant is subjected to environmental impact assessment (EIA) and, with power more than 300 MW, to single authorization procedure (for plan end grid connection asset) by Ministry for Economic Development

- ***Targets:***
  The following topics are treated: environmental impact (geology, biology, hydro, etc.), human medicine, details project description including constructions, energy economic use, technical alternative, etc.
- ***Main measures:*** All restrictions and guideline must be respected.

Nuclear units: No nuclear power

Photovoltaic:
Simplified authorization (PV and grid connection) procedures

- ***Targets:*** Encouraging the construction of PV generation and facilitate market competition

- ***Main measures:*** Subsidies; Time frame: 2020

Wind energy:
Simplified authorization (Wind Farm and grid connection) procedures

- ***Target:***Encouraging the construction of Wind generation and facilitate market competition.
- ***Main measures****:* Subsidies; Time frame: 2020

Biomass:
Simplified authorization (biomass plant and grid connection) procedures

- ***Target:*** *encouraging the construction of Biomass generation and facilitate market competition.*
- ***Main measures:*** *subsidies; Time frame: 2020*

J. Lithuania

Thermal units: Encourage new biofuel-fired Thermal power plants

Nuclear units: Construction of the Visaginas Nuclear Power Plant (Visaginas NPP) is the key strategic project in terms of the development of competitive domestic power generation by 2020. The Visaginas NPP is project is a project of regional importance, supported by European Commission.

Renewables:
Power generation from renewable energy sources will account for at least 20 % of the final electricity consumption. Competitive and affordable price is the main criterion for the power generation from renewable energy sources. In its efforts to promote renewable energy, Lithuania will take steps to gradually introduce suitable and clear market conditions that would take into account total costs of energy produced from renewable energy sources, including back-up capacity, balancing and grid expansion costs. The state will also set priorities on the most economically viable renewable energy technologies.

Hydro power units:
In 2020 Lithuania should have at least 141 MW installed capacity of hydro electric power plants.

Photovoltaic:
In 2020 Lithuania should have at least 10 MW installed capacity of solar power plants. The use of solar energy for preparation of hot water will be encouraged.

Wind energy:
In 2020 Lithuania should have at least 500 MW installed capacity of wind power plants.

Biomass:
In 2020 Lithuania should have at least 355 MW installed capacity of biomass power plants.

CHP:
In order to increase energy efficiency and power system decentralization, encourage small-scale CHP installation closer to the users.

K. FYR of Macedonia

Nuclear units:
Strategy for energy development envisaged usage of nuclear energy for covering the electricity needs but there is no further elaboration on this.

Hydro power units:
Government prescribes feed-in tariffs for electricity produced from SHPP. In accordance to the Energy Law the transmission system operator and distribution system operators should provide priority access for the electricity generated from RES pursuant to the constraints that are raised from the operational possibilities of the power system.

Hydro power plants can obtain the status of preferential generators provided that their installed capacity is lower or equal to 10 MW. The price of electricity generated and delivered by hydro power plants in a period of one calendar month shall be calculated on the basis of feed-in tariffs for separate blocks. The Block Quantity of electricity delivered per block (kWh) feed-in tariff for electricity delivered per block (€¢/kWh) is as follows:

- *I ≤ 85,000 12.00*
- *II > 85,000 and ≤ 170,000 8.00*
- *III > 170,000 and ≤ 350,000 6.00*
- *IV > 350,000 and ≤ 700,000 5.00*
- *V > 700,000 4.50*

The preferential generator shall be entitled to apply feed-in tariffs for electricity generated by hydro power plants for a period of 20 years.

Photovoltaic:
Government prescribes feed in tariffs for electricity produced from photovoltaic system and also subsidies for the solar thermal collectors. Photovoltaic power plants can obtain the status of preferential generator provided their installed capacity is lower or equal to 1 MW. The feed-in tariffs for electricity generated and delivered by photovoltaic power plants, depending on the plant's installed capacity, shall be 30 €¢/kWh for power plants with installed capacity ≤50 kW, and 26 €¢/kWh for power plants with installed capacity>50 kW. The preferential generator shall be entitled to apply the feed-in tariffs for electricity generated by photovoltaic power plants for a period of 15 years. Subsidies for buying and installation of thermal solar collectors are 30 % of the total cost but not more than 300 € per household in the frame of the Budget assets.

Greater share of solar energy in the final energy consumption in 2020. The Program for subsidies for buying and install solar thermal collectors in household is on the annual level.

Wind energy:
Government prescribes feed in tariffs for electricity produced from wind plants. Wind power plants can obtain the status of preferential generator provided their installed capacity is lower or equal to 50 MW. The feed-in tariff for electricity generated and delivered by wind power plants shall be 8.9 €¢/kWh. The preferential generator shall be entitled to apply the feed-in tariffs for electricity generated by wind power plants for a period of 20 years.Greater involvement of electricity produced from wind energy. The RES Rulebook prescribes measuring wind potential for electricity generation and issuing approvals for measuring wind potential for electricity generation. Also, Ministry of economy installed the wind measurement equipment on the five locations. Several studies were made in the last period to determine the wind energy potential in FYR of Macedonia and to select the best sites for WPP construction.

Other RES:
The main objective of the RES Strategy is to provide information on the potential and possible exploitation of renewable energy sources in the FYR of Macedonia. Quantification of such knowledge shall be made by determining the following: target share in total energy (RES target), which is share of energy generated from RES in the total energy consumption; manner and dynamics of attaining RES target and RES electricity target.

Share of Renewable Energy Sources in the final energy consumption until 2020 should be 21 %. The target from paragraph 1 from this Article should be achieved with construction of new energy facilities which use renewable energy sources as stronger energy efficiency measures in accordance with the Strategy for utilization of Renewable Energy Sources in the FYRof Macedonia until 2020 and Strategy for development of the Energy Efficiency in the FYRof Macedonia until 2020.

Present Strategy undertakes relevant analyses aimed to determine: installed capacity per plant required to obtain the status of preferential electricity producer from RES, for all RES types; total installed capacity eligible for application of feed-in tariffs to be used for purchase of electricity from RES, for all RES types; financing mechanisms for feed-in tariffs. Environmental aspects have been addressed mainly by means of RES environmental impact assessment by determining total greenhouse gas emissions (expressed in kton CO2-equivalents) that can be reduced with the use of RES.

CHP:
Rulebook on high efficient combined heat and power plants establish a register for high efficient combined heat and power plants and issuing of guarantee of origin of electricity produced by CHP as well as register of such guarantees.Register of CHP and issuing guarantee of origin of electricity produced by CHPP.

L. Norway

Thermal units: No thermal gas production without CCS

Nuclear units:Not accepted

Hydro power units: Positive development of small and medium hydro; Included in Green certificate market

Photovoltaic:No policies

Wind energy: Included in Green certificate market, but will not be sufficient for offshore development

Biomass:Positive to biomass; Included in Green certificate scheme; time frame: 2020

Other RES:Encourage RES development up till 13.6 TWh

CHP: No new CHP without CCS; Targets: 13.6 TWh; Green certificates

M. Poland

Thermal units:

a) Ministry of Environment regulation on the installation of emission standards - 22.04.2011 - implementation of LCP Directive: Qualitative target: Determination of boundary level of pollutant emission - numbers as in LCP directive
b) Industrial Emission Directive (IED): Qualitative target: Determination of boundary level of pollutant emission - numbers as in IED
c) Minister of Environment regulation on the free allocation of CO2 emission - 27.09.2011 - implementation of Climate Policy: Qualitative target: percentage of free allowances in the total CO2 emission: 2013 - 70%; 2014 - 65%; 2015 - 60%; 2016 - 54%; 2017 - 47%; 2018 - 39%; 2019 - 29%
d) Energy Roadmap 2050: Qualitative target: reduction of CO2 emissions by 80% until 2050.

The quantitative target is to reduce air pollution and GHG emission

Nuclear units:

a) Atomic Law Act - 29.11.2000
b) Act on the preparation and implementation of investment in nuclear power facilities and associated investment - 29.06.2011

The quantitative target is a diversification of generation; Quantitative target: 6000 MW until 2030.

CHP and other decentralized thermal units

a) Energy Law Act with latest amendments
b)) Regulation of the Minister of Economy of 26 July 2011 on specific responsibilities to obtain and present to the redemption of certificates of origin, the replacement fee and to confirm the data on the amount of electricity generated from high efficient cogeneration sources.

Trading company must purchase certain level of energy from high efficient cogeneration units. This amount in compare to total energy coming from all cogeneration units must ensure the part not less than:
1) units fired by natural gas or unit less than 1MWe (yellow certificate)
2011 - 3,3%
2012 - 3,5%
2) units fired by methane from hard coal mines (purple certificate)
(2011 - 0,4%, 2012 - 0,6%, 2013 - 0,9%, 2014 - 1,1%, 2015 - 1,3%, 2016 - 1,5%, 2017 - 1,8%, 2018 - 2,3%
3) other high efficient CHP units (red certificate)
2011 - 22,2%, 2012 - 23,2%

Certificates of origin (red, yellow, purple) in addition to market price of electric energy determine additional income for companies which generate high efficient energy in cogeneration process. Maximum prices of certificates are different for different types of certificates. Upper limit of the price is determined annually by President of Energy Regulatory Authority. Current values are as follow:

1) Yellow certificate:
2012 - 31,8 €/MWh, 2013 - 36,9 €/MWh

2) Purple certificate:
2012 - 14,8 €/MWh, 2013 - 14,8 €/MWh

3) Red certificate:
2012 - 7,2 €/MWh, 2013 - 7,4 €/MWh

1) Until the end of 2012: Working on the amendment of Regulation (b) is currently in progress.
2) Until the end of 2018 (b)
3) Until the end of 2012: Working on the amendment of Regulation (b) is currently in progress.

Renewables:

a) Energy Law Act with latest amendments
b) Regulations of the Minister of Economy of 23 February 2010 and of 18 October 2012 amending Regulation on specific responsibilities to obtain and present to the redemption of certificates of origin, the replacement fee, purchase of electricity and

heat produced from renewable energy sources, and to confirm the data on the amount of electricity generated from renewable energy sources

c) Draft Energy Law: The law stipulates the quantitative percentage targets of renewable energy for the years 2012-2020 to be included in the portfolio of energy sold to final consumers by trading companies. The financial support refers to certificates of origin tradable on the Polish Power Exchange, so-called Green Certificates, the price of which is determined by the market. However, the cap for the price of the Green Certificates is set by the so-called replacement fee, which is the fee paid to the National Fund for Environmental Protection and Water Management in case of shortage of green energy and certificates on the market. Therefore the maximum price of renewable energy is the sum of the average market energy price in the year preceeding the year for which the certificates are issued (yearly officially announced by the Regulator) and the price of the certificates of origin.

d) The draft law on renewable energy sources*:* The law is to create the conditions favoring different types of technologies of RES production. The feed-in tariffs refer to microinstallations, differentiated according to their size in hydropower, solar, wind onshore and biogas, the price ranges of which (min-max) are set for the years 2013-2014. The feed-in support is limited to 15 years from the start of exploitation of the mentioned types of micro installations but no longer than until 2035.

   For other types of units in hydropower, solar, wind offshore, wind onshore, biomass, biogas, biofuel, co-fire and geothermal production, the support system is based on tradable certificates of origin that shall take into account the so-called energy correction coefficients in different technologies. The price of certificates is set by the market while the correction coefficients are set up until 2017, with the possibility of their adjustment. The law stipulates also price cap ranges for years 2013-2017 for every of the technology. This kind of support system is limited to 15 years from the start of exploitation of the mentioned types of micro installations but no longer than until 2035.

N. Portugal

Thermal units: No policy (beyond already licensed capacity)

Nuclear units: Nuclear is not in the agenda

Hydro power units: An undergoing national plan (launched in 2007) is been implemented in order to explore national hydro power resources.

- ***Targets:*** *70% of national hydro power resources to be explored until 2020: 9000 MW (total).*
- ***Main measures:*** *Capacity payments;*
- ***Time frame:*** *2020*

Photovoltaic:
Revised NREAP to decrease the development of solar power by 60% (compared to previous plan); Non-mature technologies not to be supported by electricity tariffs but by other mechanisms instead (e.g. CO2 emission trading schemes).

- ***Targets:*** *PV: 500 MW in 2020; Solar Thermal: 50 MW in 2020;*
- ***Main measures:*** *Other mechanisms than feed-in tariffs shall be used to further developments (details to be published).*

Wind energy:
Revised NREAP to decrease the development of wind power by 20% (compared to previous plan);

- ***Targets:*** Wind: 5300 MW in 2020*;*
- ***Main measures:*** Feed-in tariffs or other shall be used to further developments (details to be published)

Biomass:
Revised NREAP to decrease the development of biomass and biogas by 20% (compared to previous plan);

- ***Targets:*** Biomass + Biogas + renewable CHP: 750 MW in 2020;
- ***Main measures:*** Feed-in tariffs or other to be used to further developments (details to be published)

Other RES:
Revised NREAP to strongly decrease the development of waves (compared to previous plan); Non-mature technologies not to be supported by electricity tariffs but by other mechanisms instead (e.g. CO2 emission trading schemes)

- ***Targets:*** 6 MW in 2020;
- ***Main measures:*** Other mechanisms than feed-in tariffs to be used to further developments (details to be published)

O. Romania

Thermal units:
"Romania's Energy Strategy" issue by Ministry of Economy, Trade and Business Environment foresees necessity of installing new units and retrofitting of the old ones.

Nuclear units:
"Romania's Energy Strategy" issue by Ministry of Economy, Trade and Business Environment foresees the necessity of building two new units.

Hydro power units:
"Romania's Energy Strategy" issue by Ministry of Economy, Trade and Business Environment foresees the necessity of new hydro units and the Law 134/2012 which amends Law

220/2008 on establishing the promotion system of energy production from renewable energy sources encourage the small hydro units.

- ***Main measures*:** For energy produced in small hydro power plants (installed capacity of 10 MW): 3 certificates for each MWh generated and delivered if plants are new and 2 certificates per MWh if plants are retrofitted.

Photovoltaic:
Law 134/2012 amending Law 220/2008 on establishing the promotion system of energy production from renewable energy sources. This includes, but is not limited to the system of promotion through green certificates.

- ***Main measures*:** Six certificates for each MWh of solar energy generated and delivered.

Wind energy:
Law 134/2012 amending Law 220/2008 on establishing the promotion system of energy production from renewable energy sources.

- ***Main measures:*** Two certificates by 2017 and one certificate from 2018 for each MWh generated and delivered by wind energy producers.

Biomass:
Law 134/2012 amending Law 220/2008 on establishing the promotion system of energy production from renewable energy sources.

- ***Main measures*:** Three certificates for each MWh of biomass energy produced and delivered.

Other RES:
Law 134/2012 amending Law 220/2008 on establishing the promotion system of energy production from renewable energy sources.

- ***Main measures:*** Three certificates for each MWh of biogas and geothermal energy produced and delivered.

CHP: "National Strategy for heat supply through centralized production and distribution systems" approved by Government Decision 882/ 2004; Other policy which encourage district heating is to promote high efficiency cogeneration through a support scheme (Government Decision 1215/ 2009),

- ***Main measures*:** "National Strategy for heat supply through centralized production and distribution systems": Metering and control heat, heat cost allocators, thermostatic control valves; Thermal insulation of buildings; Rehabilitation of production capacities and distribution of thermal energy; Rehabilitation of the final points in the thermal distribution chain.

P. Serbia

Thermal units:
The main issue regarding centralized thermal units in Serbia is their age and old technology. The energy policy is to continue with building of new thermal units. Main fuel type is lignite, and the plan is to install new combined gas and heat power plant (CCGT). By the year 2025, the plan is to have 2.3 GW of new thermal capacity. Also 1.2 GW of old capacity is planned to be mothballed.

Nuclear units:
Serbian government introduced moratorium on building nuclear units till year 2015.

Hydro power units:
Main targets are modernization, revitalization and building of new hydro capacities in future. There are three main ways of building hydro units: building by Serbian power company EPS, building by issuing energy permissions to domestic or foreign investors or by giving a concession rights to domestic or foreign investors.

By the year 2025, the plan is to have approximately 0.8 GW of new hydro capacity. Feed-in tariff for production of electrical energy from small HPP (0.2 to 30 MW) are in range from 7 - 13.7 c€/kWh.

Photovoltaic:
Feed-in tariff for production of electrical energy from PV (0.03 MW and above) are in range from 16 - 21 c€/kWh, depending of the size of the units.

Wind energy:
Main encouragement measures regarding possible new investments in onshore WPP are related to feed-in tariffs, which are set by relevant authorities i.e. Ministry of Energy, Development and Environmental protection of Republic of Serbia. By the year 2030, the plan is to have approximately 1000 MW of new onshore wind capacity, but that is very much dependent on economic conditions, feed-in tariffs, and amount of reserve in our power system. Serbia does not have strategy beyond year 2030.Feed-in tariff for production of electrical energy from offshore WPP is currently 9.2 c€/kWh.

Biomass:
For the moment, main policy is raising the public awareness of the potential of biomass usage in energy production. The plan in years to come is to introduce the biomass in some gas power plants instead of fossil fuel. Feed-in tariff for production of electrical energy from biomass is currently in range from 8-13.8 c€/KWh, depending on the size of units.

CHP:
Feed-in tariff for production of electrical energy from small CHP units is currently in range from 8-8.9 c€/kWh, depending on the type of fossil fuel.

Q. Spain

In Spain, the regulatory framework governing electricity generation using renewable energies revolves around a mechanism known as the feed-in tariff whose operation is based on guaranteeing a price higher than that existing in the wholesale market for the technology employed. This cost increment is financed by electricity tariffs themselves.

In 2020, the new Plan's degree of success should be measured against other parameters. The strategies being developed should provide a boost to research, development and innovation on renewable technologies, proceed further in the implementation of more mature technologies and incorporate other newer and less developed technologies at experimental level. However, the success of the policy to foster renewable energies over the coming years should be measured in terms of achievement of the established development objectives, and especially in terms of attaining these in a way compatible with the technical, economic and environmental sustainability of the energy system as a whole while fostering competition between technologies and their competitiveness with traditional sources, an aim which is ultimately the surest guarantee that a technology will remain stable over time as part of the energy mix. Specific indicators are defined to monitor all of this.

R. Sweden

Sweden's main measure on the generation side is the electricity certificate system. This is a subsidy system that is unbiased with respect to technology, it benefits the RES generation that has the lowest cost regardless if it is biomass, hydro power, PV, wind power or other. The most economically efficient power generation will be built. Renewable electricity producers are awarded certificates, which conventional producers and consumers are forced to buy. This system is designed to create an increase of 25 TWh of RES from 2002 until 2020. Since 1st January 2012 Sweden and Norway have operated a joint electricity certificate market. In addition to the Swedish target of an increase of 25 TWh, the intention of the joint market is that it should increase the generation of renewable electricity with further 13.2 TWh between 2012 and 2020. The renewable generation built during the period 2012 and 2020 will receive certificates regardless if it is built in Sweden or in Norway.

Thermal units: No special policies.

Nuclear units: Swedish government decided in 2009 to allow investments in new nuclear reactors when the old reactors come to end-of-life. Before 2009 the policy has been set on decommissioning. The technical lifetime of current reactors end up during 2032-2045.

Hydro power units: No special policies.

Photovoltaic: There is an investment subsidy for PV, where up to 35 % of the investment cost can be financed.

Wind energy: The Swedish Government has set a planning framework of 30 TWh electricity yearly coming from wind power generation.

Biomass: No special policies.

CHP: No special policies.

S. Switzerland

Thermal units:
Combined cycle gas turbines (CCGT, 400-500MW units) planned as mid-term replacements of decommissioned nuclear power plants. CO2 emission compensations required for such plants.

- ***Targets:*** 1 CCGT by 2020, as many as 9 in total depending on pursued energy strategy and supply & demand developments (incl. RES).
- ***Measures:*** Full CO2 compensation required with at least 50% done nationally. The remainder e.g. via ETS (provided CH becomes eligible to the ETS);
- ***Time frame:*** 2050

Nuclear units:
Switzerland is currently pursuing a phase-out of nuclear power plants.

- ***Targets:*** Existing nuclear power plants are to be decommissioned and 'replaced' with non-nuclear alternatives. The first plant is to be decommissioned by early 2020 and the last ones are currently foreseen to be decommissioned by mid 2030.

Hydro power units:
Several large scale hydropower projects are being pursued by Swiss energy utilities. Small scale hydropower (<10 MW) is to be promoted via feed-in tariffs. The main restriction for both is public acceptance. Also, the available potential for hydropower production in Switzerland has already been largely exploited.

- ***Targets:*** Max +3.16 TWh;
- ***Main measures****:* Feed-in tariffs for small scale hydropower (<10MW), acceleration of permit granting procedures and identification of priority areas suitable for power plants.

Photovoltaic:
Small PV plants (<10 kW) are to be supported by a 30% coverage of investment costs. Larger PV plants will be supported by feed-in tariffs. The main current restrictions for the construction of PV plants are long permitting procedures and overwhelming demand for only limited funds (backlog).

- ***Targets:*** Promotion of PV (+10.4 TWh), in particular as part of existing infrastructure (e.g. on rooftops).
- ***Main measures*****:** Feed-in tariffs for larger PV plants (>10 kW), 30% coverage of investment costs for small PV plants (<10kW), improved land use planning;
- ***Time frame:*** 2050

Wind energy:
To be promoted via feed-in tariffs. Public acceptance is again the main restriction.

- ***Targets:*** Promotion of onshore wind; +4 TWh;
- ***Main measures:*** Feed-in tariffs, acceleration of permit granting procedures and identification of priority areas suitable for power plants,
- ***Time frame:*** 2050 (possibly earlier)

Biomass:
The main restrictions are public acceptance and resource competition (e.g. heating, CHP);

- ***Targets:*** +1.1 TWh;
- ***Main measures:*** Feed-in tariffs;
- ***Time frame:*** 2050

Other RES:
Support scheme for research into deep geothermal technologies;

- ***Targets:*** Research and development of the technology for it to be made feasible for implementation; +4.4 TWh (tentative);
- ***Main measures****:* Financial support for research: e.g. coverage of investment guarantees; financial support for pilot projects;
- ***Time frame:*** 2050

CHP:
The main restriction for CHP is that like most RES (except hydro), CHP plants produce electricity above the current market price;

- ***Targets****:* Promotion of CHP plants, in particular from industrial processes, large buildings and district heating areas; +3.4 TWh (of which 2 TWh by 2025);
- ***Main measures****:* Financial support of plants 350kW-20MW provided all the produced heat is used in one form or other.
- ***Time frame:*** 2050

Other relevant trends:
The overall budget for feed-in tariffs for RES (excluding small scale PV and large-scale hydropower) is to be significantly increased. Funding for feed-in-tariffs is provided by a charge on total electricity consumption. The overall budget for feed-in tariffs to be gradually increased from the current 210 Mio CHF/year to a maximum of 840 Mio CHF/year by 2040. Afterwards a gradual reduction is expected.

T. United Kingdom

Thermal units: Electricity Market Reform (EMR)

Nuclear units: Electricity Market Reform (EMR)

Hydro power units: EMR, Feed-in Tariffs (FITs), Renewable Obligation Certificates (ROCs)

Photovoltaic: Feed in Tariffs (FITs)

Wind energy: Renewable Obligation Certificates (ROCs)

Biomass: Renewable Obligation Certificates (ROCs)

Other RES: Feed in Tariffs (FITs)

2.3.2 Summary of national policies on generation

In the following table and figures, we provide an overview of countries having policies and/or measures with a specific focus on generation sources or technologies. This summary reflects the current policies in Europe. Previous polices may have been different and future policies will certainly be. Thus the answers here do not reflect the *development of the topic* (for example the deployment of PV in the country) but the *existence of a policy on that topic*.

