E★U★R★E★L

Convention of National Associations of Electrical Engineers of Europe

ENERGY TRANSITION FOR EUROPE
a necessity or a green dream?

A DOCUMENT FROM THE EUREL TASK FORCE

ENERGY TRANSITION

Preface

The study was prepared by the EUREL task Force “Energy Transition”. The task force has members from Austria, Belgium, Germany, Israel, the Netherlands, Poland, Romania Slovenia and Switzerland.

EUREL is the Convention of National Associations of Electrical Engineers of Europe.

It was founded in Switzerland in 1972 and in 2013 comprises 9 National Associations in 9 countries.

EUREL´s aims and objectives are to facilitate the exchange of information and to foster a wider dissemination of scientific, technical and related knowledge relevant to electrical engineering. In this way, EUREL contributes to the advancement of scientific and technical knowledge for the benefit of both profession and the public it serves.

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1 Introduction

The nuclear accident in Fukushima in March 2011 was one of the turning points in the energy policy of some European countries. Especially in Germany and Switzerland the governments lately decided on a fundamental new way in the Energy policy. In Germany this is called “Energiewende” (“energy transition”) and in Switzerland the government declared the program as “Energy Strategy 2050”.

Moreover, the EU member states have different energy policies, particularly for electricity, due to their past development and their different resources. It seems that in medium term (10 to 20 years) there will be no identical electricity policy in the member states. But there might be common energy policy components (i.e. efficiency goals) and common platforms.

This study is dealing with these common energy elements for a common European energy strategy and policy. The document is structured as follows. In chapter 2 the current European electrical energy programs and initiatives are summarized. Chapter 3 gives an overview of the National Energy Programs of the home countries of the task Force’s members. Of course this is a selection and not directly representative for the whole EU, but it gives a good impression of the diversity of the member states. This overview is followed in chapter 4 by elements for the future European energy concept. In order to give a short view in the future, the next chapter is dealing with Breakthrough technologies for the future. The study has its focus mainly on electricity. It is closed with recommendations on how the strategy for a future energy policy might look like.

2 Current European electrical energy production, consumption, resources and plans

2.1 Energy production, consumption and resources

The primary energy consumption in the EU28 showed a maximum in 2005 and since then fell by approximately 10 % (Figure 2.1). The reasons for that decline are on one hand due to economy crisis and stagnation and on the other hand due to energy efficiency programs in the various countries. The development of the selected countries is quite different. While Germany, Poland and Romania had in average a decrease of primary energy consumption since 1990, there is an increase in Austria, Belgium, the Netherlands, Poland and Slovenia. There are very different and country specific reasons. They cannot be discussed here in any detail. Important is that apparently the consumption in general is going to follow a downward leading path.

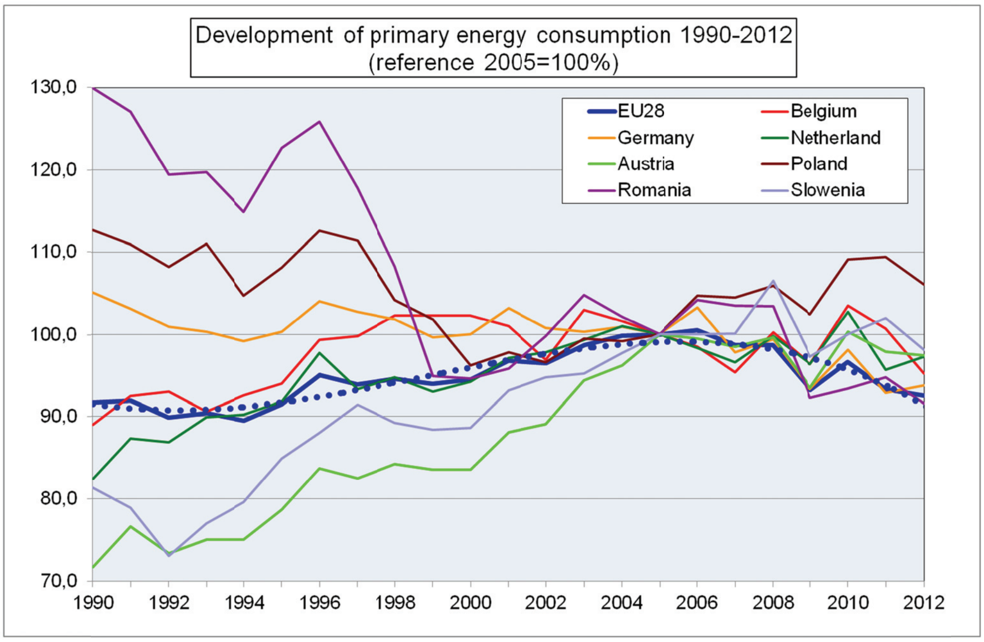

Figure 2-1: Primary energy consumption

This tendency is also true in the gross power generation in the EU28 overall, but not in all selected countries (Figure 2.2). There is steady increase of the power generation in Austria and the Netherlands, while in Germany and Poland one can observe a decline of the generated TWh's since 2008. This shows that the changes of energy generation and consumption over the last decade in the various European countries are quite different.