Table 2.4 Summary of national policies on generation

++	: existing operational measure(s)
+	: existing policy or politically desirable
-	: existing policies or measures not in favour of the technology
blank	: no answer or no policy

	Centralized Thermal units	Nuclear power plants	Hydro Power Units	PV	Wind	Biomass	Other Res	CHP
Austria			++	++	++	++		
Belgium	++	-		++	++	++	++	
Bosnia and Herzegovina			+	+	+			
Bulgaria								
Croatia								
Cyprus								
Czech Republic	++			+		+		
Denmark					++	++		
Estonia								
Finland								
France	++		+	++	++	++		++
Germany		-		++	++	++	++	++
Greece			+	++	++	++	++	++
Hungary								
Iceland								
Ireland								
Italy			++	++	++	++	++	++
Latvia								
Lithuania		++	+	+	+	+	+	+
Luxembourg								
FYR Macedonia			++	++	++	++	++	
Montenegro								
Netherlands								
Norway			++		++	++		
Poland	++	++	++	++	++	++		++
Portugal			++	+	+	+	+	
Romania	++	++	++	++	++	++	++	
Serbia	++		++	++	++	+		
Slovak Republic								
Slovenia								
Spain			++	++	++	++	++	++
Sweden		++		++	++	++	+	
Switzerland	++	-	++	++	++	++	++	++
United Kingdom				++	++	++	++	

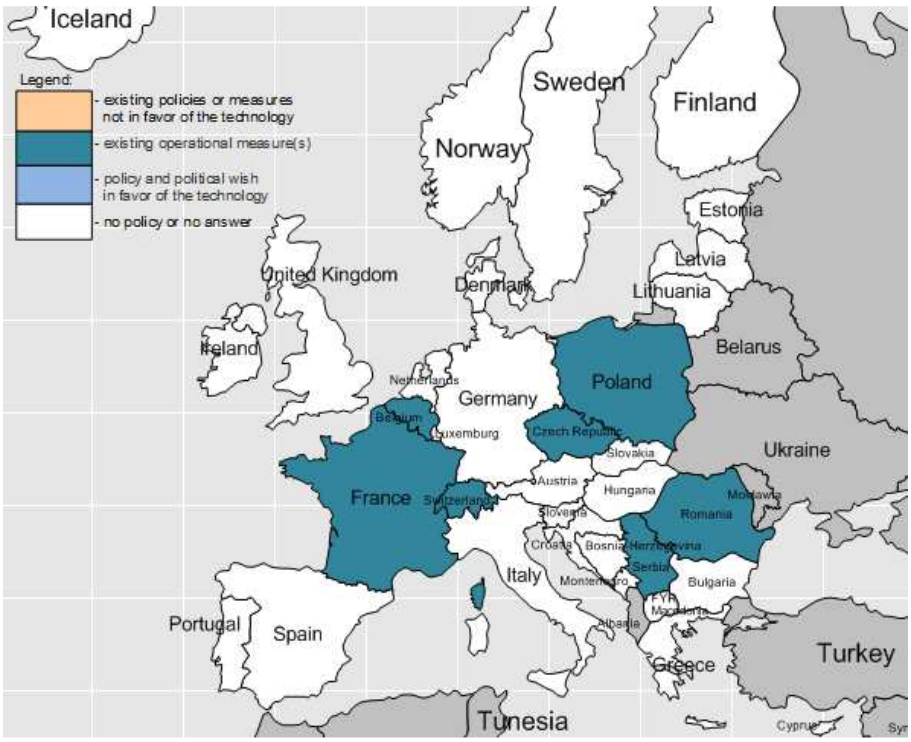

Figure 2.7 Map of national policies on centralized thermal units

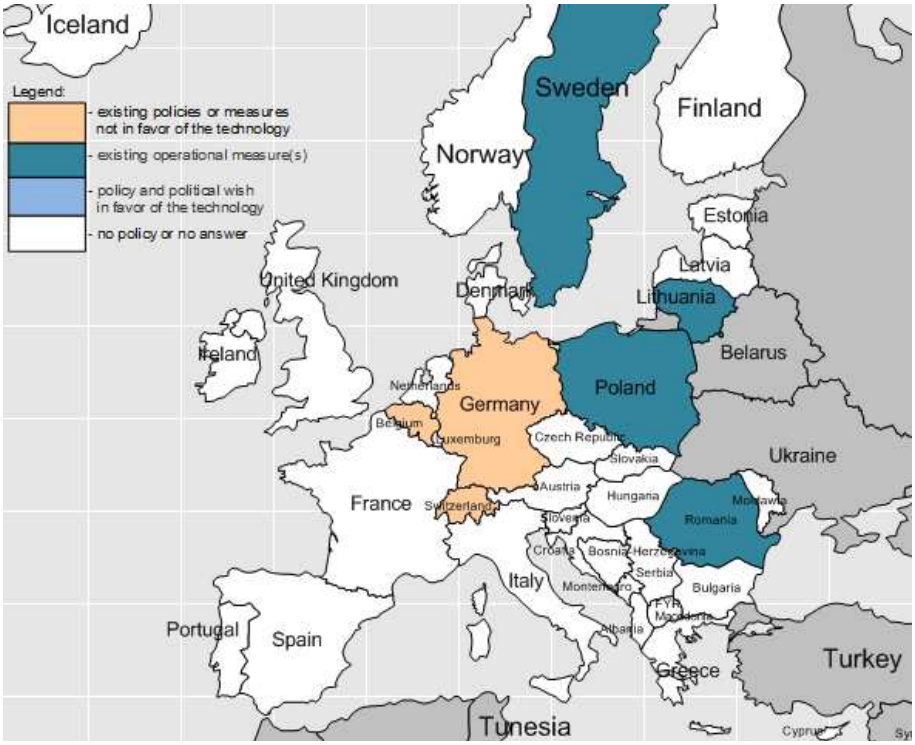

Figure 2.8 Map of national policies on nuclear power plants

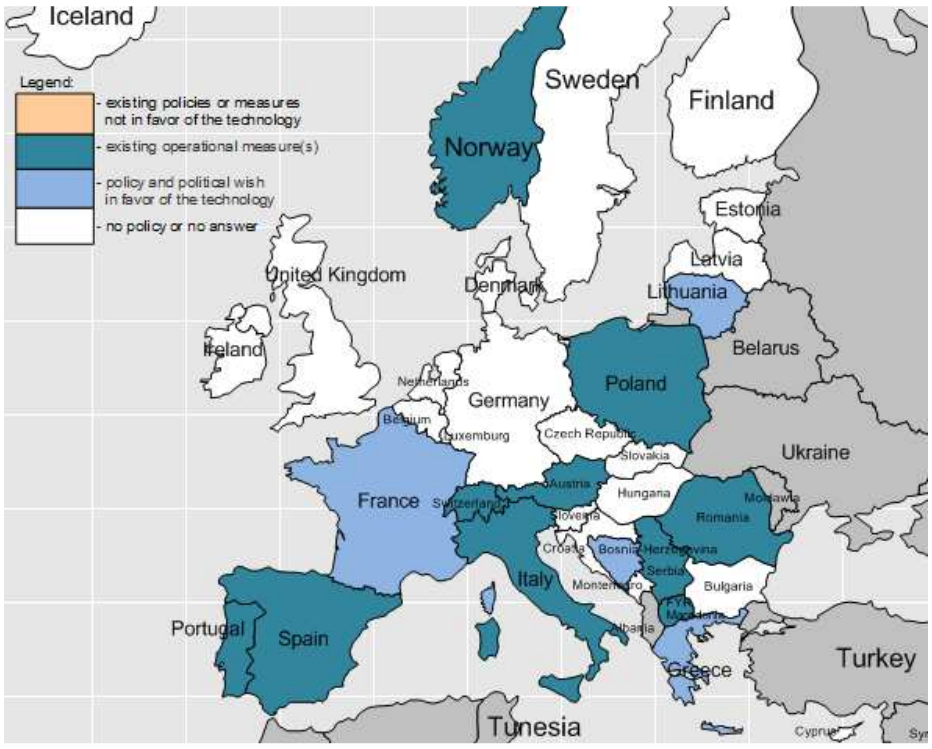

Figure 2.9 Map of national policies on hydro power plants

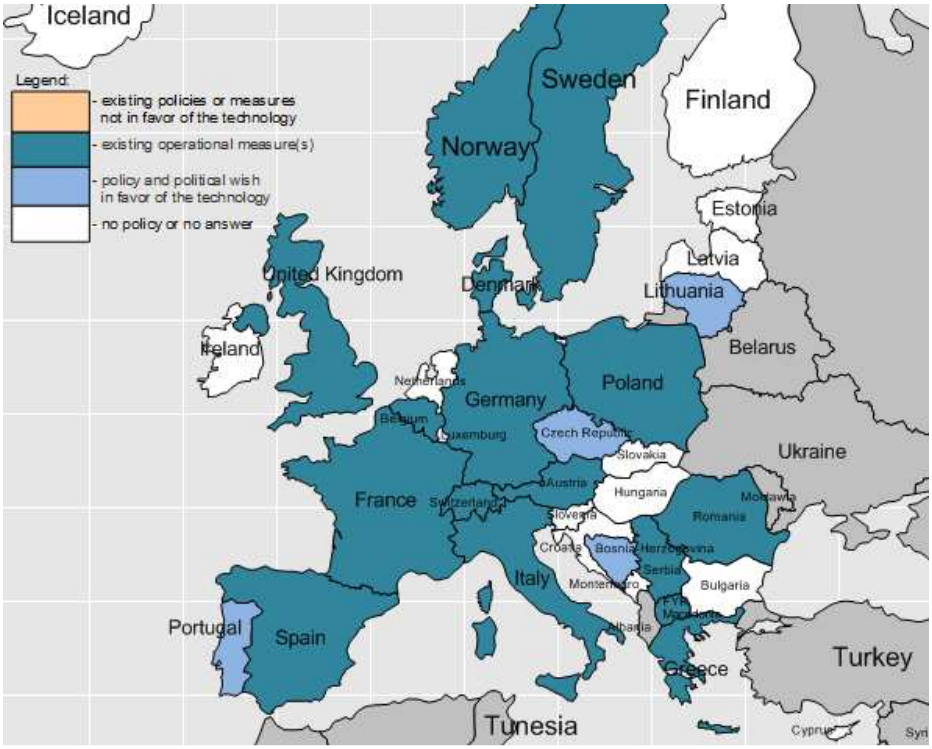

Figure 2.10 Map of national policies on PV and/or Wind sources.

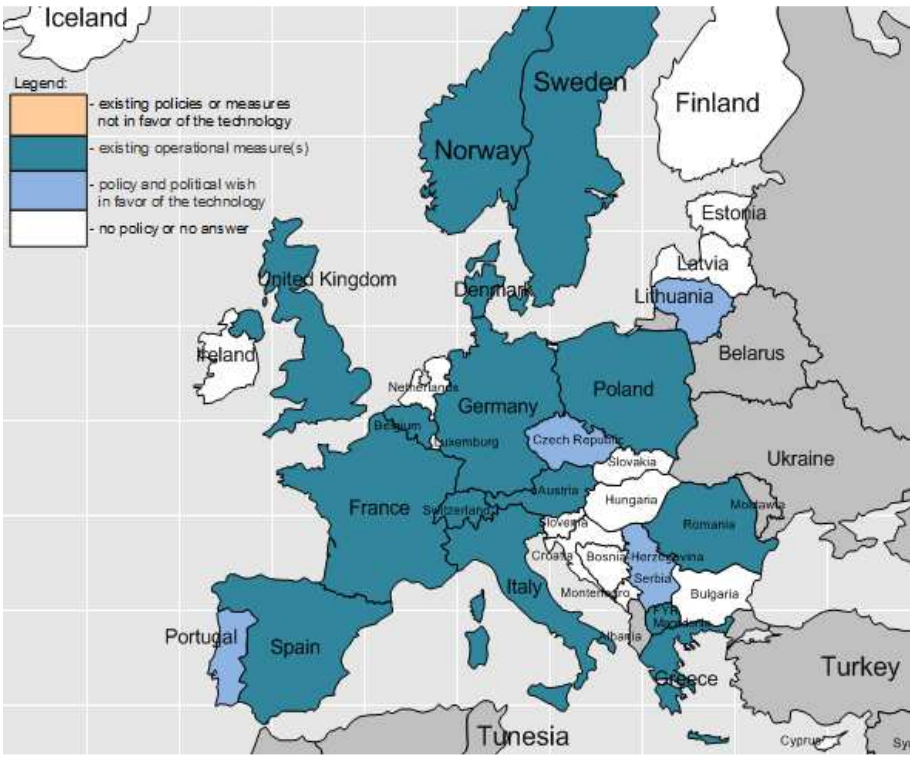

Figure 2.11 Map of national policies on biomass and other RES

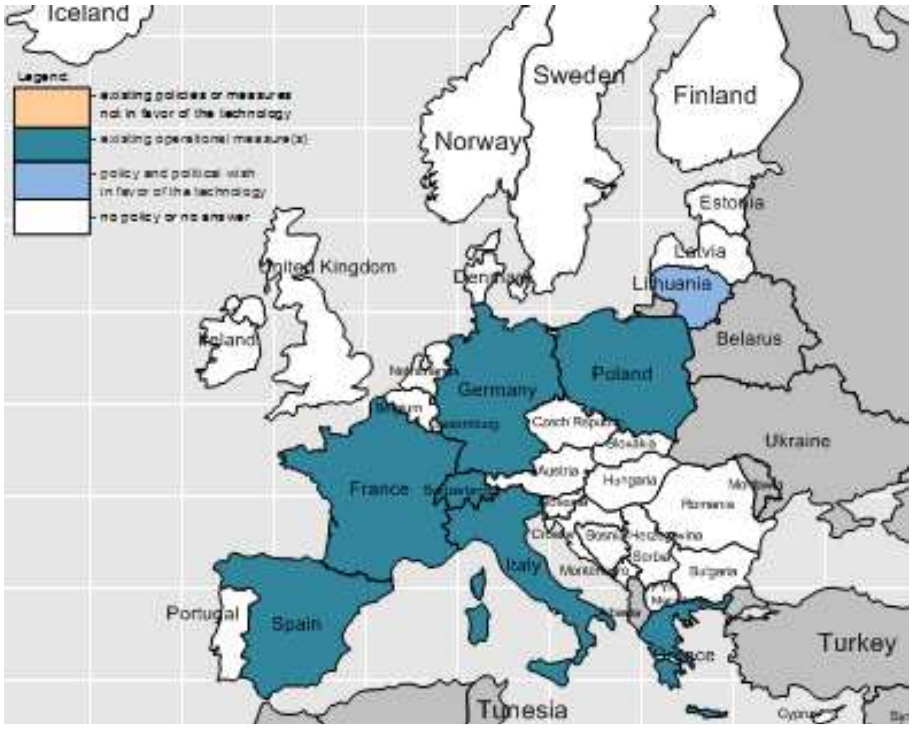

Figure 2.12 Map of national policies on CHP

Table 2.5 Summary of measures for generation

	Centralized Thermal units	Nuclear power plants	Hydro Power Units	PV	Wind	Biomass	Other Res	CHP
Austria	All restrictions and guideline must be respected	no nuclear power in Austria	Subsidies	Subsidies, feed-in-tariffs; Time frame: 2020	Subsidies, feed-in-tariffs; Time frame: 2020	Subsidies, feed-in-tariffs; Time frame: 2020		
Belgium	Capacity payments (or some related mechanisms) and/or tendering processes may be considered	Taxation on the incomes nuclear rente		Support in investment	Green certificates mechanism with guaranteed minimum price	Support in investment	Support in investment	CHP certificates; Premiums for heating networks
Bosnia and Herzegovina	None	no nuclear	Subsidies for small hydro	Subsidies	Subsidies		None	None
Czech Republic	Support of co-generation and high efficiency of units	Support of nuclear	support of new Pumped Storage	Support of roof installations only	Support tailored according to economic possibilities, natural conditions and limitations in protection areas	Special support of large units of 10 - 100 MW	After fulfillment of Czech RES obligations, gradually no RES subsidies	Heat pumps preferred to classical sources
Denmark	Coal used as fuel on central power plants should be phased out by 2030 and replaced by biomass	no nuclear	no hydro	supported by a PSO (Public Service Obligation) scheme		Biomass will replace coal in the central power plants by 2030		Electricity and heat systems should be based on RES by 2035
France	no transposition law in France for the moment	objective to reduce the share of nuclear in electricity production to 50% in 2025	Official law concerning concessions	Subventions for PV (installation and feed-in-tariff)	Subsidies for on- and offshore wind (installation and feed-in-tariff)			

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
Germany	Revenues achievable in the energy market	Nuclear phase-out by 2022		Subsidies	Subsidies	Subsidies	Subsidies	Subsidies
Greece	modernization and upgrading of existing thermal power plants along with the reinforcement of the transmission system at 400 kV voltage level	encouraged but there are severe environmental obstacles	priority in dispatch and are remunerated by a fixed Feed in Tariff (FIT).	priority in dispatch and are remunerated by a fixed Feed in Tariff (FIT).	priority in dispatch and are remunerated by a fixed Feed in Tariff (FIT).	priority in dispatch and are remunerated by a fixed Feed in Tariff (FIT).	++ priority in dispatch and are remunerated by a fixed Feed in Tariff (FIT).	CHP of high efficiency (<50 MW) are treated by the existing legislation equally to RES plants
Italy	permitting procedure (for construction and operation is subject to environmental impact assessment (EIA) and, with power more than 300 MW, to single authorization procedure	no nuclear		Incentives and simplified authorization (PV and grid connection) procedures	Incentives and simplified authorization (Wind Farm and grid connection) procedures	Incentives and simplified authorization (biomass plant and grid connection) procedures	Incentives and simplified authorization procedures	Incentives and simplified authorization procedures
Lithuania	Encourage new biofuel-fired Thermal power plants		introduction of suitable and clear market conditions	introduction of suitable and clear market conditions	introduction of suitable and clear market conditions	introduction of suitable and clear market conditions	introduction of suitable and clear market conditions	encourage small-scale CHP installation closer to the users.
FYR Macedonia		Strategy for nuclear development envisaged but no further elaboration	feed-in tariffs for electricity produced from SHPP (<10 MW)	feed-in tariffs for electricity produced from PV (<1 MW)	feed-in tariffs for wind electricity preferential if (<50 MW)	feed-in tariffs	feed-in tariffs	issuing of guarantee of origin of electricity produced by CHP

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
Norway	No thermal gas production without CCS	Not accepted	Positive development of small and medium hydro; Included in Green certificate market	No policies	Included in Green certificate market, but not sufficient for offshore development	Positive to biomass; Included in Green certificate scheme; time frame: 2020	Encourage RES development up till 13.6 TWh	No new CHP without CCS
Poland	Ministry of Environment regulation on the installation of emission standards reduce air pollution and GHG emission	Atomic Law Act Act on the preparation and implementation of investment in nuclear power facilities and associated investment 6000 MW until 2030	Energy Law Act with amendments Draft Law on RES	Energy Law Act with amendments Draft Law on RES	Energy Law Act with amendments Draft Law on RES	Energy Law Act with amendments Draft Law on RES	Energy Law Act with amendments Draft Law on RES	
Portugal	no policy (beyond already licensed capacity)	no nuclear	undergoing national plan (launched in 2007) is been implemented in order to explore national hydro power resources Capacity payments	Other mechanisms than feed-in tariffs shall be used to further developments (details to be published)	Feed-in tariffs or other shall be used to further developments (details to be published)	Feed-in tariffs or other shall be used to further developments (details to be published)	Other mechanisms than feed-in tariffs shall be used to further developments (details to be published)+	

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
Romania	Strategy: installing new units and retrofitting of the old ones	Strategy: necessity of building two new units	For energy produced in SHPP (< 10 MW): 3 certificates / MWh if plants are new and 2 certificates / MWh if plants are retrofitted	6 certificates / MWh of solar energy generated and delivered	2certificates by 2017 and 1 certificate from 2018 / MWh generated and delivered by wind energy producers	3 certificates / MWh of biomass energy produced and delivered	3 certificates / MWh ++	Strategy
Serbia	Strategy: continue building new units	moratorium on building nuclear units till year 2015	Feed-in tariff SHPP (0.2 to 30 MW) are in range from 7 - 13.7 c€/kWh.	Feed-in tariff for PV (0.03 MW and above) are in range from 16 - 21 c€/kWh, depending of the size of the units	Feed-in tariff for offshore WPP is currently 9.2 c€/kWh	Feed-in tariff for biomass is currently in range from 8-13.8 c€/KWh, depending on the size of units		Feed-in tariff for production of electrical energy from small CHP units is currently in range from 8-8.9 c€/kWh, depending on the type of fossil fuel
Spain			RES support schemes have been cancelled for new installations	RES support schemes have been cancelled for new installations	RES support schemes have been cancelled for new installations	RES support schemes have been cancelled for new installations	RES support schemes have been cancelled for new installations	
Sweden	No special policies	allow investments in new nuclear reactors when the old reactors come to end-of-life	No special policies	investment subsidy for PV, where up to 35 % of the investment cost can be financed	30 TWh electricity yearly coming from wind power generation	No special policies	No special policies	

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
Switzerland	Full CO2 compensation required with at least 50% done nationally. The remainder e.g. via ETS (provided CH becomes eligible to the ETS);	currently pursuing a phase-out of nuclear power plants	Feed-in tariffs for SHPP (<10MW), acceleration of permit granting procedures and identification of priority areas suitable for power plants	Feed-in tariffs for larger PV plants (>10 kW), 30% coverage of investment costs for small PV plants (<10kW), improved land use planning	Feed-in tariffs, acceleration of permit granting procedures and identification of priority areas suitable for power plants	Feed-in tariffs	Financial support for research: e.g. coverage of investment guarantees; financial support for pilot projects; ++	Financial support of plants 350kW-20MW provided all the produced heat is used in one form or other ++
United Kingdom	Electricity Market Reform (EMR)	Electricity Market Reform (EMR)	EMR, Feed-in Tariffs (FITs), Renewable Obligation Certificates (ROCs)	Feed-in Tariffs (FITs)	Renewable Obligation Certificates (ROCs)	Renewable Obligation Certificates (ROCs)	Feed-in Tariffs (FITs)	

Table 2.6 Summary of targets

	Centralized Thermal units	Nuclear power plants	Hydro Power Units	PV	Wind	Biomass	Other Res	CHP
Austria	Topics: environmental impact (geology, biology, hydro, etc.), human medicine, project description including constructions, energy economic use, technical alternative, etc		Encouraging the construction of hydro generation and facilitate market competition; plus 1000 MW	Encouraging the construction of PV generation and facilitate market competition; plus 1200 MW	Encouraging the construction of wind generation and facilitate market competition; plus 2000 MW	Encouraging the construction of biomass generation and facilitate market competition; plus 200 MW		
Belgium				13% of energy consumption in 2020 to be from renewable sources	13% of energy consumption in 2020 to be from renewable sources	13% of energy consumption in 2020 to be from renewable sources	13% of energy consumption in 2020 to be from renewable sources	
Bosnia and Herzegovina					350 MW of wind by 2019, 640 MW by 2023			
Czech Republic	50 - 60% generation share						18-25% generation share	
Denmark	'Coal used as fuel on central power plants should be phased out by 2030 and replaced by biomass				50% wind power in the electricity system by 2020	Biomass will replace coal in the central powerplants by 2030.		

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
France	Around 4 GW of oil units and 3,6 GW of hard coal units will shut down between 2012 and 2015 because of this directive.	An announced objective is to reduce to 50% the share of nuclear in electricity production in 2025.		5.4 GW of solar for 2020	- Onshore wind : 19 GW - Offshore wind : 6 GW	3 GW of biomass for 2020		
Germany		-	80% of energy consumption in 2020 to be from renewable sources 2050	80% of energy consumption in 2020 to be from renewable sources 2050	80% of energy consumption in 2020 to be from renewable sources 2050	80% of energy consumption in 2020 to be from renewable sources 2050	80% of energy consumption in 2020 to be from renewable sources 2050	
Italy		no nuclear	target 2020: Hydro 17,8 GW; (ref. PdS)	target 2020: Solar 8,6*GW (ref. PdS)	target 2020: Wind 12,7 GW (ref. PdS)	target 2020: Biomass 3,8 GW (ref.PdS)		
Lithuania			In 2020 Lithuania should have at least 141 MW installed capacity of hydro power plants.	In 2020 Lithuania should have at least 10 MW installed capacity of solar power plants.	In 2020 Lithuania should have at least 500 MW installed capacity of wind power plants.	In 2020 Lithuania should have at least 355 MW installed capacity of biomass power plants.		
Norway			70% of national hydro power resources to be explored until 2020: 9000 MW (total)		Encourage RES development up till 13,6 TWh	Encourage RES development up till 13,6 TWh	Encourage RES development up till 13,6 TWh	
Poland		6000 MW until 2030						

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
Portugal		no nuclear	70% of national hydro power resources to be explored until 2020: 9000 MW (total)	PV: 500 MW in 2020 Solar Thermal: 50 MW in 2020	5300 MW in 2020	Biomass + Biogas + renewable CHP: 750 MW in 2020	6 MW in 2020	
Serbia	By the year 2025, the plan is to have 2.3 GW of new thermal capacity. Also 1.2 GW of old capacity is planned to be mothballed.		By the year 2025, the plan is to have approximately 0.8 GW of new hydro capacity.		By the year 2030, the plan is to have approximately 1000 GW of new onshore wind capacity, but that is very much dependent on economic conditions, feed-in tariffs, and amount of reserve in our power system. We still, don't have strategy beyond year 2030.	The plan in years to come is to introduce the biomass in some gas power plants instead of fossil fuel.	By the year 2025, the plan is to have 2.3 GW of new thermal capacity. Also 1.2 GW of old capacity is planned to be mothballed.	
Spain		55,600 GWh of annual production in 2020	11,676 MW in 2020 (hydro >10 MW without storage)	7,250 MW (pv) and 4,800 MW (Solar Thermal) in 2020	35,000 MW (onshore) and 750 MW (offshore) in 2020	1,950 MW in 2020	Geothermal: 50 MW in 2020 Waves: 100 MW in 2020	

	Centralized Thermal	Nuclear power	Hydro Power	PV	Wind	Biomass	Other Res	CHP
Sweden					30 TWh electricity yearly coming from wind power generation			
Switzerland	1 CCGT by 2020, as many as 9 in total depending on pursued energy strategy and supply&demand developments (incl. RES)	Existing nuclear power plants are to be decommissioned and 'replaced' with non-nuclear alternatives	Max +3.16 TWh	Feed-in tariffs for larger PV Promotion of onshore wind; +4 TWh plants (>10 kW), 30% coverage of investment costs for small PV plants (<10kW), improved land use planning	Promotion of onshore wind; +4 TWh	+1.1 TWh	Research and development of the technology for implementation; +4.4 TWh (tentative);	Promotion of CHP plants, in particular from industrial processes, large buildings and district heating areas; +3.4 TWh (of which 2 TWh by 2025);
United Kingdom								

2.4 Storage

In this part the main policies regarding storages like pump storage plants, batteries and other kind of storages are analyzed. For a lot of European countries plans for the new installation of pump hydro power plants exists. However for the other storage types nearly no policies exist.

2.4.1 National policies on storage

A. Austria:

Restrictions:
There are lots of issues concerning public acceptance of new projects, insufficient transmission grid capacities both nationally and cross-border and rentability. There is a wish for new PSP projects but their implementation depends highly on future rentability.

B. Belgium:

There are some barriers to develop storage: Land use restrictions, positive business case (capital intensive - low and volatile number of running hours) and technical risk for some technologies.

C. *Bosnia and Herzegovina:* No policy

D. Czech Republic: There is some support of pump storage facilities. Other storage types are supported with R&D.

E. Denmark:

The topology in Denmark doesn't allow establishment of PSP. Batteries could be useful components in a Smart Grid ; however, they are still considered as too expensive to be an attractive investment. There are no political goals regarding storage. The trend is to integrate electricity and gas systems and then use the storage capabilities of the gas system as long term electricity storage. In shorter periods demand side management is seen as the "storage".

F. *France:* No policy

G. Greece:

There is a general policy to encourage the construction of Pump Storage Plants (PSP) in order to cope with the expected large penetration of fluctuating RES (especially Wind Farms).There are also pilot projects for small stand-alone systems (in islands of Kythnos and Ikaria) that incorporate energy storage in batteries and PSPs respectively).

H. Germany:

In the electricity sector, the current Renewable Energy Act (Erneuerbare-Energien-Gesetz – EEG), is the crucial basis for further development in the production of renewable energies. Grid connection requirements, grid reconstruction and development, as well as the promotion of storage technologies, will be of fundamental importance.

The integrated energy and climate program of the Federal Government emphasizes, for instance, the necessary creation of storages, the use of optimisation options and the possible contribution of electric mobility to intelligent integration in the future energy system. The existing incentives include in particular § 118(7) EnWG, which stipulates that grid fees for newly constructed pump storage plants will be dropped for ten years.

I. Italy:

The Ministry allows TSO includes batteries and other kinds of storage in the Development National Plan.

J. Lithuania:

There are some discussion and analysis whether it is appropriate or not to extend the Kruonis pumped storage power plant by placing additional turbine. For the other storage types no policies exists.

K. *FYR of Macedonia*: There are no policies or measures for storage.

L. Norway:

- No restrictions concerning pump storage plants.
- No projects due to unfavorable economy
- No policy on other kinds of storage

M. ***Poland:*** Energy Law for PSP Batteries and other kind of storages.

N. Portugal:

An undergoing national plan (launched in 2007) is been implemented in order to explore national hydro power resources including pumped-storage. The qualitative target is to integrate intermittent power sources (operating reserve) as well as to minimize energy "spills". Nearly 3000 MW of new hydro installed capacity until 2020 is to be pumped-storage hydro or pure pumped-storage. The main measure will be capacity payments. For the other storage types no policies exists.

O. Romania:

The "Romania's Energy Strategy" issue by Ministry of Economy, Trade and Business Environment foresees the necessity of building a Pumped Storage Plant around 2020.

P. Serbia:

In general, Serbia have the resources for building new Pump Storage capacities, especially bearing in mind the price for peak energy in regional electricity market. But these projects

are very expensive, and there are studies to find appropriate financing model, whether it will be strategic partnership with other countries/companies or financing from their own resources. The target is to have new 1.28 GW in Pump Storage Plants in 2025.

Q. Spain:

Support for R&D-Innovation in energy storage systems is planed up to 2020 in Spain as a financial measure. Enhanced capacity for the integration of renewable energies in the electricity system is the expected result.

R. Sweden:

- No planned pumped storage projects
- No policy for other storage types.

S. Switzerland:

For Pump Storage plants, some restrictions exist: Public acceptance of new projects as well as insufficient transmission grid capacities both nationally and cross-border. The quantitative targets however are a significant increase of pumped storage as a key element of the new energy strategy:

+4.0 TWh of pumped storage by 2020
+7.5 TWh (including the +4.0) by 2050.

T. *United Kingdom*: No policy.

2.4.2 Summary of national policies on storage

In the following table and figures, we provide an overview of countries having policies and/or measures with a specific focus on storage technologies. This summary reflects the current policies in Europe. Previous polices may have been different and future policies will certainly be. Thus the answers here do not reflect the *development of the topic* (for example the deployment of pumped hydro storage in the country) but the *existence of a policy on that topic*.

Table 2.7 Overview of national policies for storage

++ : existing operational measure(s)

+ : existing policy or politically desirable

blank : no answer or no policy

	Pump Storage Plants	Batteries	Other kinds of Storage
Austria	+		
Belgium		++	
Bosnia and Herzegovina			
Bulgaria			
Croatia			
Cyprus			
Czech Republic	+	+	+
Denmark			+
Estonia			
Finland			
France			
Germany			++
Greece	+	+[2]	+
Hungary			
Iceland			
Ireland			
Italy	+	+	+
Latvia			
Lithuania	+		
Luxembourg			
FYR Macedonia			
Montenegro			
Netherlands			
Norway			
Poland			++
Portugal	++		
Romania	+	+	+
Serbia	+		
Slovak Republic			
Slovenia			
Spain	++	++	
Sweden			
Switzerland	++		
United Kingdom			

[2] Only for very small isolated systems in islands

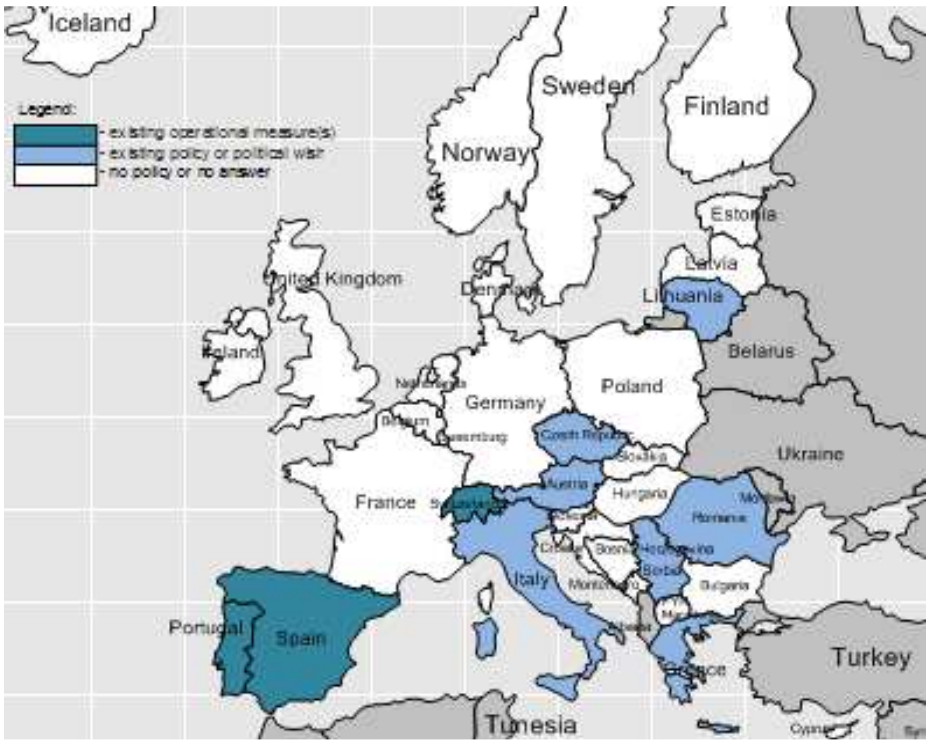

Figure 2.13 Map of national policies on pump storage plants

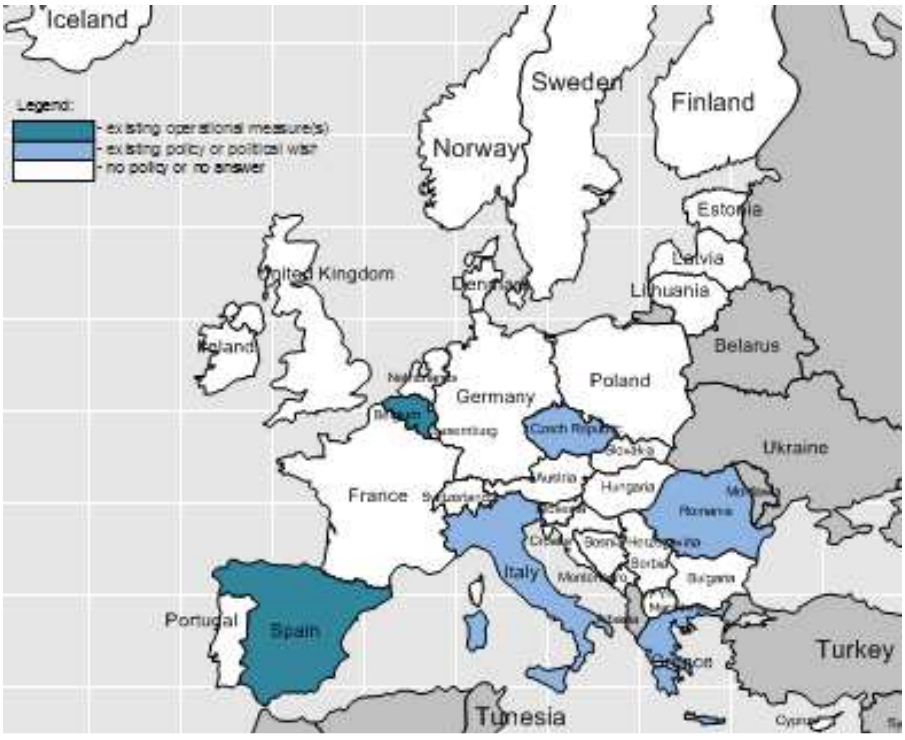

Figure 2.14 Map of national policies on batteries

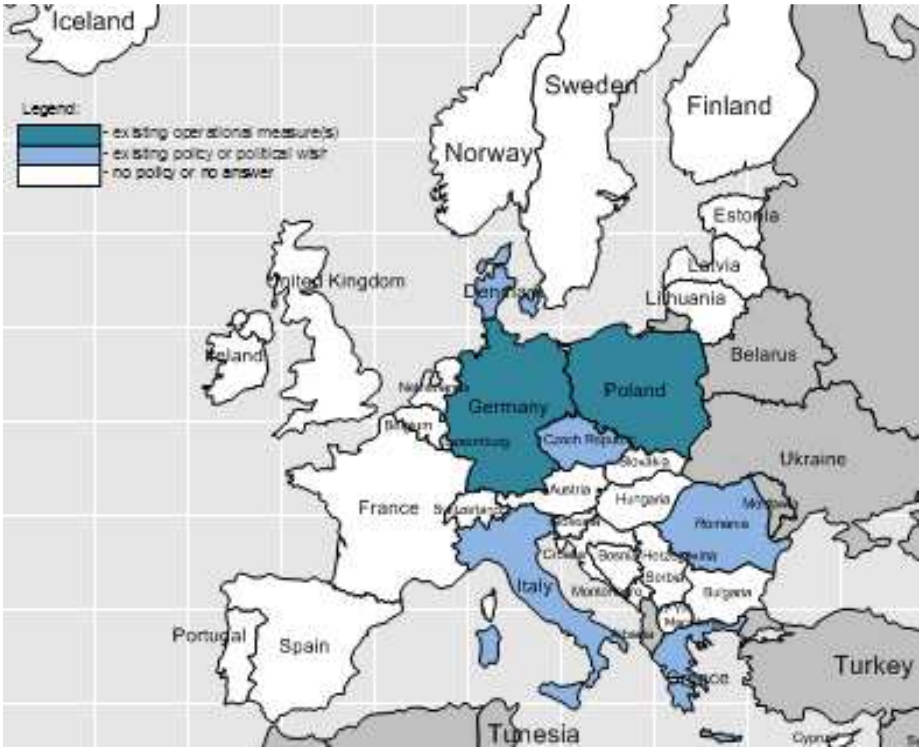

Figure 2.15 Map of national policies on other kind of storages

2.5 Summary of national policies

Without going too much into details, the country reports that have been collected by ENTSO-E and summarized above provide a good overview of the current energy policies in EU member states. Although all country reviews are written according to a provided template in the TSO questionnaire, national influences can be distinguished. The collection of national reports reflects the European Union as it is: a mosaic of countries, with their own culture and heritage, but within a global framework. However, it is possible to draw some general conclusions. All countries are faced with comparable challenges concerning energy, electricity and environment, and very often, comparable policies exist – within the national context – to cope with those challenges.

It is important to realize that the country reviews only provide a snapshot of the current situation in some countries. The market situation can change rapidly and policies can change as well within the political framework.

Table 2.8 Summary of main measures

	Pump Storage Plants	Batteries	Other kinds of Storage
Austria	Increase public acceptance		
Belgium	Improve land use conditions	Positive business case	
Czech Republic	support of pump storage facilities	R&D support	R&D support
Denmark		Improve business plan	The trend is to integrate electricity and gas systems and then use the storage capabilities of the gas system as long term electricity storage. In shorter periods demand side management is seen as the "storage".
Germany			R&D support
Greece	encourage the construction of Pump Storage Plants (PSP)	pilot projects for small stand-alone systems (in islands of Kythnos and Ikaria) that incorporate energy storage in batteries and PSPs respectively).	
Italy		TSO include batteries and other kinds of storage in the Development National Plan	TSO include batteries and other kinds of storage in the Development National Plan
Lithuania	analysis whether it is appropriate or not to extend the Kruonis pumped storage power plant by placing additional turbine		
Norway	No restrictions concerning pump storage plants		
Poland		Energy Law for PSP Batteries and other kind of storages	Energy Law for PSP Batteries and other kind of storages
Portugal	An undergoing national plan is implemented in order to explore national hydro power resources including pumped-storage ~3000 MW of new hydro installed capacity until 2020 is to be pumped-storage hydro		
Romania	Strategy to build a Pumped Storage Plant around 2020		
Serbia	Plan, till year 2025 is to have new 1.28 GW in Pump Storage Plants		
Sweden	No planned pumped storage projects		

	Pump Storage Plants	Batteries	Other kinds of Storage
Switzerland	+4.0 TWh of pumped storage by 2020 +7.5 TWh (including the +4.0) by 2050		
United Kingdom	No policy		

3 EUROPEAN POLICIES REVIEW

A European Energy Policy will firmly commit the European Union (EU) to a low consumption economy based on more secure, more competitive and more sustainable energy. Priority energy objectives involve ensuring the smooth functioning of the internal market in energy, security of strategic supply, concrete reductions in greenhouse gas emissions caused by the production or consumption of energy and the EU's ability to speak with a single voice on the international stage. The European Commission's Energy Roadmap 2050 of 15 December 2011 [2] recognises the vital role of storage technologies for a progressively decarbonised European energy system.

The evolution of the energy sector towards a sustainable system will trigger dramatic changes in the patterns of supply and demand. In all scenarios of the Energy Roadmap 2050, the share of renewable energy sources (RES) in gross final energy consumption will achieve at least 55% in 2050. Switching to RES will inevitably lead to a situation where, from time to time, generation will largely exceed demand or vice versa, with specific concerns on transmission and distribution networks. The growing penetration of RES, in particular non-dispatchable generation such as wind and solar photovoltaic (PV), will therefore increase the need for flexibility in the energy system. Energy storage is especially well suited to respond to this challenge and ensure a continued security of energy supply at any time.

Energy storage can provide services along the whole energy value chain and can support in numerous aspects the transition towards a secure, competitive and decarbonised energy system in Europe: balancing demand & supply, managing transmission & distribution grids, promoting demand side management, shaping new market designs.

Due to the fact that multiple storage technologies will be needed to cover the various requirements of the system (short vs. long duration, small vs. large scale), technological innovation in storage technologies is highly needed in order to open the development to most current storage technologies (e.g. electrochemical, chemical, mechanical, electrical, thermal). In addition, regulations should take also into account the technical and economic potential of energy storage (e.g. market design further facilitating the use of energy storage for provision of reserve and balancing power).

4 REVIEW OF RELEVANT SCENARIO STUDIES

4.1 Methodology

A number of relevant sources or documents are reviewed, mainly by looking at the summaries and conclusions in each report. In the review it is focused on both technological, economic and policy related aspects. To some degree it is also looked for information about need for R&D. The main findings in the reports are structured according to the framework described in chapters 4.1.2 and 4.1.3.

After review of each document a recommendation for possible further use in e-Highway2050 is given in Chapter 4.4. A more detailed summary of the global and European studies is available in Annex 3.

4.1.1 List of relevant studies

The reviewed scenario studies are grouped according to the following categories:

A. *Global scenario studies*

- BP Energy Outlook 2030 [12]
- Energy [R]evolutions [13]
- IEA Energy Technology Perspectives 2012 [14]
- IEA World Energy Outlook 2011 [15]
- Shell Energy Scenarios 2050 [16]

B. *European scenarios studies*

- EU Energy Roadmap 2050 [2]
- IRENE-40 [4]
- EURELECTRIC's Power Choices [3]
- ECF Power Perspectives 2030 [18]
- REALISEGRID [19], [20]
- ECF Roadmap 2050 [21], [36]
- SUSPLAN [5] / LinkS [6]
- Getting in the right Lane for 2050 [28]
- Northern European Solar and Wind Intermittency Study (NEWSIS) [29]
- EREC RE-thinking 2050 [30]
- PWC Roadmap to 2050 for Europe and North Africa [31]
- PWC Moving towards 100% renewable electricity in Europe & North Africa by 2050 [32]

C. *Regional/ national studies*
A comprehensive list of national studies is found in Annex 1.

D. *Other relevant studies about a specific possibility/challenges etc*

- Energy Corridors [17]

- FENIX [22]
- ICOEUR [7]
- Medgrid [8]
- MedRing [23]
- NSCOGI [24]
- OffshoreGrid [9]
- UCTE-IPS study [10]
- WindSpeed [11]
- TWENTIES [33]
- EWIS [34]
- Feature of an electricity supply system based on variable input [35]

4.1.2 Structuring the findings in the scenario studies

The findings from reviewing different scenario studies are structured in four different tables, see figure below. The structure is mainly based on reference [1]. The detailed tables are available in Excel spreadsheets.

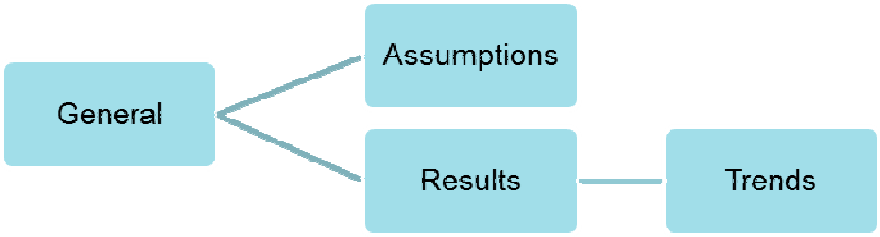

Figure 4.1 Tables that are included into the study

Table "General"

This table includes the following indicators.

Table	Indicators	Values
General	Title/Name	"scenario's title"
	Origin	"An institution, which owns the given scenario."
	Industry	NGO; GO; Petroleum; Electricity; Generic Energy
	Published	"publications year"
	Time horizon	2020; 2030; 2050
	Scope	World; EU25; EU27; EU27 +NO,CH
	Category	Predictive; Anticipative; Explorative; Mixture
	Approach	Quantitative; Qualitative; Mixture
	Modell (if any)	"model (-s) name"
	Number of scenarios	"number of scenario included"
	Other / Comments	"Any relevant comments"

Definition of the scenario categories is derived from [1] and is related to the three main categories according to their purpose:

a. **Predictive:** Scenarios which are essentially trying to describe the most plausible future
b. **Explorative:** Scenarios which are describing several plausible futures, which can start out from present trends and lead to equally likely futures
c. **Anticipative** (Normative, Back-casting): Scenarios which are built on the basis of certain visions about the future and involve working backwards to the present, finding pathways to this particular future
d. Mixture of the above mentioned

Table input "Assumptions" consist of uncertainties and options:

- During construction of scenarios uncertainties are an important part of the inputs, introducing parameters, which are uncontrollable.
- Options are another part of the inputs, which introduces controllable factors (choices) into the scenario. Combination of the options in a scenario creates a strategy.

This table describes the assumptions for the different scenarios. It includes uncertainties like development of fuel prices and CO2 prices and development of technologies and demographics. Further it includes assumed policies which are options.

Table "Results" includes main outputs from the scenario analyses, like "Primary Energy Consumption", main elements in an electricity balance and also energy or electricity related CO_2 emissions. Further, "Results" also includes "Required policy actions" and "Required financial actions".

Table "Trends" describes possible trends in the scenarios. The table is focused on trends related to fuel consumption and CO_2 emissions.

4.1.3 Structuring the findings in other reports

Findings in reports that did not fit into the structure described in 5.3, are structured according to a more "open framework" and are summarized in Annex 2. The reports handle typically about a specific challenge, problem, technology or possibility. The following structure is used:

- *Name*
- *Responsible organization**
- *Status**
- *Short description*
- *Main relevance for eHighway2050*
- *Further information*

*) Responsible organisation and status of project were not always possible to identify.

4.2 Overview of relevant studies

The tables below give a brief overview of the main scope of the most relevant global and European scenario studies.

Table 4.1 Main ideas behind the Global and European studies

Title of the Study	Scope	Origin	Published	Time horizon	No of scenarios	Main idea
Global studies						
BP Energy Outlook 2030	World	BP	2011	2030	1	Build on "based on our knowledge" approach. Implementation of carbon abatement policies in OECD. The policies support rapid growth of non-fossil power generation, especially renewables.
Energy [R] evolution	World	Greenpeace	2012	2050	2	Consistent fundamental pathway for how to protect our climate: Getting the world from where we are now to where we need to be by phasing out fossil fuels and cutting CO_2 emissions while ensuring energy security.
IEA ETP 2012	World	IEA	2012	2050	3	Examines technological options for achieving the globally agreed-upon target of limiting average global temperature increase to 2^oC
IEA WEO 2011	World	IEA	2011	2035	3	Assess the threats and opportunities facing the global energy system based on a rigorous quantitative analysis of energy and climate trends. Two explorative and one predictive scenario underlines the critical role of governments to define the objectives andimplement the policies necessary to shape our energy future.
Shell Energy Scenarios 2050	World	Shell	2009	2050	2	Two scenarios to explore how global energy and emissions may develop with or without political attention and local actions.
European Studies						
EU Energy	EU27	EU	2011	2050	7	Examines different pathways to

Title of the Study	Scope	Origin	Published	Time horizon	No of scenarios	Main idea
Roadmap 2050						reach at least 80% reduction of GHG emissions in EU27 compared to 1990 level
IRENE-40	EU27	EU FP7 /Alstom	2012	2050	5	Mission: Identify the strategies for investors and regulators enabling a more secure, ecologically sustainable and competitive European electricity system for 2020 to 2050.Transmission network analysis for 3 different technology pathways: HVAC, HVDC and UHVAC
Power choices	EU27	Eurelectric	2012	2050	2	Examines different pathways to reach 40% or 75% reduction of GHG emissions in EU27 compared to 1990 level
Roadmap 2050	EU27 +NO, CH	ECF	2010	2050	2	The mission of Roadmap 2050 is to provide apractical, independent and objective analysisof pathways to achieve a low-carbon economyin Europe. The model developed by Oxford Economics. WEO 350 used as baseline. 80% reduction - backcasting approach scenario.
Power Perspectives	EU27 +NO, CH	ECF	2010	2030	1	Power specific study related to Roadmap 2050. Models current plans up to 2020 and further projects a power mix in 2030 in line with the emission reduction trajectory for the power sector in the EC 8th March 2011 communi-cation, 1 main scenario + 9 sensitivity scenarios
REALISEGRID	EU27 +NO, CH, Balkan	EU FP7 /RSE	2011	2030	4	Four scenarios meant to explore how the European energy system is going to react to different future external developments and internal policies.
SUSPLAN	Europe	EU FP7 /SINTEF	2011	2050	4	Investigates the need for electricity and gas transmission infrastructure for integration of large volumes of RES, both a top-down and a bottom up approach

Title of the Study	Scope	Origin	Published	Time horizon	No of scenarios	Main idea
Getting in the right lane for 2050	EU27	Netherlands Environ-mental Assessment Agency and the Stockholm Resilience Centre	2009	2050	1	Identifies key policy junctions at which the EU will soon face strategic choices regarding long-term environment sustainability issues. Examines the EU of today, from a global perspective and looks at a long-term vision of the world of 2050. Identifies key decisions for today on global land and water resources, and low-carbon energy systems, including transport.
Northern European Solar and Wind Intermittency Study (NEWSIS)	Northern Europe Countries	Pöyry	2011	2030	7	Investigating the impact of weather in the future with large amounts of weather dependent renewables (especially wind and solar).
RE-thinking 2050	EU27	**EREC**	2010	2050	1	Presents a pathway towards a 100% renewable energy system for the EU
100% renewable electricity: A Roadmap to 2050 for Europe and North Africa	Europe + North Africa	**PWC**	2010	2050	1	Presents a policy roadmap towards a 100% renewable electricity system in Europe and North Africa. No numerical results.
Moving towards 100% renewable electricity in Europe & North Africa by 2050	Europe + North Africa	**PWC**	2011	2050	1	Follow-up of the above. Review of current policies, but no numerical analyses. Refers to current data in TYNDP and NREAP's

Table 4.2 Description of the different scenarios

Title of the Study	Scope	Scenario titles	Main ideas
Energy [R] evolution	World	Reference	-
		Energy [R] evolution	Consistent fundamental pathway for how to protect our climate: Getting the world from where we are now to where we need to be by phasing out fossil fuels and cutting CO2 emissions while ensuring energy security.
IEA ETP 2012	World	2DS	The 2DS scenario represents a vision of a sustainable energy system of reduced GHG emissions, consistent with the globally agreed objective of limiting average temperature rise to 2°C
		4DS	The 4°C scenario reflects pledges by countries to cut emissions and boost energy efficiency.
		6DS	The 6°C scenario reflects a scenario where no new energy or climate policies are introduced
IEA WEO 2011	World	Current Policies	Policies enacted by mid-2011 remain unchanged: including ETS covering power, industry and aviation; Energy Performance of Buildings Directive, emission standards for LDVs, 20% reduction in emissions by 2020 and 20 % renewables to reach share in energy demand.
		New Policies	Recent commitments and plans, not necessarily adopted and implemented, including ETS covering power, industry and aviation; new LDV standards.
		450	Anticipative (back-casting) scenario: Energy pathway that is consistent with a 50% chanceof meeting the goal of limiting the increase in average global temperature to 2° including 30% reduction of emissions by 2020, ETS strengthened in line with 2050 roadmap
Shell Energy Scenarios 2050	World	Scramble	The energy policies are segmented and dominated by national energy security concerns. Competition between national governments for favourable terms of energy supply.
		Blueprint	Internationally harmonised framework for carbon-trading, addressing for climate change mitigation. Fuel efficiency requirements in USA, stricter CO_2 emission allowances in EU
EU Energy Roadmap 2050	EU27	Reference	Long-term projections ofcurrent trends in economic development (GDP growth 1.7% pa) and policies implemented *by March 2010*. Takes into account rising fossil fuel prices. The 2020 targets for GHG reductions and RES shares will be achieved but no further policies and targets after 2020 (besides the ETS directive) are modeled. Sensitivities: a) a case with higher GDP growth rates, b) a case with lower GDP growth rates, c) a case with higher energy import prices, d) a case with lower energy import prices.
		Current Policy Initiatives	Includes several new initiatives adopted or being proposed by the EC*after March 2010*,mainly outlined in the Communication "Energy

Title of the Study	Scope	Scenario titles	Main ideas
			2020 - A strategy for competitive, sustainable and secure energy". This scenario analyses the extent to which measures adopted and proposed will achieve the energy policy objectives. It includes additional measures in the area of energy efficiency, infrastructure, internal market, nuclear, energy taxation and transport. Technology assumptions for nuclear were revised reflecting the impact of Fukushima and the latest information on the state of play of CCS projects and policies were included.
		Energy Efficiency	Driven by a political commitment of very high primary energy savings by 2050 and includes a very stringent implementation of the Energy Efficiency plan. It includes further and more stringent minimum requirements for appliances and new buildings; energy generation, transmission and distribution; high renovation rates for existing buildings; the establishment of energy savings obligations on energy utilities; the full roll-out of smart grids, smart metering and significant and highly decentralized RES generation to build on synergies with energy efficiency.
		Diversified Supply Technologies	Decarbonization pathway where all energy sources can compete on a market basis with no specific support measures for energy efficiency and renewables.Assumes acceptance of nuclear and CCS as well as solution of the nuclear waste issue. Significant penetration of CCS and nuclear as they necessitate large scale investments and does not include additional targeted measures besides carbon prices (Technologies compete on their economic merits alone)
		High RES	Aims at achieving a higher overall RES share and very high RES penetration in power generation, mainly relying on domestic supply.
		Delayed CCS	Similar approach to the Diversified supply technologies scenario but assumes difficulties for CCS regarding storage sites and transport while having the same conditions for nuclear as scenario 3. It displays considerable penetration of nuclear.
		Low Nuclear	Similar approach to the Diversified supply technologies scenario but assumes that public perception of nuclear safety remains low and that implementation of technical solutions to waste management remains unsolved leading to a lack of public acceptance. Same conditions for CCS as scenario 3. Considerable penetration of CCS.
IRENE-40	EU27	BAU	-
		CCS	Substantial contribution from CCS to attain 80% goal
		Efficiency	Lower electricity demand than in the other scenarios
		RES	High contribution of RES to 80% goal. Assumptions for RES from ECF 2050 Road Map
		DESERTECH	Similar to RES but with import from Africa. Assumptions for RES from ECF 2050 Road Map

Title of the Study	Scope	Scenario titles	Main ideas
Power Choices	EU27	Baseline	-
		Power Choices	The EURELECTRIC Power Choices should be seen as compass to indicate the way to carbon-neutral electricity in Europe by 2050.
Roadmap 2050	EU27 +NO, CH	Baseline	-
		80% reduction of CO2 emissions	Goal: To realize an economy-wide GHG reduction of 80%. The pathways range in share of renewable energy sources (RES, from 40% to 80%) versus fossil CCS and nuclear energy. Additionally, a pathway with 100% RES is assessed, and sensitivities on the relative shares of fossil with CCS and nuclear are performed.
Power Perspectives	EU27 +NO, CH		Power specific study related to Roadmap 2050, Models current plans up to 2020 and further projects a power mix in 2030 in line with the emission reduction trajectory for the power sector in the EC 8th March 2011 communication, 1 main scenario + 9 sensitivities
REALISEGRID	EU27 +NO, CH, Balkan	Optimistic	High technological improvement, economic & population growth; Strong climate mitigation; Bounded electricity interties.
		Competing	High technological improvement, economic & population growth; Strong climate mitigation; Free electricity interties.
		Centric	Low technological improvement, economic & population growth; Strong climate mitigation; Free electricity interties.
		Pessimistic	Low technological improvement, economic & population growth; Weak climate mitigation; Bounded electricity interties.
SUSPLAN	Europe +surroun-ding countries	Red	Low-tech, Indifferent public attitude. Mainly centralized development with traditional technologies.
		Blue	High-tech, indifferent public attitude. Many advanced technologies but low interest from public and commercial actors. Mainly large-scale developments driven by governmental regulations and agreements. DESERTEC and North Sea Grid realized in this scenario.
		Green	High-tech, positive public attitude. Many advanced but mainly distributed technologies for RES energy.Reduced growth in energy demand.
		Yellow	Low-tech, positive public attitude. Reduced growth in energy demand, mainly achieved through changed behaviour of consumers as there are fewer advanced technologies to “help” energy efficiency improvements.
Getting in the right lane for 2050	EU27	Vision for 2050	Goal: Produce food for a global population of nine billion while minimizing biodiversity loss; mitigate climate change while enhancing energy security for the EU; practical and workable solutions for an EU transport system that is low carbon, including a power grid that would allow citizens to become electricity producers and would help ensure

Title of the Study	Scope	Scenario titles	Main ideas
			a dependable supply of electricity.
Northern European Solar and Wind Intermittency Study (NEWSIS)	Northern Europe Countries	Target Met	Wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns, thermal generation becomes 'intermittent' in its operation. CO_2emission limit: 100 g CO_2/kWh.
		Capacity Payment	Price volatility is reduced by modelling a capacity payment mechanism.
		Offshore Grid	Interconnectors to Nord Pool become increasingly valuable in high wind scenarios asthere is a rise in demand for hydro to balance wind generation
		Flexible Demand	There is considerable potential in the demand-side to mitigate intermittency, and it is the most effective of the measures investigated.
		Reduced Renewables	CO_2emission limit: 150 g CO_2/kWh.
		Reduced Renewables (low CO_2)	CO_2emission limit: 100 g CO_2/kWh.
		Germany N-S Split	
RE-thinking 2050	EU27	100% Renewable Energy Vision	Presents a possible pathway towards a 100% renewable energy system for the EU
100% renewable electricity: A Roadmap to 2050 for Europe and North Africa	Europe + North Africa	-	Not a scenario study but a policy roadmap towards a 100% renewable electricity system in Europe and North Africa.
Moving towards 100% renewable electricity in Europe & North Africa by 2050	Europe + North Africa	-	Follow-up of the above with review of current policies, TYNDP and NREAP's.

4.3 Scenarios comparisons

This section presents a graphical comparison of some key factors in relevant scenario studies. The comparison focuses on electricity demand and generation in EU27 in 2050 but economic growth and population are also included. Data for 2010 from the Reference scenario in the EU Energy Roadmap 2050 is also shown for comparison. Note that these are calculated data and not measurements.

The different reports/studies present the information in different forms, time frame or geographical perspective, and many of the studies do not present comparable results. Furthermore, for several of the studies (parts of) the information is only given in diagrams and not in quantitative table formats. Information given only in graphs is not included in the comparison. Table 4.3 summarizes the comparability of 2050 data for EU in the global and European studies. The studies that present directly comparable data are highlighted in light blue.

As shown in the table the comparison is mainly based on the following reports/studies: *EU Energy Roadmap 2050, EURELECTRIC's Power Choices* (mainly the Power Choice scenario), *ECF Roadmap 2050, SUSPLAN* and *EREC's RE-thinking 2050*. However, these studies also to some degree have different geographical resolution that must be kept in mind when the information is compared. EU Energy Roadmap 2050 and Power Choices are both based on the PRIMES model and provide results for EU27. SUSPLAN covers whole of Europe but we have extracted the data for the 25 countries in EU that are synchronously interconnected, i.e. EU27 minus Cyprus and Malta. The figures in the ECF Roadmap 2050, on the other hand, are for EU27 + Norway and Switzerland.

Table 4.3 Comparability of scenario studies for Europe in 2050

Title of the Study	Assessment of comparability
BP Energy Outlook 2030	Time perspective not 2050
Energy [R] evolution	Includes a lot of data, but demand and power generation are given for OECD Europe and East-Europe/Eurasia. Not comparable with EU-27.
IEA Energy Technology Perspectives 2012	No exact figures for power demand or generation in EU.
IEA World Energy Outlook 2011	Time perspective is not 2050
Shell Energy Scenarios 2050	Information is too aggregated to be relevant for EU
EU Energy Roadmap 2050	Included in the comparison
IRENE-40	Only demand is included in comparison. Exact figures for generation are not found in the report.
Power choices	The Power Choices scenario is included in the comparison. The report only shows differencial numbers for the Baseline scenario.
ECF Roadmap 2050	Included in the comparison
ECF Power Perspectives	Time perspective is not 2050
REALISEGRID	Time perspective is not 2050
SUSPLAN	Included in the comparison

Getting in the right lane for 2050	No figures for power demand or generation are found
Northern European Solar and Wind Intermittency Study (NEWSIS)	Time perspective not 2050. Geographical scope only northern Europe.
RE-thinking 2050	Included in the comparison
100% renewable electricity: A Roadmap to 2050 for Europe and North Africa	No figures are given
Moving towards 100% renewable electricity in Europe & North Africa by 2050	No figures are given

Average economic growth (GDP) in EU27 up to 2050 ranges from 1.7 % p.a in EU Energy Roadmap, 1.8 % p.a in Power Choices and ECF Roadmap 2050, to 2.0 % p.a in IEA WEO.

Figure 4.2 presents the estimated population in Europe in 2050 and Figure 4.3 presents electricity demand. *Note that the two Power Choices scenarios show gross electricity demand while the other scenarios show final electricity demand.* No scenarios expect a net reduction in electricity demand by 2050.

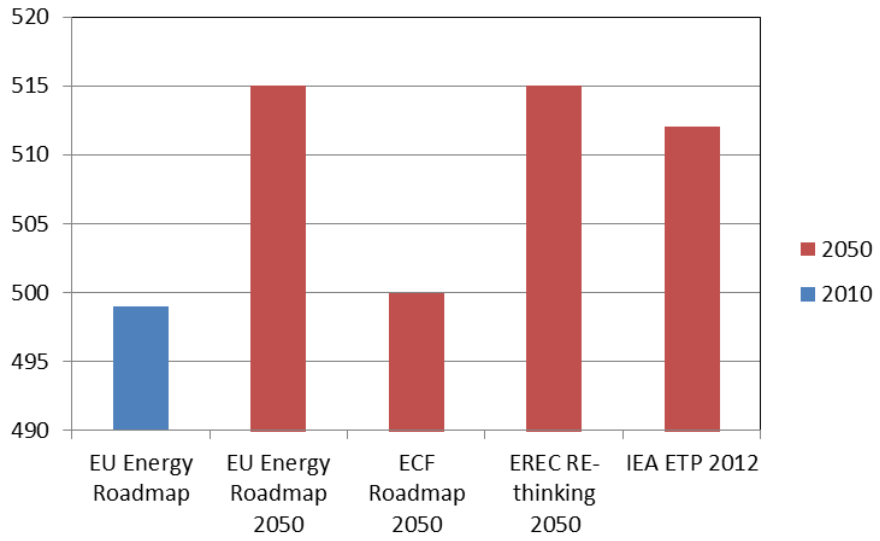

Figure 4.2 Population in Europe in 2050 (million)

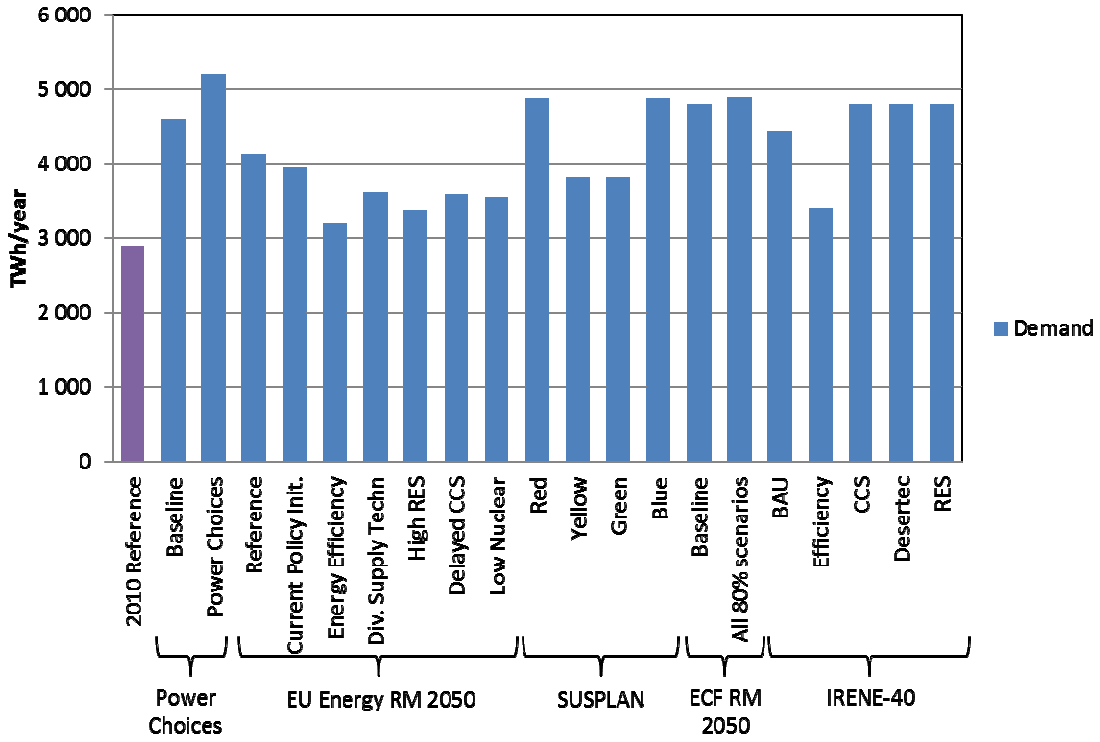

Figure 4.3 Electricity demand in the different studies (TWh/year)

Figure 4.4 shows installed generation capacity in 2050 for Power Choices, EU Energy Roadmap 2050, SUSPLAN and EREC RE-thinking 2050. The ECF Roadmap 2050 study does not have the same disaggregation into different technologies and values for the three technology pathways are shown separately in Figure 4.5 for EU27 + Norway and Switzerland.

The following figures show in more detail the installed capacity for *fossil generation* (Figure 4.6), *nuclear generation* (Figure 4.7) and *renewable generation* (Figure 4.8).

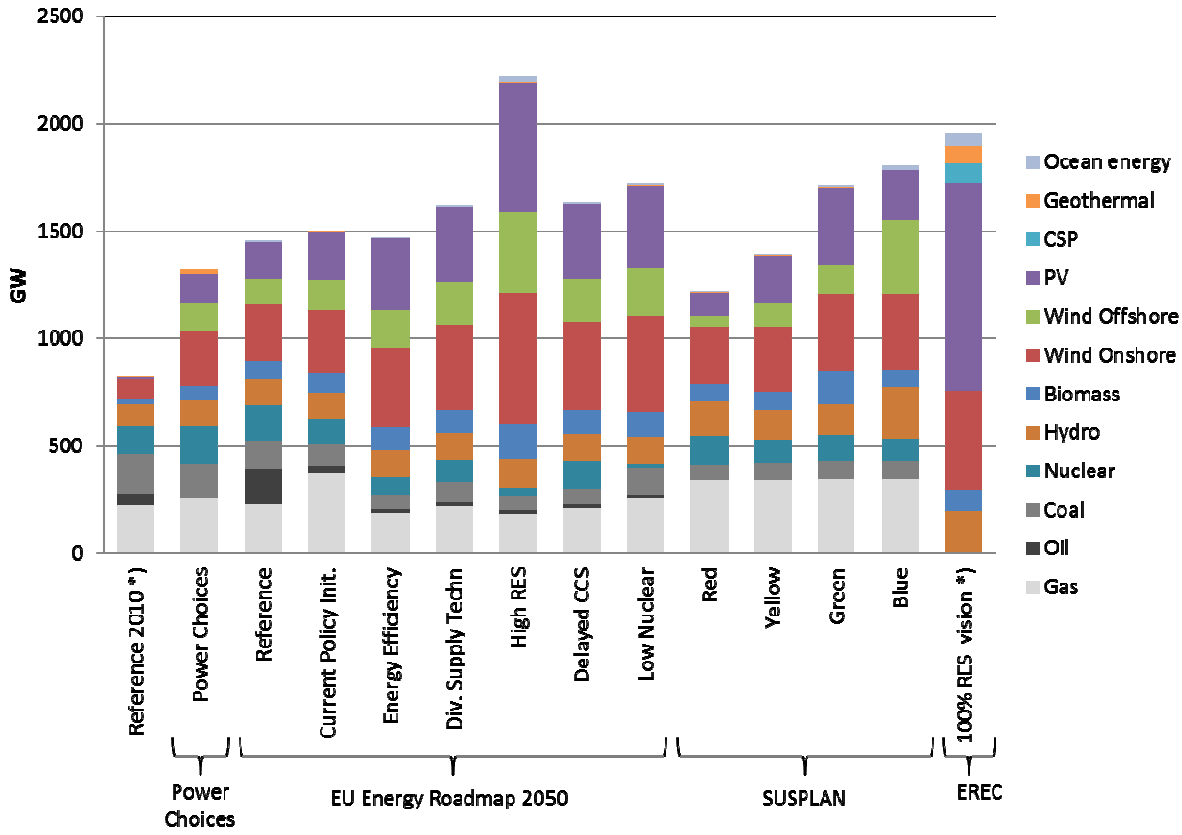

Figure 4.4 Installed generation capacity for EU27 in 2050 in the different scenarios (GW)

*) "Wind onshore" for EREC includes both onshore and offshore wind. Only the EREC study has separate figures for PV and CSP.

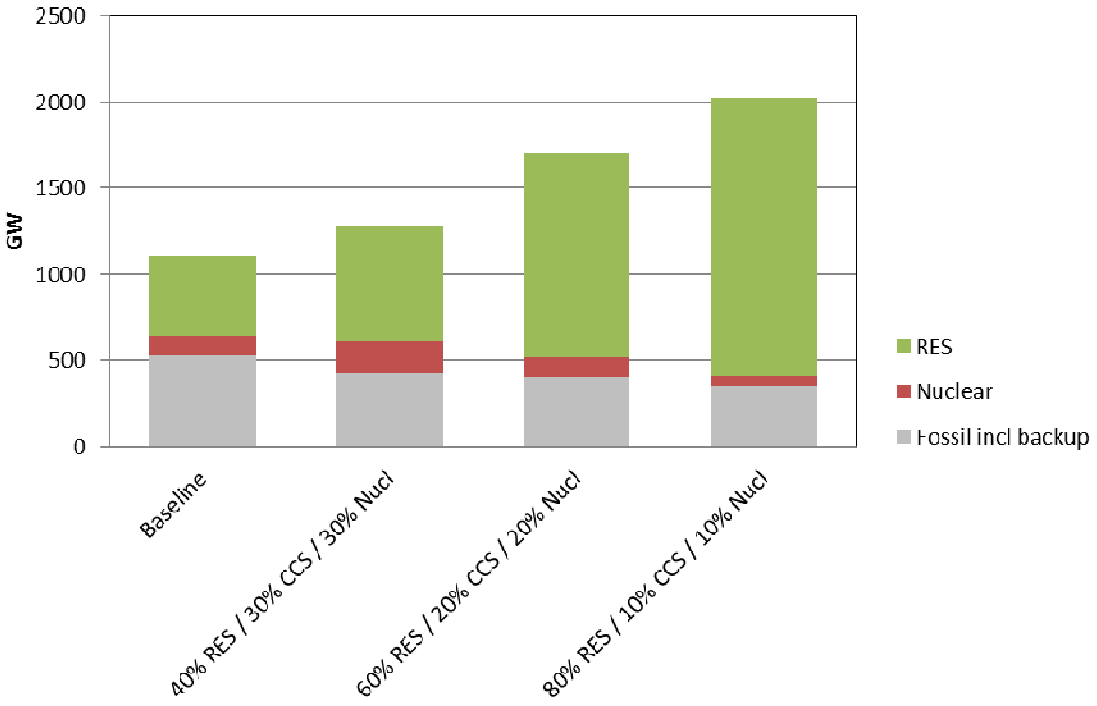

Figure 4.5 Installed generation capacity in Europe in 2050 in the ECF Roadmap 2050 (GW)

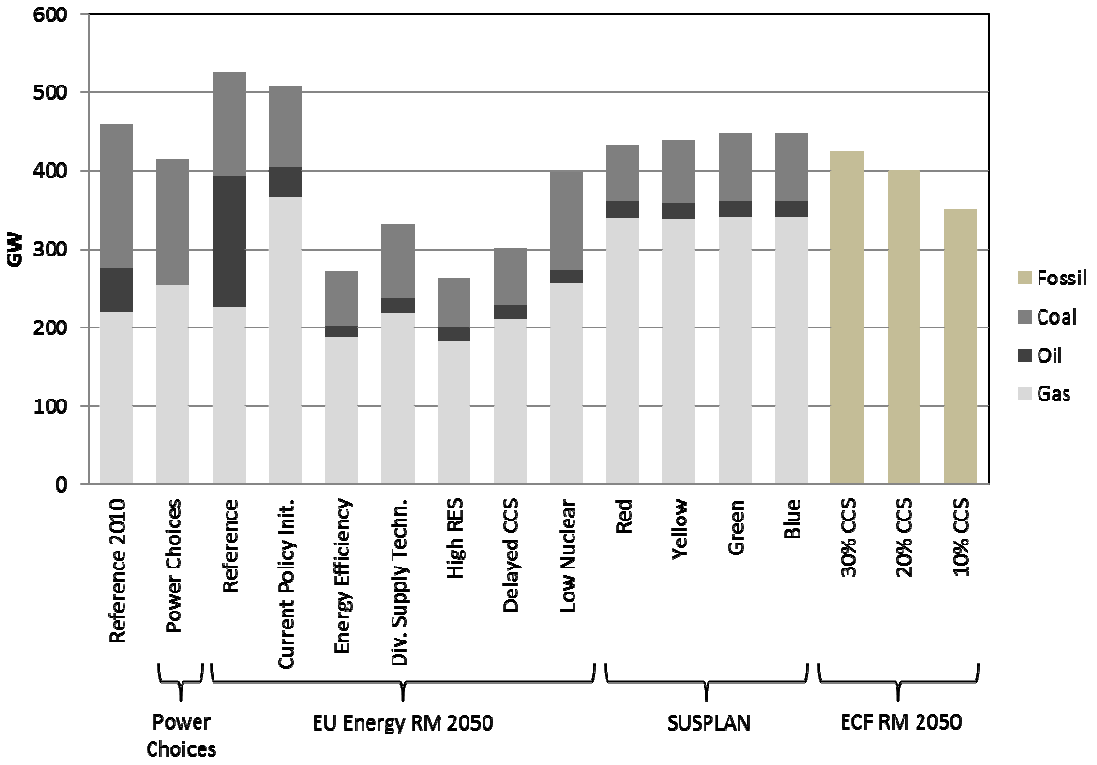

Figure 4.6 Installed capacity of fossil generation forEurope 2050 in the different scenarios

When reviewing the fossil capacity in the different scenario studies, it is also important to note that the use of CCS differs significantly between the studies and also between the scenarios in each study. However, few of the studies present exact numbers for CCS capacity and whether this is used in coal or gas fired units. We therefore present the CCS information verbally in Table 4.4.

Table 4.4 Shares of fossil fuel with CCS in different scenario studies

Title of the Study	Scenario title	Gas (GW)	Oil (GW)	Coal (GW)	Fossil (GW)	Comments
Power Choices	Power Choices	253		162		Gas figure includes both gas and oil. 81 GW of Gas/oil and 110 GW of coal has CCS
EU Energy Roadmap 2050	Reference	226	168	131		100 GW of fossil production has CCS
	Current Policy Init.	366	38	104		39 GW of fossil production has CCS
	Energy Efficiency	187	15	70		149 GW of fossil production has CCS
	Div. Supply Techn.	218	19	94		193 GW of fossil production has CCS
	High RES	182	19	62		53 GW of fossil production has CCS
	Delayed CCS	210	18	73		148 GW of fossil production has CCS
	Low Nuclear	255	18	125		248 GW of fossil production has CCS
ECF Roadmap 2050	40% RES / 30% CCS / 30% Nucl				425	Capacity includes 270 GW backup to meet peak demand
	60% RES / 20% CCS / 20% Nucl				400	Capacity includes 240 GW backup to meet peak demand
	80% RES / 10% CCS / 10% Nucl				350	Capacity includes 190 GW backup to meet peak demand
SUSPLAN						No CCS included

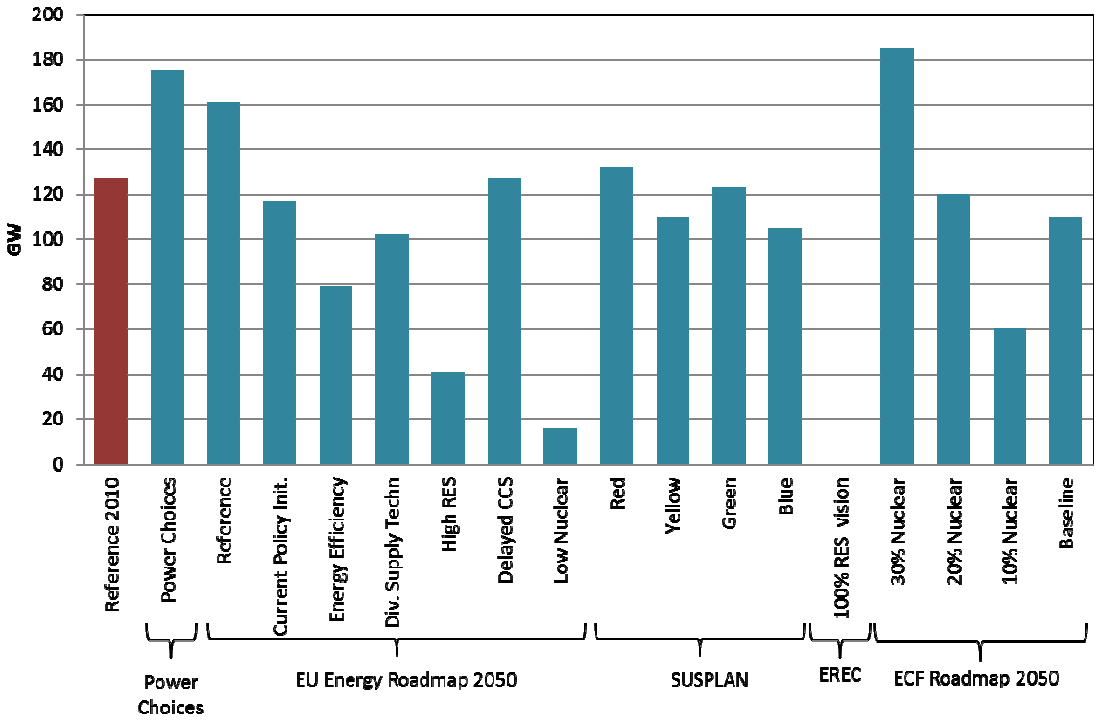

Figure 4.7 Installed nuclear capacity for Europe 2050 in the different scenarios

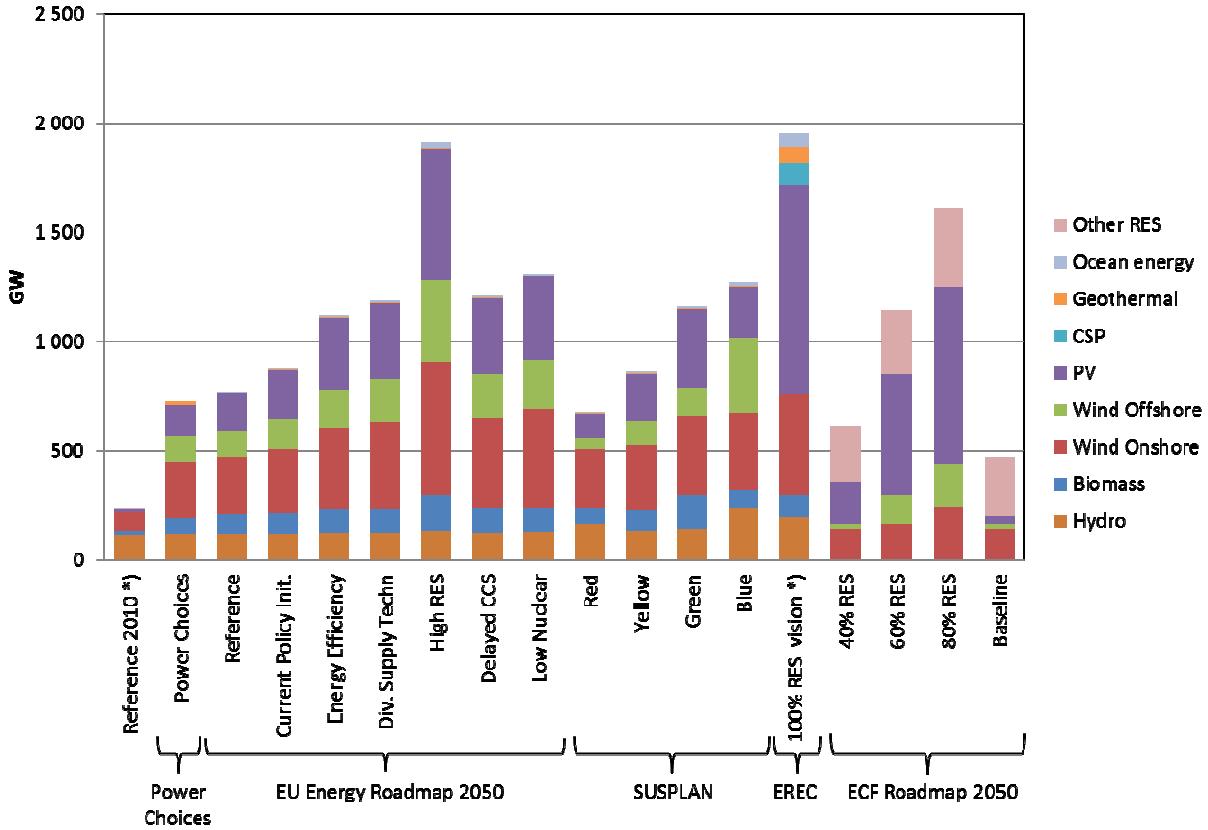

Figure 4.8 Installed capacity of renewable generation in Europe 2050

4.4 Recommendations for further use

Recommendations for further use and relevance to the e-HIGHWAY2050 project are summarized in the following tables.

Table 4.5 Overview of key findings in the global scenario studies

Title of the Study	Relevance for eHighway2050
BP Energy Outlook 2030 [12]	Limited relevance. Global trends to 2030.
Energy [R]evolution [13]	Limited relevance. Global scenarios and information given as "OECD Europe" and "Eastern Europe/Eurasia". A lot of specific cost information for different technologies. No nuclear or CCS technologies. Based on IEA WEO to 2035.
IEA Energy Technology Perspectives 2012 [14]	Global scenarios. Main interest for e-Highway2050 is information related to different technologies. Separate section for Europe, but limited information compared to European studies.
IEA World Energy Outlook 2011 [15]	Updated version in 2012. Development of global fuel prices to 2035, several European figures in 3 scenarios: CO2 prices, demand, power generation and capacity by source. Electricity consumption per sector, cumulative power retirement by source 2012-2035, cumulative gross capacity addition 2012-2035. Furthermore, additional possibilities for energy efficiency in Europe beyond already announced policies.
Shell Energy Scenarios 2050 [16]	Limited relevance. Global trends with aggregated data.

Table 4.6 Overview of key findings in the European scenario studies

Title of the Study	Relevance for eHighway2050
EU Energy Roadmap 2050 [2]	Very relevant low carbon emission scenarios including evaluation of impacts on infrastructure (table 29). Detailed overview of policy measures. Confirmation of the central role the eletricity will play in decarbonisation of transport, industry and buildings. Learning curves for technologies.
Getting in the right Lane for 2050 [28]	Discussing the future EU Energy system in a broader context.
IRENE-40 [4]	Concludes that Europe needs a supergrid and that a overlay HVDC network is the prefered solution due to lowest costs, best control possibilities and highest expected public acceptance. Recommendations related to coordination of network control. WP3 should consider the technology database of IRENE-40.
Northern European Solar and Wind Intermittency Study (NEWSIS) [29]	The study considers the effects of interconnection and smart energy on the system, with detailed analysis of wind correlation and plant operation. The study investigates the impact of weather in the future with large amounts of weather dependent renewables (especially wind and solar).

Power Choices [3]	1. Scenarios (very relevant) 2. Key findings 3. Investment in transmission lines
Power Perspectives 2030 [18]	Very relevant scenarios for 2030. Based on the objective to reduce domestic greenhouse gas emissions by at least 80% below 1990 levels in 2050.
REALISEGRID [19], [20]	Technology Roadmap for the integration of promising innovative power transmission technologies.Scenario studies. Framework for cost-benefit analysis of transmission expansion investments
Roadmap 2050 [21]	Based on a target of nearly decarbonised power sector in 2050. Alternative realisation compared to "EU Energy Roadmap 2050". Includes analysis of need for expansion of transmission capacities. The dedicated policy recommendations in Volume 2 are relevant for the policy analyses in e-Highway2050 WP5 [36].
SUSPLAN [5]/LinkS [6]	1. Scenario methodology and scenarios to 2050 2. Need for cross border capacities dependent on type of RES to 2050 [6] 3. Policy recommendations [37]
RE-thinking 2050 [30]	Only one scenario: 100% renewable energy system by 2050. Relevant input to e-Highway2050 scenario "100% RES".
100% renewable electricity: A Roadmap to 2050 for Europe and North Africa [31] / Moving towards 100% renewable electricity in Europe & North Africa by 2050 [32]	Limited relevance for the scenario analyses since there are no numerical results presented, but relevant for the policy analyses in e-Highway2050 WP5.

Table 4.7 Overview of key findings in other studies

Title of the Study	Relevance for eHighway2050
Energy Corridors [17]	From 2007. Analysis of need for electricity corridors and capacity between European Union and neighbouring countries up to 2030.
FENIX [22]	Boost Distributed Energy Resources by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralized management.
ICOEUR [7]	1. Synchronous interconnection ENTSO-E – IPS/UPS long term alternative 2. Asynchronous connection may be an mid-term solution
Medgrid [8]	1. Volume of possible import from Africa 2.Plans for interconnections Africa/Europe

MedRing [23]	Linking Europe with the Southern Mediterranean through electricity and gas interconnections.
NSCOGI [24]	By December 2012 at least two plausible Scenarios comprising a) radial offshore wind connections and b) an integrated offshore grid solution will be produced. Related to the European supergrid as Norway hydroelectric plants act as a giant battery and several HVDC inteconnection between countries link renewable energy sources across northern seas of Europe to the rest of Europe.
OffshoreGrid [9]	Concepts for combined connection of offshore wind farms and cross border connections
UCTE-IPS [10]	1. Non-synchronous system HVDC coupling UCTE-IPS/UPS recommended 2.Limited possibilities for power exchange due to the internal congestions in the systems concerned
WindSpeed [11]	Potential for 135 GW offshore wind in the Central and Southern North Sea in 2030. Coordinated North Sea Policies between involved nations including among other spatial planning with integration of Offshore Wind Energy, incorporating near shore and further from shore developments, offshore grid implemented. Recommendations related to offshore grid development and TSOs role.
TWENTIES [33]	6 demonstration projects to evaluate the contributions from intermittent generation and flexible load to system services and flexibility of the transmission grid that could be important input to the technology assessment and grid analyses of e-Highway2050. The project does not perform scenario studies or analyses of future grid development.
EWIS [34]	EWIS focused on the immediate network related challenges from large scale wind integration by analysing detailed representations of the existing electricity markets, network operations and the physical power flows and other system behaviours. No scenario studies or analyses of future grid development towards 2050, but could be relevant input to the technology assessment and grid analyses of e-Highway2050.
Feature of an electricity supply system based on variable input [35]	Not directly relevant for the scenario studies, but could be relevant input to the following technology assessment and grid analyses of e-Highway2050.

4.5 Summary of studies review

The main findings can be summarised in the following way:

In the global scenario studies the main relevant information for e-Highway2050 project are development of fuel prices, CO_2 prices, GDP and population. Furthermore, expected development of technologies (learning curves) is important.

There are mainly two types of European studies:

i. *Studies analysing how the European energy or electricity system should develop to obtain low carbon emissions, e.g. "EU Energy Road Map 2050", "Power Perspectives 2030" and "Power Choices".*

ii. *Studies of a specific issue related to decarbonisation of the energy or power system, e.g. IRENE-40 (what kind of a pan-European grid is preferred in a long term perspective in Europe).*

Several of the reviewed studies have the same time perspective as eHighway2050 and analyses alternatives for a European power system with very low emissions of CO_2. Especially the "EU Energy Road Map 2050" is reflecting EUs aims about a low carbon energy system in 2050 and with reduction of GHG emissions by 80-95% by 2050 compared to 1990 levels. The Road Map has five scenarios for how the low carbon future may be achieved and provides consistent and quantitative information related to the alternatives.

The European Climate Foundation's (ECF) two studies "Roadmap 2050" and "Power perspectives 2030" and Eurelectric's "Power choices" provides alternative scenario analysis compared to "EU Energy Road Map 2050" and should be used to complement the knowledge basis for the further eHighway2050 work.

Both in global and in European studies there are several trends related to scenarios focusing on a low carbon society in 2050 and these trends should be included in the further eHighway2050 work:

- *The percentage reduction of GHG compared to 1990 is larger in the power sector than in other sectors*
- *The GHG emissions from the power sector is low (less than 20%) in 2050 compared to 1990*
- *The electricity consumption increases in all scenarios, also in "Energy Efficiency" scenarios*
- *Important factors that increase the electricity consumption are electrification of the transport and the heating sector*
- *A combination of several efforts are necessary, e.g. increased share of RES, nuclear, CCS and energy efficiency. One of the efforts may be omitted, but at least two are always included.*
- *The share of RES is high*
- *Energy efficiency is a cost efficient contribution to reduction of GHG emissions*
- *Grid upgrades/expansions will be necessary*

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Annex 1 – NATIONAL STUDY REVIEW

National studies

A. Austria

Name of the study	Origin	Published	Time horizon	Scope	web link to the sutdy
e-mobility in Austria	Umweltbundesamt	2010	2020 & 2050	analyses of reachable potentials of electric vehichles undtil 2020 and 2050	http://www.umweltbundesamt.at/aktuell/presse/lastnews/newsarchiv_2010/news100430/
economic factor of windpower	ministry of traffic, innovation and technology	2011	up to 2040	evaluation of the economic factor of wind energy (workplaces, economic driver etc.)	http://www.igwindkraft.at/redsystem/mmedia/2011.04.27/1303893992.pdf
Roadmap Smart Grids Austria, pathway to the future of electrical power grids	Fachverband der Elektro- und Elektronikindustrie, Österreichs E-Wirtschaft	2009	2020 / 2050	adress relevant national emphasises, key aspects to modernise electricity gird, supports political desicion making with basic informations for decision making, illustrats chances challanges and impacts of smart girds etc.	http://www.energiesystemederzukunft.at/edz_pdf/20100618_smartgrids_roadmap_austria.pdf
Renewable Energy 2020, Potentials and use in Austria	Umweltbundesamt	2009	2020	evaluation of RES-Potentials (including hydro power) in Austria and their use (heating, energy and mobility)	http://www.energiestrategie.at/images/stories/pdf/02_bmlfuw_09_erneuerbare2020.pdf

B. Belgium

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
Towards 100% renewable energy in Belgium by 2050	Commissioned by the Belgian Federal and Regional Energy Ministers	20/12/2012	2050	This "Backcasting" study aims to describe how the Belgian energy system can be transformed into a system that relies on 100% renewable1 energy sources2 by 2050. It constitutes a response to the request made by the four Ministers in charge of energy to analyze the feasibility as well as the impacts of such a transition towards renewable energy sources. The study is carried out by a Consortium of three research organisations (the Federal Planning Bureau, ICEDD and VITO), that have pooled their expertise to provide a comprehensive answer to the questions raised by the four previously mentioned Ministries.	http://www.plan.be/publications/Publication_det.php?lang=en&TM=30&IS=63&KeyPub=1191
Commission on Energy 2030 - Belgium's Energy Challenges Towards 2030	Commision set up the Federal Government (Royal Decree)	22/06/2007	2030	The main objective of the assignment given to the Commission ENERGY 2030 for studying Belgium's energy policy up to 2030, in a European context, is set out in the study's Summary Memorandum, formally enacted through the Royal Decree. The goal is to «provide the scientific and economic analyses necessary to evaluate Belgium's options with regard to the energy policy up to 2030». Furthermore, it is stated that the study will «specifically focus on the economic, social and environmental aspects associated with the various options or scenarios for investment policy involving production, storage and transport while bearing in mind the different types and sources of renewable and non-renewable energy as well asexamine the issues of security of supply, energy independence and technical feasibility». The study also looks into the cost of the energy system, trends in regional and national energy demand, honouring agreements concerning the environment and the maintenance or further development of technological know-how.	http://www.ce2030.be/

Prospective Study Electricity 2008-2017	Federal Public Service Economy, S.M.E.s, Self-Employed and Energy in collaboration with the Federal Planning Bureau	Dec-09	2017/2020	Federal Study about the Energy Mix Evolution in Belgium (published every 4 years)	http://economie.fgov.be/fr/consommateurs/Energie/Securite_des_approvisionnements_en_energie/Etude_prospective_electricite/
Prospective Study Electricity (second edition)	Federal Public Service Economy, S.M.E.s, Self-Employed and Energy in collaboration with the Federal Planning Bureau	expected in 2013	2020/2030	Federal Study about the Energy Mix Evolution in Belgium (published every 4 years)	to be published
GEMIX report - The complete title in French is "Quel mix énergétique idéal pour la Belgique aux horizons 2020 et 2030 ?"	Commissioned by the Belgian Federal Minister	9 Octobe r 2009	2030	Evolution of the Belgian energy mix between 2020 and 2030	http://economie.fgov.be/fr/binaries/rapport_gemix_2009_fr_tcm326-76356.pdf
GEMIX2 (update) - "Quel	Commissioned by the Belgian	July 2012	2020/2030	Evolution of the Belgian energy mix between 2020 and 2030	http://economie.fgov.be/fr/binaries/Gemix2_fr_tcm32

mix énergétique idéal pour la Belgique aux horizons 2020 et 2030 ?"	Federal Minister				6-201917.pdf
WP21-08 Impact of the EU Energy and Climate Package on the Belgian energy system and economy	Federal Planning Bureau	19/12/2008	2020	This Working Paper described and analysed the impact of the EU Climate-Energy Package on the Belgian energy system and economy.	http://www.plan.be/press/press_det.php?lang=en&TM=30&IS=67&KeyPub=764
WP9-11 Impact of the EU Climate-Energy Package on the Belgian energy system and economy - Update	Federal Planning Bureau (Update 2010 Study commissioned by the Belgian federal authority)	15/07/2011	2020	By the end of 2008, the Federal Planning Bureau published the Working Paper 21-08. This Working Paper described and analysed the impact of the EU Climate-Energy Package on the Belgian energy system and economy. Since then, however, a lot has changed: the macroeconomic projections altered radically further to the financial and economic crisis, recent developments in the field of oil and gas supply and demand made fossil fuel price projections to be revised upwards and a number of energy efficiency measures were agreed upon and put into law in the course of 2008 and 2009. All this made the 2008 study less relevant whilst only 2 years old. This study report then updates the analysis reported in the Working Paper 21-08 and dedicates special attention to the stepping up to -30% for the EU greenhouse gas reduction target. It is based on the new economic and policy context and benefits from recent analyses of the European Commission conducted at EU level.	http://www.plan.be/publications/Publication_det.php?lang=en&TM=30&IS=63&KeyPub=1068
Federal Development Plan of the Transmission Grid (150-380 kV)	Elia in collaboration with the Federal Planning Bureau	01/09/2011	2020	Development Plan of Elia's transmission grid, including its grid expansion strategy by 2020. Legal obligation	http://elia.be/repository/pages/1db76a6ba65f47dc9cb67221218fab6c.aspx?language=FR

	and the Federal Public Service				
National Renewable Energy Action Plan for Belgium		Nov. 2011	2020	Belgium notified the national renewable energy action plans to the EC. This plan set out the sectoral targets, the technology mix they expect to use, the trajectory they will follow and the measures and reforms they will undertake to overcome the barriers to developing renewable energy.	http://ec.europa.eu/energy/renewables/transparency_platform/doc/dir_2009_0028_action_plan_belgium.zip
Studie: Onthaalcapaciteit decentrale productie in Vlaanderen 2011-2020	Elia, Infrax, Eandis and Vito	10/09/2012	2020	Study with the geographic breakdown of potential RES (wind, photovoltaïc and CHP) in the Flemish Region by 2020	http://www.elia.be/~/media/files/Elia/publications-2/investment-plans/8343_studie_onthaalcapaciteit_v9.pdf
Prognoses voor hernieuwbare energie en warmtekrachtkoppeling tot 2020	Vito on behalf of the Flemish Energy Agency	Octob. 2009	2020	RES Forecast in the Flemish Region by 2020	http://www2.vlaanderen.be/economie/energiesparen/milieuvriendelijke/Cijfers&statistieken/Prognosestudie_HEB_WKK_tot_2020.pdf
Estimation du potentiel de développement d'électricité renouvelable décentralisée pour l'ensemble de la Région wallonne	ICEDD-APERE FOR	2008-2009		Study to evaluate the absolute potential for wind energy development in the Walloon Region	

C. United Kingdom

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
DECC 2050 Pathways	DECC		2050	Heat, Power and Transport	http://www.decc.gov.uk/en/content/cms/tackling/2050/calculator_on/calculator_on.aspx
Future Energy Scenarios	National Grid	Sep 12	2030/ 2050	Heat, Power and Transport	http://www.nationalgrid.com/uk/Gas/OperationalInfo/TBE
Heat Economics Study	Redpoint	Jul 12	2050	Heat., Power and Transport	http://www.baringa.com/files/documents/NG-003_-_Redpoint-Baringa_-_Heat_Economics_Study-_Final_-_v20120924-1_1.pdf
2050 Pathways for Domestic Heat	DELTA/ENA	Okt 12	2050	Domestic Heat	http://www.energynetworks.org/gas/futures/2050-pathways-for-domestic-heat.html
Gas Futures report	Redpoint	Nov 10	2050	Heat Power and Transport	http://www.energynetworks.org/gas/futures/gas-futures-reports.html
Annual Energy Statement	UK Government	Nov-2012		Provides an overview of the progress made in the UK implementing policy on energy and climate change over the last 12 months	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/annual-energy-statement/7086-annual-energy-statement-2012.pdf
Gas Generation Strategy	UK Government	Dez-2012		Sets out the role that gas will play in the future generation mix	http://www.decc.gov.uk/en/content/cms/meeting_energy/oil_gas/gasgenstrat/gasgenstrat.aspx
Energy Efficiency Strategy	UK Government	Nov-2012		Designed to maximise the benefits of existing policy and to realise the wider energy efficiency potential across the UK economy	http://www.decc.gov.uk/assets/decc/11/tackling-climate-change/saving-energy-co2/6927-energy-efficiency-strategy--the-energy-efficiency.pdf

Electricity System: Assessment of Future Challenges	UK Governm ent	Aug-2012		Assesses the possible impacts of the move to a low carbon economy on the electricity system as a whole. It considers the challenges to balancing supply and demand, and looks at whether there are more cost effective ways to operate the system in the future	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/future-elec-network/6098-electricity-system-assessment-future-chall.pdf
UK Renewable Energy Roadmap	UK Governm ent	Jul-2011		Sets out a comprehensive action plan to accelerate the UK's deployment and use of renewable energy	http://www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/re_roadmap/re_roadmap.aspx#
Energy Security Strategy	UK Governm ent	Nov-2012		Assessment of UK energy security, the challenges and risks to energy security and the Government's policy response.	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/energy-security/7101-energy-security-strategy.pdf
Electricity Market Reform: Policy Overview	UK Governm ent	Nov-2012		Will introduce a number of measures necessary to reform the electricity market to deliver secure, clean and affordable electricity: Feed-in Tariff with Contracts-for-Difference (incentivise the deployment of low carbon generation); Capacity Market, if required, will incentivise sufficient reliable capacity (both generation and non-generation providers of capacity - such as DSR and storage); Emissions Performance Standard to provide a regulatory back stop on the amount of emissions a new fossil fuel power station can emit; introduction of a Carbon Price Floor in 2013 to help strengthen the carbon price signal to investors	http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/energy-markets/7090-electricity-market-reform-policy-overview-.pdf
National Policy Statements for Energy Infrastructure	UK Governm ent	Jul-2011		Set out national policy against which planning applications for major energy project proposals will be assessed and decided	http://www.decc.gov.uk/en/content/cms/meeting_energy/consents_planning/nps_en_infra/nps_en_infra.aspx

D. Poland

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
Polish Energy Policy until 2030	Ministry of Economy	2009	2030	The basic directions Polish Energy Policy: - improving energy efficiency, - increase security delivery of fuel and energy, - diversification of electricity generation (nuclear power), - development of renewable energy sources, including biofuels. The pursuit for a zero energy growth (without an increase in demand for primery energy). Consistent decrease in the energy intensity of the Polish economy to the EU-15.	http://www.mg.gov.pl/Bezpieczenstwo+gospodarcze/Energetyka/Polityka+energetyczna
The second National Action Plan Energy Efficiency for Polish 2011	Ministry of Economy	2012	2016	The second National Action Plan was prepared in connection with the obligation the European Commission report on the Directive on the efficiency of energy use and energy services 2006/32/EC and the Directive on the energy buildings 2010/31/EC. This document was developed on the basis of Act of 15 April 2011 (Journal of Laws No 94, item. 551) on energy efficienc. In developing the National Action Plan, the following assumptions: - the proposed actions will be based as much as possible mechanisms market and use minimal budget financing, - implementation of the objectives will be achieved according to the principle, ie including through maximum use of the existing mechanisms and infrastructure organizational, - assumes the participation of all stakeholders in order to use the national energy efficiency potential.	http://www.mg.gov.pl/node/15923

Polish Nuclear Power Program	Ministry of Economy Polish Government Plenipotentiary for Nuclear Energy	2010	2030	Document included for example: Objectives and schedule Polish Nuclear Energy Programme, Nuclear power in the context of long-term energy policy, Cost analysis and economic justification for the development of nuclear energy, Providing conditions for the safe use of nuclear energy, The costs of implementation and funding of the Programme Polish Nuclear Energy, The choice of location, Public consultation and the process of informing the public the preparation and implementation of the PEJ.	http://bip.mg.gov.pl/files/upload/12331/20101216_PEJ_KRM_wer_2.pdf
Update forecasts of demand fuel and energy by 2030	Author - Energy Market Agency for Ministry of Economy	2011	2030	The document contain: - forecast of final demand for electricity and heating according to economic development forecasts published by the Ministry of Finance, - projection costs of electricity generation and electricity prices on wholesale market for an updated forecast of the structure of energy sources, - forecast CO2 emission from electricity generation	http://www.mg.gov.pl/files/upload/11099/ARE%20MG_2011_Raport_koncowy_01_09_2011.pdf

E. France

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
Rapport Energies 2050	Ministry of Economy, Finance & Industry	2012	2050	Analysis of different scenarios for energy policy in France	http://www.strategie.gouv.fr/content/rapport-energies-2050
Trajectoires 2020 - 2050 vers une économie sobre en carbone	Centre d'Analyse Stratégique	2012	2050	Analysis of necessary conditions to aim at a carbon-free economy in 2050 in the best economic and social conditions	http://www.strategie.gouv.fr/content/trajectoires-2020-2050-vers-une-economie-sobre-en-carbone-rapport
Scénario NégaWatt 2011	NégaWatt	2011	2050	A scenario for energy transition with a very high level of voluntarism	http://www.negawatt.org/scenario-negawatt-2011-p46.html

Diviser par quatre les rejets de CO2 dus à l'énergie : le scénario Negatep	Sauvons le climat *(pro-nuclear environmental association)*	2012	2050	A scenario aiming at a four-fold reduction in the use of fossil fuels	http://www.sauvonsleclimat.org/best-of-slchtml/diviser-par-quatre-les-rejets-de-co2-dus-a-lenergie-le-scenario-negatep/35-fparticles/465-diviser-par-quatre-les-rejets-de-co2-dus-a-lenergie-le-scenario-negatep.html
Generation Adequacy Report 2012	RTE	2012	2030	Prospective analysis on long-term supply-demand scenarios. These scenarios are used by RTE for studies conducted on the safety of the electricity system and on the upgrades and development of the transmission network	http://www.rte-france.com/en/news-cases/news/generation-adequacy-report-2012-security-of-supply-should-be-guaranteed-through-2015

F. Germany

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global	Deutsche Energie Agentur	2012	2050	development of energy consumption, heat consumption and transport sector in Germany in due consideration of the development of Europe/global, energy storage (hydrogen and methane) and development of RES	http://www.erneuerbare-energien.de/fileadmin/ee-import/files/pdfs/allgemein/application/pdf/leitstudie2011_bf.pdf
National grid development plan 2013	German TSOs	2013	2023, 2033	Grid development, development of RES and conventional power plant fleet	http://www.netzentwicklungsplan.de/content/netzentwicklungsplan-2013-erster-entwurf
dena-Netzstudie II –	Deutsche	2010	2015, 2020,	development of RES, grid development	http://www.dena.de/projekte/erneuerbare/dena-

Integration erneuerbarer Energien in die deutsche Stromversorgung im Zeitraum 2015 – 2020 mit Ausblick 2025	Energie Agentur		2025		netzstudie-ii.html
Energiekonzept 2050	fvee	2010	2050	Energy efficiency, Energy system based on RES in 2050	http://www.fvee.de/fileadmin/politik/10.06.vision_fuer_nachhaltiges_energiekonzept.pdf

G. Greece

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
LONG-TERM ENERGY PLANNING (ΜΑΚΡΟΧΡΟΝΙΟΣ ΕΝΕΡΓΕΙΑΚΟΣ ΣΧΕΔΙΑΣΜΟΣ)	Council of National energy Strategy/Min. of Development	2009	2030 and beyond	Strategic horizon for Long-term Planning	http://www.sees.gov.gr/images/stories/pdfs/mes-2009.pdf
NATIONAL RENEWABLE ENERGY ACTION PLAN IN THE SCOPE OF DIRECTIVE 2009/28/EC	Min. of Env., Energy and Cl. Change	2010	2020	RES targets in Greece for year 2020	http://www.ypeka.gr/LinkClick.aspx?fileticket=CEYdUkQ719k%3D&tabid=37
2nd NATIONAL PLAN FOR ENERGY EFFICIENCY (2ο ΕΘΝΙΚΟ ΣΧΕΔΙΟ	Min. of Env., Energy and Cl. Change	2011	2016	Under the frame of Directive 2006/32/EC	http://www.opengov.gr/minenv/wp-content/uploads/downloads/2011/09/2o_SDEA.pdf

ΔΡΑΣΗΣ ΕΝΕΡΓΕΙΑΚΗΣ ΑΠΟΔΟΣΗΣ)					
Draft 10-year plan for Transmission System Development	IPTO	2012 (draft)	2023	Plan for the expansion and development of the Transmission System	http://www.admie.gr/diaboyleyseis/diaboyleysi/article/913/

Scope	**web link to the study**
Strategic horizon for Long-term Planning	http://www.sees.gov.gr/images/stories/pdfs/mes-2009.pdf
RES targets in Greece for year 2020	http://www.ypeka.gr/LinkClick.aspx?fileticket=CEYdUkQ719k%3D&tabid=37
Under the frame of Directive 2006/32/EC	http://www.opengov.gr/minenv/wp-content/uploads/downloads/2011/09/2o_SDEA.pdf
Plan for the expansion and development of the Transmission System	http://www.admie.gr/diaboyleyseis/diaboyleysi/article/913/

H. Italy

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
Development Transmission Plan		yes	>2020	Development Plan for Transmission grid	http://www.terna.it/default/Home/SISTEMA_ELETTRICO/piano_sviluppo_rete/pds_2012.aspx
Previsioni della domanda elettrica in Italia e del fabbisogno di potenza necessario. Anni 2012 - 2022		yes	2012-2022	Provisional demad	http://www.terna.it/default/Home/SISTEMA_ELETTRICO/statistiche/previsioni_domanda_elettrica.aspx
National Action Plan for renewable energy in Italy		yes	2020	RES targe in Italy	http://approfondimenti.gse.it/approfondimenti/Simeri/AreaDocumentale/Documenti%20Piano%20di%20Azione%20Nazionale/PAN%20DETTAGLIO.pdf
Italian National Action Plan for energy Efficiency		yes	2020	EnergyEfficency target	http://www.efficienzaenergetica.enea.it/doc/paee2011/paee2011luglio.pdf and http://www.gse.it/it/Conto%20Termico/GSE_Documenti/_DM_28_DICEMBRE_2012_CONTO_TERMICO.PDF

I. Switzerland

Name of the study	Origin	Published	Time horizon	Scope	web link to the study	Comment
Wege in die Stromzukunft - 'pathways to a new electricity future'	VSE	2012	2050	Analysis (without recommendations) of 3 different energy pathways going to 2050. Paths from 'improved BAU' with moderate RES promotion to a fundamental change in socities perception and usage of energy along with a strong promotion of RES	http://www.strom.ch/uploads/media/VSE_Wege-Stromzukunft_Kurzbericht_2012.pdf	This report is very much politically motivated, and based on the notion of nuclear phase-out and the resulting electricity supply gap.

Energy strategy and perspectives 2050	BFE	2012	2050	More than a dozen reports including documents on hydropower potential, grid extensions and environmental and economic analysees of the measures and consequences envisioned in the energy strategy 2050. Documents in German, some also in French.	http://www.bfe.admin.ch/themen/00526/00527/index.html?lang=de&dossier_id=05673	These reports are the main sources of information for the previous page, and foresee a future RES/CCGT strategy. It is important to state, that while this is the position of the federal office of energy, and thus the executive at this time, the parliament has not yet approved the corresponding regulations and discussions and negotiations are ongoing.
Energiezukunft Schweiz - 'Energy future Switzerland	ETH Zurich	2011	2050	Analysis of available options for a sustainable energy system going towards 2050.	http://www.cces.ethz.ch/energiegespraech/Energiezukunft_Schweiz_20111115.pdf	
Zukunft Stromversorgung Schweiz - 'Future electricity supply Switzerland'	Swiss Academies of Arts and Sciences	2012	2050	Analysis of mid (2020 and 2035) to longterm (2050) developments in the electricity and adjacent sectors (e.g. e-mobility).	www.akademien-schweiz.ch/dms/D/Publikationen/Berichte/Zukunft_Stromversorgung_Langfassung.pdf	

J. CzechRepublic

Origin	Published	Time horizon	Scope	web link to the study
Ministry of Industry and Trade	August 2012	2040	Update of Czech Energy Policy (governmental proposal)	http://www.mpo.cz/dokument108147.html
Ministry of Industry and Trade	March 10. 2004	2030	Czech Energy Policy	http://download.mpo.cz/get/26650/46323/556503/priloha003.doc

WORLD ENERGY CONGRESS			World Energy Policy	http://www.wec.cz/en/03_documents.html
Ministry of Industry and Trade	July 2012	2050	Raw Material Policy of CzechRepublic	http://www.mpo.cz/dokument106134.html
Energy Regulatory Office	2012	2011	Annual Data Summary of Electric Power System	http://www.eru.cz/user_data/files/statistika_elektro/english/2011/Report_2011.pdf

K. Denmark

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
This webpage contains links to a collection of scenarios					http://www.ea-energianalyse.dk/themes/105_theme_energy_scenarios.html
Scenarios developed in Energinet.dk (unfortunately only in danish)					http://www.energinet.dk/DA/El/Udvikling-af-elsystemet/Sider/Scenarier.aspx

L. Norway

Name of the study	Origin	Published	Time horizon	Scope
Nettmeldingen	OED	2012		National grid development
Energiutredningen	OED	2012		Long term framework for enegy policy

M. FYR Macedonia

Name of the study	Origin	Published	Time horizon	Scope	web link to the study
Macedonian transmission Development Study 2010-2020 with vision for 2030		Approved bt Regulatory Commission	2010-2030		http://www.mepso.com.mk//CMS99/Content_Data/Dokumenti/%D0%90%D1%80%D1%85%D0%B8%D0%B2%D0%B0/%D0%90%D1%80%D1%85%D0%B8%D0%B2%D0%B0%20%D0%B7%D0%B0%20%D1%81%D1%82%D1%83%D0%B4%D0%B8%D0%B8/studija%202011.pdf.pdf
Energy Development strategy in the Republic of Macedonia until 2030		Adopted in April 2010	2010-2030	The main objective of the Strategy for energy development is to define the most favorable long term development of the energy sector in the Republic of Macedonia with a view of providing a reliable and good quality energy supply to the consumers.	
Strategy for utilization of RES in the Republic of Macedonia until 2020		Adopted in September 2010	2010-2020	The main objective of the RES Strategy is to provide information on the potential and possible exploitation of renewable energy sources in the FYR of Macedonia. Quantification of such knowledge shall be made by determining the following: target share in total energy (RES target), which is share of energy generated from RES in the total energy consumption; manner and dynamics of attaining RES target and RES electricity target	

Strategy for improvement of the Energy efficiency in the Republic of Macedonia until 2020		Adopted in September 2010	2010-2020	The objective of the Strategy for improvement of the energy efficiency in the FYR of Macedonia until 2020 (SIEE) is to develop a framework for accelerating adoption of energy efficiency practices in a sustainable fashion through implementation of a series of programs and initiatives that are linked to creating reduction of import dependence, energy intensity, the non-productive use of electricity, preparing a good climate to maximize the involvement of and opportunities for the private sector complementary advocacy, and training activities. SIEE defines priorities related to the national goals for security of energy supply, sustainable economic development and competitively of the economy. SIEE identifies the potential for rational energy savings in order to meet the target of at least 9% energy savings until 2018.	
Fisrt Energy Efficiency Action Plan of Republic of Macedonia until 2018		Adopted in April 2011	2010-2018	To develop and implement energy efficiency measures to achieve national indicative energy savings target	

N. Romania

Name of the study	Origin	Published	Time horizon	Scope
National Action Plan for Energy Efficiency		http://www.minind.ro/energie/PNAEE_var_finala.pdf	2016 -extended to 2020	promotion of energy efficiency in all sectors

National Action Plan on Renewable Energy		http://www.minind.ro/energie/PNAER_final.pdf	2020	achieve EU target for EU "20-20-20" mentioned in Package Strategic "Energy - Climate Change", which was approved in the European Council and adopted by the European Parliament in December 2008, concerning integration of renewable energy in the national energy system structure; ensure energy independence of the national economy; Romanian participation in the European market for green certificates for RES
Romania's Energy Strategy for the period 2007 - 2020, approved by Government Decision 1069/2007		http://www.minind.ro/energie/strategia_energetica_a_romaniei_2007_2020.pdf	2020	achieve fundamental objectives of EU energy policy: sustainability, competitiveness and security in energy supply
Study on the development directions of the National Grid in Romania for the period 2011-2035 as part of the national energy strategy		document currently under public consultation	2035	achieve fundamental objectives of EU energy policy: sustainability, competitiveness and security in energy supply

O. Spain

Name of the study	Origin	Published	Time horizon	Scope
National Action Plan	2010	www.idae.es	2011-2020	Analysis of saving and efficiency measures in all sectors
Renewable Energy Plan (PER)	2010	www.idae.es	2011-2020	Planning of renewable power by 2020 to achieve the objectives

Prospective Study of Energy Consumption in the water sector	July2010	www.idae.es		The study analyzesthe interdependencebetween waterand energyin our countryand the rolethat scienceand technology canplay in reducingthe energy consumed inthewater cycle
Project-SPAHOUSEC SECH. Analysisof energy consumptionin the residential sectorin Spain.	2010	www.idae.es		SPAHOUSECThe project, conducted byIDEA, hasallowed us to analyzethe energy consumptionofmore than 17million households inSpain
TechnologicalMap ofsmart cities	2012	www.idae.es	2020	Itaims toidentify the keytechnologies that are partof thesmart cities, determining what are the barriersand needsfor future implementationin urbanSpanish
Technological Map: heat and cold Renewable Solar Power, Geothermal and Biomass	2012	www.diae.es		In this map are developed technological aspects such as: the state pf art of the main technologies for applications of renewable heat and cold: initiatives and institutions (mainly public) most relevant to contribute to the development of the sector in Europe; forecasts and projections of future expected market; current barriers facing the sector; innovative projects focused mainly in our country.
Map of electric mobilitytechnology.	2012	www.idae.es		Analysis of sustainable mobility in order to mitigate the negative effects due to the widespread use of private vehicles for transportation

Annex 2 – OTHER SCENARIO STUDIES

This Annex summarizes key findings from scenario studies that do not fit into the suggested review structure in Chapter 4.

Name: ENCOURAGE (Energy Corridors), project under EU's 6th framework program
Responsible organization:
Status: Finalized 2007

Short description:

The ENCOURAGED (Energy corridor optimisation for European markets of gas, electricity and hydrogen) project identified and assessed the economically optimal energy corridors between European Union (EU) and neighbouring countries. The objectives of the project were to:

• Assess the economic optimal energy (electricity, gas and hydrogen) corridors and related network infrastructure for connecting the EU with its neighbouring countries and regions.

• Identify, quantify and evaluate the barriers to and potential benefits of building optimal energy corridors connecting the EU with its neighbours.

• Propose necessary policy measures to implement the recommended energy corridors with a focus on investment and the geopolitical framework.

Main relevance for eHighway2050:
Analysis of need for electricity corridors and capacity between European Union and neighbouring countries up to 2030. The following "main EU borders" were analysed: South border with North Africa, South East border with Turkey, East border with IPS/UPS.
Further information:
http://ec.europa.eu/research/energy/pdf/energy_corridors_en.pdf

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Name Medgrid
Responsible organization: Medgrid
Status: On-going project

Short description:
Medgrid is a project which aims to promote and develop a Euro-Mediterranean electricity network that would provide North Africa & Europe with renewable electricity, mostly from solar. The goal is to install 20GW of generating capacity, with 5GW being devoted for exports to Europe. The Medgrid project was envisioned by a consortium of twenty plus utilities, grid operators, equipment makers, financing institutions and investors, mostly European. The plan is to build five interconnections at a cost of around 5 billion euros ($6.7 billion), including between Tunisia and Italy.

Main relevance for eHighway2050:
The plan is to build five interconnections at a cost of around 5 billion euros ($6.7 billion), including between Tunisia and Italy. The long term goal is to meet about 15% of Europe's electricity demand in 2050.

Further information: www.medgrid-psm.com/en/

Name: OffshoreGrid
Responsible organization: 3E (coordinator)
Status: Finalized in 2011

Short description:
OffshoreGrid was a techno-economic study within the Intelligent Energy Europe program. It developed a scientifically based view on an offshore grid in Northern Europe along with a suited regulatory framework considering technical, economic, policy and regulatory aspects. The project was targeted for European policy makers, industry, transmission system operators and regulators. The geographical scope was the regions around the Baltic and North Sea, the English Channel and the Irish Sea. Several of the results were of general character and could be applied to other regions as well.

Main relevance for eHighway2050:
When considering cross border connections, offshore grid development should be a joint or coordinated activity between the developers of the wind farms, their hub connections and transmission system operators.
There are different concepts for connecting wind farm:

- Directly to shore
- Wind farm hubs: the joint connection of various wind farms in close proximity to each other, thus forming only one transmission line to shore.
- Tee-in connections: the connection of a wind farm or a wind farm hub to a pre-existing or planned transmission line or interconnector between countries, rather than directly to shore
- Hub-to-hub connection: the interconnectors of several wind farms hubs, may create transmission corridors between various countries.

When developing international interconnection cables, the possibility of hub-to-hub solutions should be investigated, particularly when there are or could be in the future large wind farms hubs in each country far from shore but close to each other.

Further information: http://www.offshoregrid.eu/

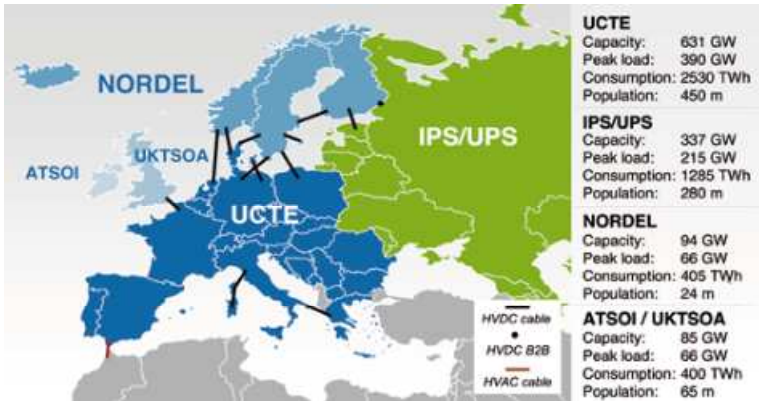
Name: UCTE-IPS
Responsible organization:
Status: Feasibility study delivered in 2008

Short description:
The Union of Co-ordination of Transmission of Electricity (UCTE) and the EPC CIS's Commission on Operational and Technological Coordination (COTC) launched in 2008 a detailed feasibility study on the synchronous interconnection of the power systems of the CIS (Commonwealth of Independent States) countries and the Baltic States (IPS/UPS) to the power systems of UCTE.

The Feasibility Study was designed to answer three major questions:

- Is a synchronous interconnection of the IPS/UPS and the UCTE possible?
- What measures have to be taken in both systems?
- What are the associated costs?

The Feasibility Study points out that even if a synchronous coupling appears viable, it must be considered as a long-term option. The results underline the overall complexity of a synchronous coupling first in the context of system security and overall reliability but also from the point of view of operability of the underlying electricity markets. Additionally, the study considers the evidence of non-synchronous system coupling possibilities by high voltage direct current (HVDC) technology, e.g. by back-to-back links. This worldwide used technique in large transmission systems may result beside its technical and economic advantages in a more cost-effective and thus "easier to realise" perspective for merging the electricity systems.



Synchronous systems in Europe (Source: "Feasibility Study: Synchronous Interconnection of the IPS/UPS with the UCTE")

Main relevance for eHighway2050:
Non-synchronous system coupling possibilities by high voltage direct current (HVDC) technology, e.g. by back-to-back links could be a preferred solution for coupling between the IPS/UPS and the UCTE power system due to the technical and economic advantages.

The transfer capacities across the interface in the steady state analyses indicated that the potential power exchanges between the UCTE and the IPS/UPS are limited. This is mainly due to the internal congestions in the systems concerned. Therefore, a synchronous

coupling would require investments in the transmission grids on both sides of the interface in order to maintain the transfer capacities available to the present markets in the two synchronous areas.

Further information: www.ucte-ipsups.org

Name: ICOEUR – Intelligent coordination of operation and Emergency Control of EU and Russian power grids, project under EUs 7th Framework program
Responsible organization:
Status: Ongoing project (2012)

Short description:
Consideration is given to different scenarios of joint operation of UCTE and NORDEL with power grids on the territory of the former USSR.

Bulk power grids may encounter major blackouts, which originate in increasing complication in monitoring, operation and control of interconnected power grids as well as in limited knowledge of the total system state. Therefore the possible future interconnection between the European and Russian electricity transmission systems requires elaborating methods for monitoring, control and protection of large scale systems and especially for the support of their interconnections. The development and prototypically implementation of these new methods and tools is the major goal of the ICOEUR project. New technologies like Wide Area Monitoring, Control and Protection as well as advanced network controllers (FACTS) and HVDC systems are considered.

The ICOEUR consortium involves leading experts with extensive knowledge of EU and Russian power systems as well as manufacturers and network operators and guarantees efficient collaboration and knowledge required for testing the methodologies developed. The joint development of innovative monitoring, simulation and control concepts, tools and equipment through international diversified ICOEUR consortium and their prototype implementation will promote their adoptions.

Extension of cross-border trade needs an adaptation of market rules, technical standards and market structures. A number of issues depending on the different possible scenarios are addressed in order to realise a market integration. Possible scenarios are:

Scenario 1. Companies in RF and the EU Member States deliver electricity to one another under bilateral mid- and long-term contracts.

Scenario 2. Russian Companies participate in the day-ahead markets in the EU Member States. Companies of the EU Member States participate in the Russian dayahead and capacity markets.

Scenario 3. Creation of a common electricity market in RF and some EU Member States.

Main relevance for eHighway2050:
Synchronous interconnection between ENTSO-E RG CE and IPS/UPS systems seems to be viable but should be considered as a long-term option due to its complexity concerning not only system security and overall reliability but also its operability in electricity market. Asynchronous interconnection should be taken into account in order to achieve a mid-term solution for a joint system/market. However, considering the higher investments needed for an asynchronous interconnection, it is essential to quantitatively assess the benefits deriving from such project. Investments in the transmission grids of both areas (ENTSO-E RG CE & IPS/UPS) have to be thought over to remove internal bottlenecks that could limit the potential power exchanges across interface lines.

Further information: http://www.icoeur.eu/

Name: Windspeed, Intelligent Energy Europe project
Responsible organization: ECN (Coordinator)
Status: Finalized in 2011

Short description:
Competing uses of the sea, costs, grid integration and other barriers are important challenges to the development of offshore wind. Windspeed aims to assist in overcoming these obstacles by offering a roadmap defining a realistic target and a development pathway up to 2030 or offshore wind energy in the Central and Southern North Sea (Belgium, Denmark, Germany, the Netherlands, Norway and the UK). The roadmap also identifies barriers and potential surplus conditions in the North-European electricity grid along with policy recommendations on how to tackle these.

Windspeed also delivers a decision support system (DSS) tool using geographical information system (GIS) software. The DSS tool produces overlaying maps, showing spatial representation of offshore wind energy potentials in relation to non-wind seas functions and environmental aspects.

Main relevance for eHighway2050:
The WINDSPEED project concludes that a capacity of 135 GW of OWE (Offshore Wind Energy) in the Central and Southern North Sea is feasible by 2030. The NREAPs includes around 32 GW for the six North Sea countries in 2020 (this also includes developments in additional sea basins).To achieve 135 GW OWE in 2030 coordinated North Sea Policies between involved nations including among other spatial planning with integration of OWE, incorporating near shore and further from shore developments and offshore grid implemented is necessary.

Technology advancement related to floating/deep-water installations available at acceptable cost is a prerequisite.

TSOs/ENTSO-E need to take a leading role related to:

Grid Configuration
Construction of T-connections and upgrades into multi term VSC HVDC solutions
Coordination between link developers (typically TSOs) and wind farm developers at early stages of the development
Planning for transnational clustering & transnational coordinated development of grid infrastructure projects to allow for flexible and harmonized technical standards
Pilot schemes to test possible solutions with a view to establishing long term changes in the regulatory framework for establishing an offshore grid

Research and Development
Standardized and scalable solutions combining HVAC, LCC HVDC and VSC HVDC

Further information: www.windspeed.eu

Name: TWENTIES, FP7 project
Responsible organization: REE (Coordinator)
Status: To be finalized in 2013

Short description:
A group of 6 Transmission System Operators (Belgium, Denmark, France, Germany, The Netherlands and Spain) with 2 generator companies, 5 manufacturers and research organisations, propose 6 demonstration projects to remove, in 3 years, several barriers which prevent the electric system from welcoming more wind electricity, and wind electricity from contributing more to the electric system.

The full scale demonstrations aim at proving the benefits of novel technologies (most of them available from manufacturers) coupled with innovative system management approaches. The contribution of wind energy to the system will show how aggregated wind farms can provide system services (voltage and frequency control) in Spain. The aggregation of wind farms with flexible generation and loads will be demonstrated in Denmark using a scalable IT platform developed by a generator. Increasing the flexibility of transmission networks will be tested in Belgium (existing sensors and coordinated power flow control devices avoiding possible large scale instabilities induced by wind farms in the CWE region) and in Spain (dynamic wind power evacuation capacity using real-time computations based on short-term generation forecasts and use of a mobile Overload Line Controller). Off-shore wind farms are addressed from a security viewpoint. Secure HVDC meshed networks will be validated in France using simulations and full scale experiments of two different HVDC circuit breaker technologies. Off-shore wind farm shut downs under stormy conditions will be demonstrated in Denmark using the world largest off-shore wind farm with balancing power provided by the Norwegian hydro capacities through a HVDC link. The experimental results will be integrated into European impact analyses to show the scalability of the solutions: routes for replication will be provided with benefits for the pan European transmission

network and the European electricity market as soon as 2014, in line with the SET plan objectives.

Main relevance for eHighway2050:
The TWENTIES project performs 6 demonstration projects to evaluate the contributions from intermittent generation and flexible load to system services and flexibility of the transmission grid. This could be important input to the technology assessment and grid analyses of e-Highway2050. The project does not perform scenario studies or analyses of future grid development.

Further information: http://www.twenties-project.eu/node/1

Name: Eureopean Wind Integration Study (EWIS), FP6 project
Responsible organization: Transpower (Coordinator)
Status: Finalized 2010

Short description:
The EWIS project was initiated by TSOs with the objective of ensuring the most effective intergration of large scale wind generation into Europe's transmission networks and electricity system. The challenges addressed include:

- How to efficiently accomodate wind generation when markets and transmission access arrangements have evolved beyond the needs of traditional controllable generation.
- How to ensure that supplies remain secure as wind varies (including required backup/reserves for low wind days and wind forecast errors as well as managing network congestion in windy conditions).
- How to maintain the quality and reliability of supplies given the new generation characteristics.
- How to achieve efficient network costs by suitable design and operation of network connections, the deeper infrastructure including offshore connections, and cross-border interconnections.

Main relevance for eHighway2050:
EWIS focused on the immediate network related challenges by analysing detailed representations of the existing electricity markets, network operations and the physical power flows and other system behaviours. The starting point was actual conditions in 2008, and 2015 was chosed as a suitable horizon for assessing how current plans will address future challenges. EWIS did not perform scenario studies or analyses of future grid development towards 2050, but could be relevant input to the technology assessment and grid analyses of e-Highway2050.

Further information: http://www.wind-integration.eu/

Name: Feature of an electricity supply system based on variable input
Responsible organization: Max-Planck-Institut für Plasmaphysik (Report IPP 18/1)
Status: 2012

Short description:
The report analyses major features of electricity production being based predominantly on variable wind onshore and offshore and on photovoltaic (PV) generation. Actual data are taken from the German demand and supply situation in 2010. On this basis, the generation capacities are scaled to higher installed powers. The main purpose of the work is to show characteristic trends and the mostly system oriented consequences of large-scale wind and PV use with fluctuating input.

Main relevance for eHighway2050:
The work is not directly relevant for the scenario studies, but could be relevant input to the following technology assessment and grid analyses of e-Highway2050.

Further information: http://edoc.mpg.de/get.epl?fid=100920&did=618631&ver=0

Annex 3 – REVIEW OF RELEVANT SCENARIO STUDIES

Table A3.1. Global Scenarios – General

Title of the Study	Origin	Industry	Published	Time horizon	Scope	Category	Approach	Modell (if any)	Number of scenarios	Other / Comments
BP Energy Outlook 2030	BP	Petroleum	2011	2030	World	Predictive	Qualitative	NA	1	Build on "based on our knowledge" approach. Update for 2012 available
Energy [R] evolution	Greenpeace	NGO	2012	2050	World	Anticipative	Quantitative	MESAP/PlaNet (supply scenarios)	2	Consistent fundamental pathway for how to protect our climate: getting the world from where we are now to where we need to be by phasing out fossil fuels and cutting CO2 emissions while ensuring energy security.
IEA ETP 2012	IEA	Generic Energy	2012	2050	World	Anticipative	Combination	ETP model	3	
IEA World Energy Outlook	IEA	Generic Energy	2011	2035	World	Mixture	Quantitative	IEA's World Energy Modell (WEM)	3	Two explorative and one anticipative scenarios, plus several case studies. Updated version in 2012.
Shell Energy Scenarios 2050	Shell	Petroleum	2008	2050	World	Explorative	Qualitative	NA	2	The Scramble scenrario focuses on national energy security

Table A3.2. Global Scenarios - Assumptions

Title of the Study	Scenario title	Economic Growth	Political/Socio-political /Government Policies	RTD and Technology	Demographics	Oil Prices	Gas Prices	Coal prices	CO2 Prices	Comments
BP Energy Outlook 2030	2030	Rapid growth of low and medium income economies.	Implementation of carbon abatement policies in OECD. The policies support rapid growth of non-fossil power generation, especially renewables.		World: 8 billion in 2030	NA				Slow changes of the energy mix due to long asset lifetime
Energy [R] evolution	Reference	World GDP is assumed to grow on average by 3.8% per year over the period 2009-2030 and then by 2,2% until 2050. GDP in OECD Europe is assumed to grow by around 1.6 and 1.3% per year over the projection period.	The Reference scenario does not include additional policies to reduce greenhouse gas emissions.	The remaining production capacities with an annual production decline between 2.5% and 5% and the additional production capacities assuming all new projects planned for 2012 to 2020 will go ahead.	World: 0.76 % average growth over the period 2007 to 2050, to 9.469 billion by 2050 (from 1.1% per year during 2009-2020 to 0.5% per year during 2040-2050). OECD Europe : 600 millions in 2050	152 $ 2010 / barrel	US : 24,04 $ 2010/GJ Europe : 26,37 $ 2010/GJ Japan LNG: 29,77 $ 2010/GJ	206,3 $ 2010/tonne	75 $ 2010/tCO2	The Reference sce?rio and the Energy [R]evolution sce?rio are based on the same projections of population and economic development.
Energy [R] evolution	Energy [R]evolution	Same as above	The Energy [R]evolution scenario has a key target to reduce worldwide carbon dioxide emissions from energy use down to a level of below 4 Gigatonnes per year by 2050 in order to hold the increase in global temperature under +2°C. A second objective is the global phasing out of nuclear energy.	Same as above	Same as above	Same as above	Same as above	Same as above		
IEA ETP 2012					Population projection EU (numbers in million): 2010:500, 2020: 511, 2030: 516, 2040: 515, 2050: 512				130-150 USD/tCO2	

Title of the Study	Scenario title	Economic Growth	Political/Socio-political /Government Policies	RTD and Technology	Demographics	Oil Prices	Gas Prices	Coal prices	CO2 Prices	Comments
IEA World Energy Outlook	New Policies	World: average 3.6%; EU: average 2%	Recent commitments and plans, not necessarily adopted and implemented, including EU: ETS covering power, industry and aviation; new LCV standards,	Normal, Nothing new	World: 26% or 8.6 billion in 2035. OECD 0.4% pr year	Growing 120 USD/barrel in 2035	EU: 12.1 USD/Btu in 2035	110 USD/Tonne in 2035	45 USD/Tonne in 2035	
IEA World Energy Outlook	Current Policies	World: average 3.6%; EU: average 2%	Policies enacted by mid-2011, remain unchanged: including EU: ETS covering power, industry and aviation; Energy Performance of Buildings Directive, emission standards for PLDVs , 20% reduction in emissions by 2020 and 20 % renewables to reach share in energy demand	Slow, Nothing new	World: 26% or 8.6 billion in 2035. OECD 0.4% pr year	Growing 135 USD/barrel in 2035	EU: 13.0 USD/Btu in 2035	118.4 USD/Tonne in 2035	45 USD/Tonne in 2035	
IEA World Energy Outlook	450	World: average 3.6%; EU: average 2%	Outcome-driven scenario: energy pathway that is consistent with a 50% chance of meeting the goal of limiting the increase in average global temperature to 2° including 30 % reduction of emissions by 2020, ETS strengthened in line with 2050 roadmap	Fast, Nothing new	World: 26% or 8.6 billion in 2035. OECD 0.4% pr year	Stable 97 USD/barrel in 2035	EU: 9.4 USD/Btu in 2035	67.7 USD/Tonne in 2035	120 USD/Tonne in 2035	
Shell Energy Scenarios 2050	Scramble	Strong economic growth	The energy policies are segmented and dominated by national energy security concerns. Competition between national governments for favourable terms of energy supply.		World: 40 % or 9 billion in 2050	Volatile prices	Volatile prices	Volatile prices		
Shell Energy Scenarios 2050	Blueprints	NA	International harmonised framework for carbon-trading, addressing for climate change mitigation. Fuel efficiency requirements in USA (carbons assessment, CAFE, taxes on less efficient vehicles). Stricter CO2 emission allowances in EU	Development of innovative solutions and adoption of proven practices. Surge of electric transport.	World: 40 % or 9 billion in 2050	OPEC rises oil production to maintain low prices and defer development of substitutes.				

Table A3.3 Global Scenarios - Results

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe	Coal, Mtoe	Oil, Mtoe	Gas, Mtoe	Nuclear, Mtoe	Hydro, Mtoe	Biomass, Waste, Mtoe	Solar, Wind and Other Renewables, Mtoe	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concentration, ppm	Required Policy actions	Required Financial Actions	Comments
BP Energy Outlook 2030	2030	World	2030	16 604	4 609	4 719	4 300	1 006	1 137	NA	860	37	37,0	>450	Policies slowing down oil consumption in China. Energy policies are driven by security of supply and climate change concerns.	OPEC investment in new production capacities	The scenario uses term "liquids" which includes both crude oil and biofuels
Energy [R] evolution	Reference	World	2050	World : Increases by 61% from about 11942 Mtoe/yr in 2009 to 19251 Mtoe/yr in 2050. OECD Europe : Increases by 9% from the current 1796 Mtoe/yr to 1960 Mtoe/yr in 2050.		5373						46					
Energy [R] evolution	Energy [R]evolution	World	2050	World : Increases by 10% compared to current consumption until 2020 and decreases slightly afterwards to 2009 levels. The overall primary energy demand will be reduced by 40% in 2050 compared to the Reference scenario. OECD Europe : Decreases by 36% by 2050 compared to current consumption and it is expected by 2050 to reach 1142 Mtoe/yr.		1236						44			1. Phase out all subsidies for fossil fuels and nuclear energy. 2. Internalise the external (social and environmental) costs of energy production through 'cap and trade' emissions trading. 3. Mandate strict efficiency standards for all energy consuming appliances, buildings and vehicules. 4. Establish legally binding targets for renewable energy and combined heat and power generation. 5. Reform the elctricity markets by guaranteeing priority access to the grid for renewble power generators. 6. Provide defined and stable returns for investors, for example by feed-in tariff programmes. 7. Implement better labelling and disclosure mechanisms to provide more environmental product information. 8. Increase research and developement budgets for renewable energy and energy efficiency. The European Commission published a survey in Dec 2005 which concluded that feed-in tariffs are by far the most efficient and successful mechanism (same conclusion in March 2010 at the IEA Renewable Energy Workshop by the Fraunhofer Institute and in 2006 by the Stern Review on the Economics of Climate Change). Concept conceived by Greenpeace: the Feed-in Tariff Support Mechanism (FTSM).		

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe	Coal, Mtoe	Oil, Mtoe	Gas, Mtoe	Nuclear, Mtoe	Hydro, Mtoe	Biomass, Waste, Mtoe	Solar, Wind and Other Renewables, Mtoe	Power Generation, thousands TWh	Energy-related CO2 Emissions, Gt/a	CO2 Concentration, ppm	Required Policy actions	Required Financial Actions	Comments
IEA ETP 2012		World	2050								EU:RES covers 2/3 of the production in 2050 with wind having a share of 30%	EU 2050: appr 4100 TWh/y					
IEA World Energy Outlook	New Policies	World	2009-2035	16961	4101	4645	3928	1212	475	1911	690	Europe 2035 (in WEO 2012) 3938 TWh/y	36,4				
IEA World Energy Outlook	Current Policies	World	2009-2035	18302	5419	4992	4206	1054	442	1107	481	Europe 2035 (in WEO 2012) 4247 TWh/y	43,3				
IEA World Energy Outlook	450	World	2009-2035	14870	2316	3671	3208	1664	520	2329	161	Europe 2035 (in WEO 2012) 3676 TWh/y	21,6				
Shell Energy Scenarios 2050	Scramble	World	2000-2050	21 018	6 282	3 368	2 580	1 027	NA	3 129	4 657		NA	>550	Encouraging local coal industry by national governments. Weak attempts to moderate the consumption. By the end of the period a supply crisis will require strong actions from governments. Economic slowdown by 2020, growth restored by 2030.	Building nuclear capacity. Growth of investments into unconventional oil projects (oil sands, shale etc.).	

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe	Coal, Mtoe	Oil, Mtoe	Gas, Mtoe	Nuclear, Mtoe	Hydro, Mtoe	Biomass, Waste, Mtoe	Solar, Wind and Other Renewables, Mtoe	Power Generation, thousands TWh	Energy-related CO2 Emissions, Gt/a	CO2 Concentration, ppm	Required Policy actions	Required Financial Actions	Comments
Shell Energy Scenarios 2050	Blueprints	World	2000-2050	18367,24945	4 968	3 750	2 914	1 194	NA	1 361	4 180		app. 25	450	Synergy between national and sub-national policies (city level).	Major investments into new infrastructure leads to an early replacement of the capital stock. Massive deployment of CCS.	

Table A3.4. Global Scenarios - Trends

Title of the Study	Scenario title	Coal Trend	Oil trend	Gas Trend	Nuclear trend	Hydro Trend	CO2 Emissions trend	Comments
BP Energy Outlook 2030	2030	Growth of coal consumption is driven by China and India, but is expected to flatten by 2030.	OPECs share grows from 40 to 46% in 2030	Strong growth of gas production. Gas displaces coal in power generation.			The emissions' level will peak by 2020 and is expected to fall by 2030	Europe's energy deficit remians roughly at today's level for oil and coal, but is increasing for gas. This is matched by gas production growth in the FSU and trade.
Energy [R] evolution	Reference							
Energy [R] evolution	Energy [R]evolution	Coal PP built between 2005-2020 will be replaced by renewable energy sources by 2040			Nuclear is phased out by 2045			
IEA ETP 2012								Global scenarios. Main interest for eHighway2050 are information related to different technologies. Separate section for Europe, but limited information compared to European studies.
IEA World Energy Outlook	New Policies							
IEA World Energy Outlook	Current Policies							
IEA World Energy Outlook	450							
Shell Energy Scenarios 2050	Scramble		OPEC maintains strong prices					
Shell Energy Scenarios 2050	Blueprints							

Table A3.5. European Scenarios - General

Title of the Study	Origin	Industry	Published	Time horizon	Scope	Category	Approach	Modell (if any)	Number of scenarios	Other / Comments
EU Energy Roadmap 2050	EC	GO	2012	2050	EU27	Explorative	Combination	PROMETHEUS; USGS; PRIMES	7	1 Reference scenario, 1 Current Policies Initiative scenario and 5 "low-carbon" scenarios aiming for at least 80% reduction of CO2 emissions compared to 1990 level.
Getting in the right lane for 2050	EU27	Netherlands Environmental Assessment Agency and the Stockholm Resilience Centre	GO	2009	2050	Anticipative	Combination	NA	1	Identifies key policy junctions at which the EU will soon face strategic choices regarding long-term environment sustainability issues. Examines the EU of today, from a global perspective and looks at a long-term vision of the world of 2050. Identifies key decisions for today on global land and water resources, and low-carbon energy systems, including transport.
IRENE-40	EUs 7th framework program	NGO	2012	2050	EU27+NO, CH	Explorative	Quantitative		5	Network analysis for 3 different network technologies: HVAC, HVDC and UHVAC
Northern European Solar and Wind Intermittency Study (NEWSIS)	POYRY	Electricity	2011	2030	Northern Europe Countries	Anticipative	Combination		7	Investigating the impact of weather in the future with large amounts of weather dependent renewables (especially wind and solar).
Power choices	Eurelectric	Electricity	2010	2050	EU27	Explorative	Quantitative	PRIMES	2	
Power Perspectives 2030	ECF	NGO	2011	2030	EU27+NO, CH	Mixture	Combination		1	Power specific study related to Roadmap 2050, Models current plans up to 2020 and further projects a power mix in 2030 in line with the emission reduction trajectory for the power sector in the EC 8th March 2011 communication, 1 main scenario + 9 sensitivity scenarios
REALISEGRID	EUs 7th framework program	NGO	2010	2030	Other	Explorative	Combination	TIMES	4	The four scenarios are meant to explore to what extent and how the European energy system is going to react to different future external developments and internal policies. EU27+ Iceland, Norway, Switzerland and Western Balkan
Roadmap 2050	ECF	NGO	2010	2050	EU27+NO, CH	Anticipative	Combination	Macro-economic general equilibrium model	2	The mission of Roadmap 2050 is to provide a practical, independent and objective analysis of pathways to achieve a low-carbon economy in Europe. The model developed by Oxford Economics. WEO 350 used as baseline. 80% reduction - backcasting approach scenario.
SUSPLAN	EUs 7th framework program/SINTEF	NGO	2011	2050	Europe	Explorative	Quantitative	EMPS; Green-X, MTSIM	4	Investigates the need for transmission infrastructure for integration of large volumes of RES, both a top-down and and a bottom up approach

Table A3.6 European Scenarios - Assumptions

Title of the Study	Scenario title	Economic Growth	Political/Socio-political /Government Policies	RTD and Technology	Demographics	Oil Prices	Gas Prices	Coal prices	CO2 Prices	Comments
EU Energy Roadmap 2050	Reference	Reference : GDP is expected to rise 1,7% par annum from 2010 to 2050, and more specifically by 2,0% up to 2030 and only 1,5% pa after 2030 due to shrinking and ageing population High: 2,08% per annum from 2010 to 2050 Low: 1,39% per annum from 2010 to 2050			515 mill: higher life expectancy, low fertility, inward migration	127 USD 08/boe	98 USD 08/boe	34 USD 08/boe	€50 pr tonne	
EU Energy Roadmap 2050	Current Policy Initiatives		current policies		515 mill: higher life expectancy, low fertility, inward migration				€51 pr tonne	
EU Energy Roadmap 2050	Energy Efficiency		In addition to the "current" a set of specific policies, including climate policies, stranger RES facilitation, transport measures, guarantee funds to low-carb technologies, storage and interconnections	the available technologes bcome mature sooner than "reference", rapid development of energy efficiency technologies	515 mill: higher life expectancy, low fertility, inward migration	70 USD 08/boe	49 USD 08/boe	21 USD 08/boe	€234 pr tonne	Energy Efficiency and RES are key ingredients in all decarbonisation scenarios
EU Energy Roadmap 2050	Div. Supply Technologies		In addition to the "efficiency" a set of specific policies, including additional min requirements for appliances, high renovation rates for existing buildings, passive house standards after 2020, marked penetration of ESCOs, obligation of utilitis to achieve energy savings, higher efficiency in generation, enabling more efficienet and decentralized RES, full roll-out of smart grids and AMS, decentralised RES	the available technologes become mature sooner than "reference",	515 mill: higher life expectancy, low fertility, inward migration	70 USD 08/boe	49 USD 08/boe	21 USD 08/boe	€265 pr tonne	
EU Energy Roadmap 2050	High RES		In addition to "efficiency" a set of spesific measures including confidence in and acceptance of CCS, confidence in nuclear in safety and utilisations of wastes	the available technologes bcome mature sooner than "reference",, rapid development of RES technologies as PV and energy efficiency	515 mill: higher life expectancy, low fertility, inward migration	70 USD 08/boe	49 USD 08/boe	21 USD 08/boe	€285 pr tonne	
EU Energy Roadmap 2050	Delayed CCS	Strong economic growth	In addition to "efficiency" a set of specific measures including facilitation and enabling policies, market integartion allowing RES trade, stronger policies for generation, heating and transport, infrastacture, back-up, storage and DSM	the available technologes bcome mature sooner than "reference", delayed devlopment of CCS	515 mill: higher life expectancy, low fertility, inward migration	70 USD 08/boe	49 USD 08/boe	21 USD 08/boe	€270 pr tonne	
EU Energy Roadmap 2050	Low Nuclear		In addition to "efficiency" a set of spesific measures including political decisions related to waste and safety, confidence in CCS as a credible and viable	the available technologes bcome mature sooner than "reference",	515 mill: higher life expectancy, low fertility, inward migration	70 USD 08/boe	49 USD 08/boe	21 USD 08/boe	€310 pr tonne	

Title of the Study	Scenario title	Economic Growth	Political/Socio-political /Government Policies	RTD and Technology	Demographics	Oil Prices	Gas Prices	Coal prices	CO2 Prices	Comments
			technology							
Getting in the right lane for 2050	Vision for 2050	World : average 2,8% ; OECD : 2,2%; BRIC : 4,6%; RoW : 4% from 2005 to 2030. Rising standard of living, even while aggregate GDP growth does not reflect the strength of that rise.	Market-pull policies on the short-term to stimulate technology learning and scaling up to become competitive, including targets for minimum market shares, subsidies or feed-in tariffs for clean technologies and uniform emission targets. Distortion of the level playing field of markets prevented by taking such measures at the EU level.	A low-carbon energy system requires development and deployment of new and innovative technologies. These technologies range from batteries for cars to CCS for power plants, from small-scale urban wind turbines to concentrated solar power, and from energy-efficient appliances to off-shore wind farms. Many of these technologies have been identified and are technically available, but are not yet sufficiently mature for large-scale commercial application.	Central Europe : in many cases the population is declining, due to low fertility rate.	Use in power stations projected to decline in every region, and share of generation plunging from 7% in 2005 to 1% in 2030, due to higher prices.	Share of natural gas expected to increase from 21% in 2005 to 27% in 2030.	Worldwide, coal share in total generation increases from 46% in 2005 to 55% in 2030.		Reasoning back from the 2050 vision for each theme, the study reveals strategic actions for the EU agenda for the coming five to ten years that will be decisive in achieving long-term visions. Objective : at least 80% reduction on 1990 levels in energy-related CO2 emissions within the EU
IRENE-40	BAU									80% CO2 reduction in 2050 not achieved
IRENE-40	CCS									Substantial contribution from CCS to attain 80% goal
IRENE-40	Efficiency									Lower electricity demand than in the other scenarios
IRENE-40	RES									High contribution of RES to 80% goal. Assumptions for RES from ECF 2050 Road Map
IRENE-40	DESERTECH									Similar to RES but with import from Africa. Assumptions for RES from ECF 2050 Road Map
Northern European Solar and Wind Intermittency Study (NEWSIS)	Target Met		The unexpected effects of interconnection may be a significant barrier to deployment							
Northern European Solar and Wind Intermittency Study (NEWSIS)	Capacity Payment		The unexpected effects of interconnection may be a significant barrier to deployment							
Northern European Solar and Wind Intermittency Study (NEWSIS)	Offshore Grid		Interconnectors to Nord Pool become increasingly valuable in high wind scenarios as there is a rise in demand for hydro to balance wind generation							
Northern European Solar and Wind Intermittency Study (NEWSIS)	Flexible Demand		The unexpected effects of interconnection may be a significant barrier to deployment							There is considerable potential in the demand-side to mitigate intermittency, and it is the most effective of the measures investigated

Title of the Study	Scenario title	Economic Growth	Political/Socio-political /Government Policies	RTD and Technology	Demographics	Oil Prices	Gas Prices	Coal prices	CO2 Prices	Comments
Northern European Solar and Wind Intermittency Study (NEWSIS)	Reduced Renewables		The unexpected effects of interconnection may be a significant barrier to deployment							
Northern European Solar and Wind Intermittency Study (NEWSIS)	Reduced Renewables (low co2)		The unexpected effects of interconnection may be a significant barrier to deployment							
Northern European Solar and Wind Intermittency Study (NEWSIS)	Germany N-S Split		The unexpected effects of interconnection may be a significant barrier to deployment							
Power Choices	Baseline	Growth rate : 2 % per year between 2020 and 2025 and 1.7% per year between 2025 and 2030. For the period beyond 2030, an average growth rate of 1.55 % per year is retained for the EU27, due to the ageing population, slow-down in productivity growth and to increasing competition from emerging economies.	Assumes all existing policies are pursued		Rate of Growth per year in %: 95-00 : 0,17; 00-05 : 0,34; 05-10 : 0,41; 10-15 : 0,33; 15-20 : 0,24; 20-25 : 0,15; 25-30 : 0,08; 30-35 : 0,01; 35-40 : -0,03; 40-45 : -0,07; 45-50 : -0,14 Average from 2010 to 2050 : 0,07				€(08) 42.3 in 2050	
Power Choices	Power Choices	Same as above	Sets a 75% reduction target for GHG across the entire EU economy, no binding RES-targets are set after 2020, The price of CO2 applies uniformly to all economic sectors, so that all major emitting sectors pay for their emissions. After 2020, an international carbon market defines the CO2 price, Energy efficiency is pushed by specific policies	Plug-in and hybrid cars develop, CCS is commercial available after 2025	Same as above	127 USD/BL in 2050	16 USD/MTBU in 2050	146 USD/T	€(08) 103.2 in 2050	
Power Perspectives 2030	On Track		Full implementation of existing renewable (NREAP) and grid plans (ENTSO-E TYNDP) up to 2020. Development of a power mix towards 2030 which is in line with the EC's emission reduction objectives			Same as Roadmap 2050 and IEA WEO 2009	Same as Roadmap 2050 and IEA WEO 2009	Same as Roadmap 2050 and IEA WEO 2009	€38/ton for 2020 and €85/ton for 2030	Sensitivity analysis: Higher RES, less nuclear and CCS, less transmission, less tranmission with higher RES, less onshore transmission, less coordinated RES deployment, less reserve sharing, higher energy efficiency, higher demand response, decomissed plants as back-up, overlay grid.
REALSEGRID	Optimistic	High		High technological improvement	High population growth					Strong climate mitigation. Bounded electricity inerties
REALSEGRID	Competing	High		High technological improvement	High population growth					Strong climate mitigation. Free electricity inerties

Title of the Study	Scenario title	Economic Growth	Political/Socio-political /Government Policies	RTD and Technology	Demographics	Oil Prices	Gas Prices	Coal prices	CO2 Prices	Comments
REALSEGRID	Centric	Low		Low technological improvement	Low population growth					Strong climate mitigation. Free electricity inerties
REALSEGRID	Pessimistic	Low		Low technological improvement	Low population growth					Weak climate mitigation. Bounded electricity inerties
Roadmap 2050	Baseline	GDP growth from €10 to 20 trillion (1.8% pr year)	The current climate policies are in force and carried through, but no additional policies implemented	"current technology approach" - at late state of development or beyond	EU27: stable around 500 mill	115 USD/barrel in 2050	EU: 14.8 USD/Btu in 2050	109 USD/Tonne in 2050		The scenario is based on WEO + Oxford Economics projections to 2030 and extrapolated to 2050
Roadmap 2050	Development of 80% reduction		Power sector implements CO2-free technologies	"current technology approach" - at late state of development or beyond, Power sector implements CO2-free technologies	EU27: stable around 500 mill	115 USD/barrel in 2050	EU: 14.8 USD/Btu in 2050	109 USD/Tonne in 2050	€35 pr tonne	A significantly higher CO2 price may be required to provide incentives for new investments. Three different pathways: 40%, 60% and 80% RES. Power sector is assumed to decarbonise with at least 95%. Power demand increases with 40-45 % compared to 2005 in both scenarios. In "80% reduction" scenario energy efficiency and electrification of transport and heating sector are compensating each other.
SUSPLAN	Red		There is a strong political intent to promote sustainable development and security of supply in the energy sector. It results in the use of necessary incentives and regulations for increased deployment of RES generation technologies.	The energy system will in 2050 mainly be based on the same technlogies as in 2010		As IEA WEO 2009 Reference scenario	As IEA WEO 2009 Reference scenario	As IEA WEO 2009 Reference scenario	150 USD/t CO2 As IEA WEO 2009 Reference scenario	There are no storylines that focus on nuclear or fossil/CCS as main technology developments.
SUSPLAN	Blue		There is a strong political intent to promote sustainable development and security of supply in the energy sector. It results in the use of necessary incentives and regulations for increased deployment of RES generation technologies.	A broad range of technologies will be available to a low cost. Applies to technologies for both RES production as well as EE		As IEA WEO 2009 Reference scenario	As IEA WEO 2009 Reference scenario	As IEA WEO 2009 Reference scenario	150 USD/t CO2 As IEA WEO 2009 Reference scenario	There are no storylines that focus on nuclear or fossil/CCS as main technology developments.
SUSPLAN	Green		There is a strong political intent to promote sustainable development and security of supply in the energy sector. It results in the use of necessary incentives and regulations for increased deployment of RES generation technologies.	A broad range of technologies will be available to a low cost. Applies to technologies for both RES production as well as EE		As IEA WEO 2009 450 ppm scenario	As IEA WEO 2009 450 ppm scenario	As IEA WEO 2009 450 ppm scenario	76 USD/t CO2 As IEA WEO 2009 450 ppm scenario	There are no storylines that focus on nuclear or fossil/CCS as main technology developments.
SUSPLAN	Yellow		There is a strong political intent to promote sustainable development and security of supply in the energy sector. It results in the use of necessary incentives and regulations for increased deployment of RES generation technologies.	The energy system will in 2050 mainly be based on the same technlogies as in 2010		As IEA WEO 2009 450 ppm scenario	As IEA WEO 2009 450 ppm scenario	As IEA WEO 2009 450 ppm scenario	76 USD/t CO2 As IEA WEO 2009 450 ppm scenario	There are no storylines that focus on nuclear or fossil/CCS as main technology developments.

Table A3.7. European Scenarios - Results

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
EU Energy Roadmap 2050	Reference	EU27	2050	1 763	750 TWh/y elec	108 TWh/y elec	745 TWh/y elec	1302 TWh/y	375 TWh/y	360 TWh/y	251 TWh/y solar and tidal	Gross:4931TWh, HEG:5386 TWh LEG: 4422 TWh	Carbon Intensity Indicator in electricity and steam production: 0.07 t of CO2/MWh				Attachment 2 is about "inter-connections and modelling of electricity trade". Share of RES 40.3%
EU Energy Roadmap 2050	Current Policy Initiatives	EU27	2050	1 614	513 TWh/y elec	97 TWh/y elec	772 TWh/y elec	952 TWh/y	393 TWh/y	388 TWh/y	323 TWh/y solar and tidal	Gross generation 4621 TWh	Carbon Intensity Indicator in electricity and steam production: 0.09 t of CO2/MWh				Share of RES 48.8 %
EU Energy Roadmap 2050	Energy Efficiency	EU27	2050	1 084	205 TWh/y elec	0 TWh/y elec	715 TWh/y elec	608 TWh/y	394 TWh/y	467 TWh/y	454 TWh/y solar and tidal	4 281	Carbon Intensity Indicator in electricity and steam production: 0.01 t of CO2/MWh				Share of RES 64.2 %
EU Energy Roadmap 2050	Div. Supply Technologies	EU27	2050	1 217	398 TWh/y elec	0 TWh/y elec	815 TWh/y elec	791 TWh/y	393 TWh/y	457 TWh/y	486 TWh/y solar and tidal	4 912	Carbon Intensity Indicator in electricity and steam production: 0 t of CO2/MWh				Share of RES 59.1 %
EU Energy Roadmap 2050	High RES	EU27	2050	1 134	108 TWh/y elec	0 TWh/y elec	386 TWh/y elec	180 TWh/y	396 TWh/y	494 TWh/y	843 TWh/y solar and tidal	5 141	Carbon Intensity Indicator in electricity and steam production: 0.01 t of CO2/MWh				Share of RES 83.1 %
EU Energy Roadmap 2050	Delayed CCS	EU27	2050	1 238	248 TWh/y elec	0 TWh/y elec	726 TWh/y elec	935 TWh/y	395 TWh/y	482 TWh/y	482 TWh/y solar and tidal	4 872	Carbon Intensity Indicator in electricity and				Share of RES 60.7 %

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
													steam production: 0.01 t of CO2/MWh				
EU Energy Roadmap 2050	Low Nuclear	EU27	2050	1 137	636 TWh/y elec	5 TWh/y elec	946 TWh/y elec	121 TWh/y	393 TWh/y	476 TWh/y	523 TWh/y solar and tidal	4 853	Carbon Intensity Indicator in electricity and steam production: 0.0 t of CO2/MWh				Share of RES 64.8 %
Getting in the right lane for 2050	Vision for 2050	EU27	2050	2675	107,5	143,3	358,3	358,3		358,3	716,5 (including hydro)				Some aspects of a European low-carbon energy system require greater coordintion at EU level (climate policy and carbon emission caps), while other issues can be left to the Member States (technology choice to meet caps). A EU energy policy would also have added value in increasing security of supply in negotiations with energy exporting countries on both energy imports and on climate change. Application of currently available no-regret technologies, such as heat-pumps, solar-PV and wind power, needs to be stimulated. Emission standards need to be set for newly built power plants, a clear target for phasing out power plants without carbon capture and storage, and long-term targets for emissions reduction. Substantial	Upgrading the power grid would require an extra investment of about 1000 billion euros up until 2030 in addition to the expected 2000 billion euros needed for 'business as usual' expansion.	In this low-carbon energy system, diversification of energy sources leads to increased security of supply through reduced dependency on imported fossil energy.

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
															funding for energy research needs to be provided and international R&D cooperation strengthened in a broad range of technologies that need further development.		
IRENE-40	BAU			4400 TWh/y					0,115	0,099	0,182		-34% in 2050 comp to 2010 (HVDC)				From economic and sustainability perspective the differences between the HVDC and UHVAC network scenarios are small. Including also a security perspective, HVDC is the preferred technology for an European overlay supergrid
IRENE-40	CCS			4800 TWh/y					0,12	0,08	0,2		-84% in 2050 compared to 2010				
IRENE-40	Efficiency			3400 TWh/y					0,12	0,08	0,4		-88% in 2050 compared to 2010				
IRENE-40	RES			4800 TWh/y					0,12	0,12	0,56		-68% in 2050 compared to 2010				
IRENE-40	DESERTEC H			4800 TWh/y					0,12	0,12	42.3%. 630 TWh/y is imported from Africa (13% of consumption in Europe)		-74% in 2050 compared to 2010				

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
Northern European Solar and Wind Intermittency Study (NEWSIS)	Target Met	Northern Europe Countries	2010-2030										CO2 limit: 100 g/co2/kwh			Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation. In 'Targets Met' scenario, prices become more volatile and unpredictable
Northern European Solar and Wind Intermittency Study (NEWSIS)	Capacity Payment	Northern Europe Countries	2010-2030										CO2 limit: 100 g/co2/kwh		Price volatility is reduced by modelling a capacity payment mechanism	Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
Northern European Solar and Wind Intermittency Study (NEWSIS)	Offshore Grid	Northern Europe Countries	2010-2030										CO2 limit: 100 g/co2/kwh			Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation
Northern European Solar and Wind Intermittency Study (NEWSIS)	Flexible Demand	Northern Europe Countries	2010-2030										CO2 limit: 100 g/co2/kwh		Price volatility grows in the long-term unless market designs change or there is material growth in demand side measures	Non renewable investment looks difficult, but there are isolated opportunities for profitable investment. Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
Northern European Solar and Wind Intermittency Study (NEWSIS)	Reduced Renewables	Northern Europe Countries	2010-2030										CO2 limit: 150 g/co2/kwh			Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation
Northern European Solar and Wind Intermittency Study (NEWSIS)	Reduced Renewables (low co2)	Northern Europe Countries	2010-2030										CO2 limit: 100 g/co2/kwh			Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
Northern European Solar and Wind Intermittency Study (NEWSIS)	Germany N-S Split	Northern Europe Countries	2010-2030										CO2 limit: 100 g/co2/kwh			Unless market designs change, the investment case for thermal plant is challenging – and this holds even for a significant shortfall against targets of renewables deployment	By 2030 wholesale market prices in some countries will have become highly volatile and driven by short term weather patterns; however, countries with large amounts of hydro – in particular the Nordics – are much less affected by increased price volatility. Thermal generation becomes 'intermittent' in its operation
Power Choices	Baseline	EU27	2050	1760 Mtoe in 2050									40% reduction in 2050 compared to 1990. Power sector: 66% reduction in 2050 compared to 2005 (750 Mt CO2 emitted in 2050)			Power generation in Baseline: €1815 in 2005 money (for the period 2005 - 2050)	
Power Choices	Power Choices	EU27	2050	1408 Mtoe in 2050	68	4	58	115	35	22	Wind on-shore: 53 (12%), offshore 37 (9%), Solar 16 (4%)	4800	75% reduction in 2050 compared to 1990. In the powers sector: 90% reduction in 2050 compared to 2005 level (1423 Mt to 150 Mt)		*) Enable the use of all low-carbon technologies and ensure investments in transmission and distribution lines *) Facilitate the electrification of road transport and efficient electro-technologies for heating and cooling *) Ensure that public authorities take	Power Generation in Power Choice: €2 trillion in 2005 money (for the epriod 2005 - 2050)	The total capacity of the transmission lines between countries is increased from 179 GW in 2005 to 253 GW by 2030. After 2030 the transmission capacity remains stable. The model simulates a DC linearised power flow operation (for the broader Euroepan continent) with least cost unit commitment and endogenaous investments. The model simulations

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
															a leading role in energy efficiency *) Support well functioning carbon and electricity markets *) Ensure that all sectors internalise the cost of greenhouse gas emissions *) Actively promote an international agreement on climate change		show no major congestion problems in the projected transmission network withinthe broar European grid.
Power Perspectives 2030	On Track	EU27	2010-2030	4693 TWh/y power demand in 2030	5% of total power production	0	28% of total power production	17 % of total power production	11% of total power production	10% of total power production	Wind on-shore 12%, wind off-shore 10%, solar PV 6%, geothermal 1% of total power production	4,791	60% reduction in 2030 compared to 1990			From 2020 to 2030: Capital expidenture € Billion Generation:1028, Tranmsission: 68, Backup:57	
REALISEGRID	Optimistic		2010-2030		0.5% coal production without CCS, 3.8% coal with CCS	0,002	31.8% gas without CCS, 0.6% gas with CCS	13.7 % nuclear	12.2% hydro	Wood 5.4%	Solar 1.8%, wind onshore 13.1%, wind offshore 11.7%	Electricity generation grows with 38% from 2010-2030					All REALISEGRID scenarios includes analyses of intra European electricity trade.
REALISEGRID	Competing		2010-2030		0.5% coal production without CCS, 4.1% coal with CCS	0,002	31.2% gas without CCS, 0.6% gas with CCS	13.4 % nuclear	12.2% hydro	Wood 5.4%	Solar 1.9%, wind onshore 13.2%, wind offshore 11.8%	Electricity generation grows with 38% from 2010-2030					

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
REALISEGRID	Centric		2010-2030		0.8% coal production without CCS, 0.1% coal with CCS	0,002	25.8% gas without CCS, 0.6% gas with CCS	15.6 % nuclear	14.4% hydro	Wood 5.5%	Solar 2.6%, wind onshore 15.3%, wind offshore 13.9%	Electricity generation grows with 16% from 2010-2030					
REALISEGRID	Pessimistic		2010-2030		3.4% coal production without CCS, 0% coal with CCS	0,002	28.2% gas without CCS, 0.% gas with CCS	15.4 % nuclear	13.8% hydro	Wood 5.1%	Solar 1.7%, wind onshore 14.6%, wind offshore 13.7%	Electricity generation grows with 15% from 2010-2030					
Roadmap 2050	Baseline	EU27+ NO	2050	1400								4,8	5,4		Continuation of the current policies	Disinvestment in high carbon assets and investment in low/zero carbon assets.	
Roadmap 2050	Development of 80% reduction	EU27+ NO	2050									4,9			Set of actions for improving energy efficiency, update of EU ETS, review of budget allocation, support of strategic network interconnectin plan (ENTSOE)	Disinvestment in high carbon assets and investment in low/zero carbon assets.	3 alternatives analysed: i) 80% RES, 10% CCS, 10% Nuclear, ii) 60% RES, 20% CCS, 20% Nuclear, iii) 40% RES, 30% CCS, 30 Nuclear. Considerable expansion of the transmission grid required
SUSPLAN/LinkS	Red	Europe	2030-2050		537 TWh/y		1150 TWh/y	1150 TWh/y	548 TWh/y	660 TWh/y	Wind: 727, Solar 142, geo 51, Wave 20 TWh/y,	5300 TWh/y	798 Megaton from the power sector		Common for all scenarios: *) Take into account that electricty and gas markets are strongly interwined		41 % RES in 2050

Title of the Study	Scenario title	Scope	Time horizon	Primary Energy Consumption/, Mtoe/yr	Coal	Oil	Gas	Nuclear	Hydro	Biomass, Waste	Solar, Wind and Other Renewables	Power Generation, thousands TWh	Energy-related C02 Emissions, Gt/a	CO2 Concen-tration, ppm	Required Policy actions	Required Financial Actions	Comments
															*) More certainty to the long term EU policy *) Strong support needed for a number of critical energy corridors on both the gas and the electricity markets		
SUSPLAN/LinkS	Blue	Europe	2030-2050		281 TWh/y		197 TWh/y	905 TWh/y	546 TWh/y	582 TWh/y	Wind: 1890, Solar: 611, geo 30 wave: 180 TWh/y	5300 TWh/y	347 Megaton from the power sector				70% RES in 2050: Profitable increases in transmission capacities much higher in Blue than in the others scenarios
SUSPLAN/LinkS	Green	Europe	2030-2050		173 TWh/y		0	1050 TWh/y	500 TWh/y	625 TWh/y	Wind: 1160, Solar: 470, geo: 40, wave 82 TWh/y	4200 TWh/y	66 Megaton from the power sector				71 % RES in 2050
SUSPLAN/LinkS	Yellow	Europe	2030-2050		590 TWh/y		160 TWh/y	950 TWh/y	480 TWh/y	460 TWh/y	Wind: 950, Solar: 280, geo: 35, Wave: 60 TWh/y	4200 TWh/y	321 Megaton from the power sector				54% RES in 2050

Table A3.8. European Scenarios - Trends

Title of the Study	Scenario title	Coal Trend	Oil trend	Gas Trend	Nuclear trend	Hydro Trend	CO2 Emissions trend
EU Energy Roadmap 2050	Reference						-1,1% average annual change per annum from 2005 to 2050 Total CO2 reduction by 2050: -39,2%
EU Energy Roadmap 2050	Current Policy Initiatives						-1,1% average annual change per annum from 2005 to 2050 Total CO2 reduction by 2050: -40%
EU Energy Roadmap 2050	Energy Efficiency						
EU Energy Roadmap 2050	Div. Supply Technologies						
EU Energy Roadmap 2050	High RES						
EU Energy Roadmap 2050	Delayed CCS						
EU Energy Roadmap 2050	Low Nuclear						85% CO2 reduction in 2050
Getting in the right lane for 2050	Vision for 2050	The use of fossil energy is centralised to enable the use of carbon capture and storage technology (CCS). Most fossil energy is used in large-scale power plants with integrated carbon capture and storage systems. CCS is also common practice in the industrial sector such as in steel, cement and ammonia production. A low-carbon energy system can only be achieved in 2050 if no new fossil power plants without carbon capture and storage would be built after 2025.		Demand for natural gas imports roughly equals the currently planned capacity for pipeline connections to Russia, Central Asia and North Africa, and LNG imports towards 2030 and remains stable afterwards.	While more use of nuclear power is consistent with a low-carbon energy system, its use depends on the acceptance and ma?gement of the controversial issues of nuclear waste and risk of plant failure. The use of nuclear energy is expected to vary widely between Member States		The distribution of emission reductions over sectors is an inherent part of this vision and not necessarily the most cost-effective. To achieve 2°C target, a 30% emission reduction in the EU needs to be achieved by 2020, other Annex I countries have to make a comparable effort, and developing countries reduce emissions by 15 to 30% on the baseline.
IRENE-40	BAU				Constant level of about 8000 hours of full load		
IRENE-40	CCS				Constant level of about 8000 hours of full load		
IRENE-40	Efficiency	Decreasing share		Increasing share	Some drop in full load hours		
IRENE-40	RES	Decreasing share		Increasing share	Drop in full load hours from 8000 to 7000		
IRENE-40	DESERTECH	Decreasing share		Increasing share	Some drop in full load hours		
Northern European Solar and Wind Intermittency Study (NEWSIS)	Target Met			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	High growth	Hydro helps to balance prices in a small isolated region, like Nord Pool, but has limited effect across Europe as a whole.
Northern European Solar and Wind Intermittency Study (NEWSIS)	Capacity Payment			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	High growth	

Title of the Study	Scenario title	Coal Trend	Oil trend	Gas Trend	Nuclear trend	Hydro Trend	CO2 Emissions trend
Northern European Solar and Wind Intermittency Study (NEWSIS)	Offshore Grid			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	High growth	
Northern European Solar and Wind Intermittency Study (NEWSIS)	Flexible Demand			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	High growth	
Northern European Solar and Wind Intermittency Study (NEWSIS)	Reduced Renewables			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	Lower growth	
Northern European Solar and Wind Intermittency Study (NEWSIS)	Reduced Renewables (low co2)			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	Lower growth	
Northern European Solar and Wind Intermittency Study (NEWSIS)	Germany N-S Split			In GB CCGTs run at much higher load factors	The French System will have a lot of nuclear generation.	High growth	
Power choices	Baseline						
Power choices	Power choices		Oil and gas replaced by efficient electric technologies on demand side. Residental sector: major progress in insulation and deployment for heat pumps. Transport: electrification of road transport over 90% of passenger cars power by el in 2050				
Power Perspectives 2030	On Track	Gas is replacing coal fired generation	Oil is phased of the the production portfolio in 2030	Gas plays an increasing role. In 2030 gas-fires plants act both as flexible base load and as back-up resource. 11% of the gas production is with CCS	Decerasing role going from 28% of production mix in 2010 to 17% in 2030. One of the sensitivity scenarios are based on less CCS and less nuclear		Decreasing emissions from the power production. Reduction of 60% in 2030 compared to 1990.
REALISEGRID	Optimistic	Coal decline sharply					
REALISEGRID	Competing						
REALISEGRID	Centric						

Title of the Study	Scenario title	Coal Trend	Oil trend	Gas Trend	Nuclear trend	Hydro Trend	CO2 Emissions trend
REALISEGRID	Pessimistic	More traditional energy forms					
Roadmap 2050	Baseline						
Roadmap 2050	Development of 80% reduction				Over 100 new plants in constrction by 2040		
SUSPLAN/LinkS	Red						
SUSPLAN/LinkS	Blue						
SUSPLAN/LinkS	Green						
SUSPLAN/LinkS	Yellow						