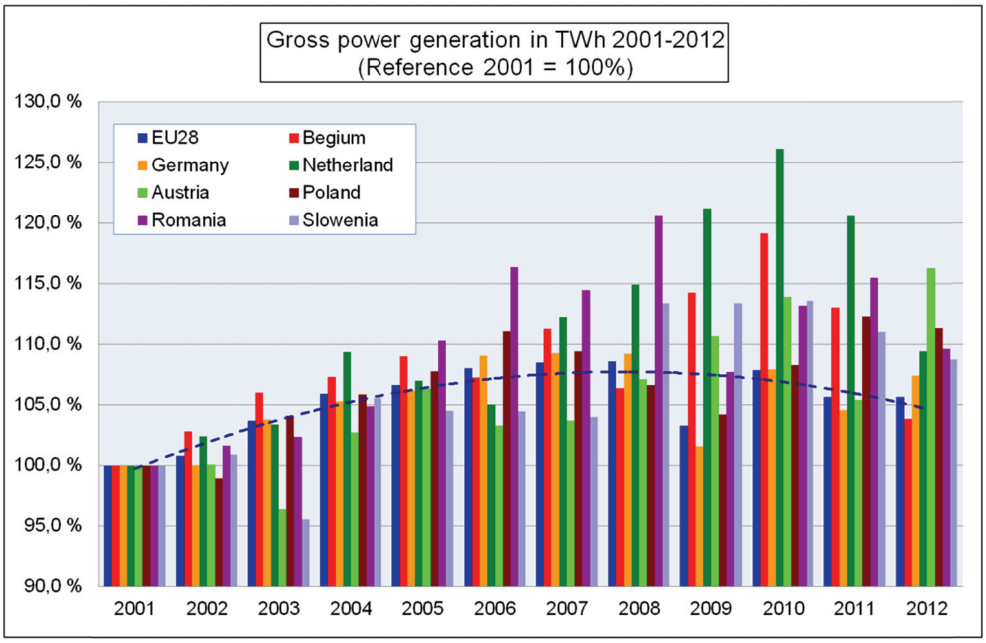

Figure 2-2: Power Generation

This specific situation for each member state can also be seen in Figure 2.3 showing the share of the renewables in power generation in the period from 2004 to 2012. We recognize a relative constant share in Austria, Romania and Slovenia over the selected period while there is a continuous increase in Belgium, Germany, the Netherlands and Poland, however, on very different share levels. In the EU28, the share of renewables in power generation is steadily increasing and finally rose by 50 % from 2004 to 2012.

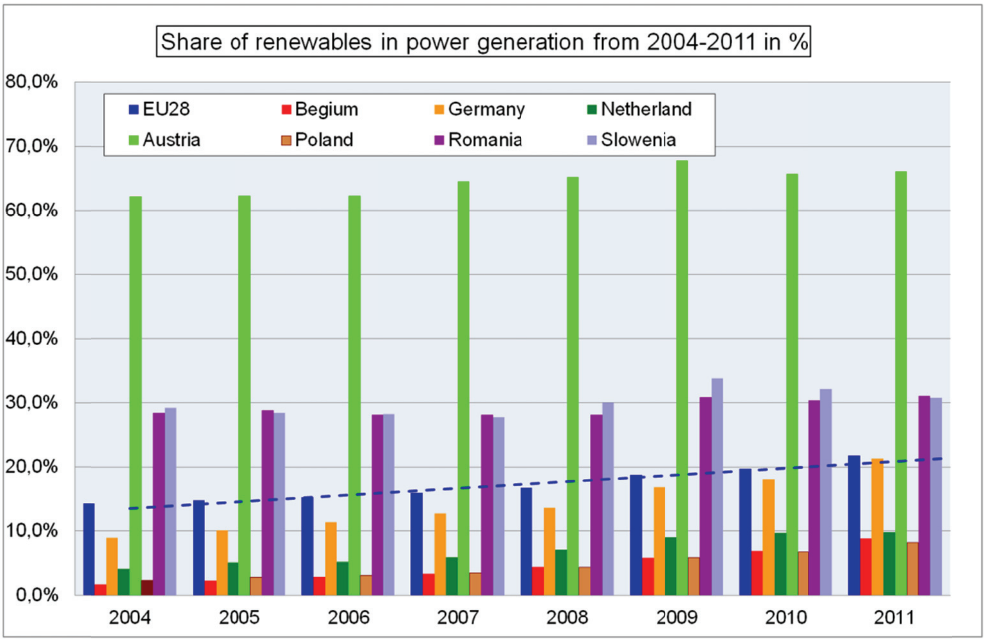

Figure 2-3: Share of renewables in power generation

Figure 2.4 shows the installed net power capacities, i.e. the power plant fleet, in the EU28 and the selected countries. In the EU 28 we observe a substantial increase of the renewable capacities. In 1990 there were basically only water power plants installed as renewable capacities. In 2012 the situation is changed to a large extent. From 1990 to 2012, the renewables' share rose from 21 % to 35 % basically due to wind, PV and biomass installations. Both the percentage of fossil and nuclear power plants in the fleet mix dropped accordingly. The share of the renewables in the power generation facilities and the fleet mix in the selected countries is totally different due to their history, their resources and their investment in the last two decades.

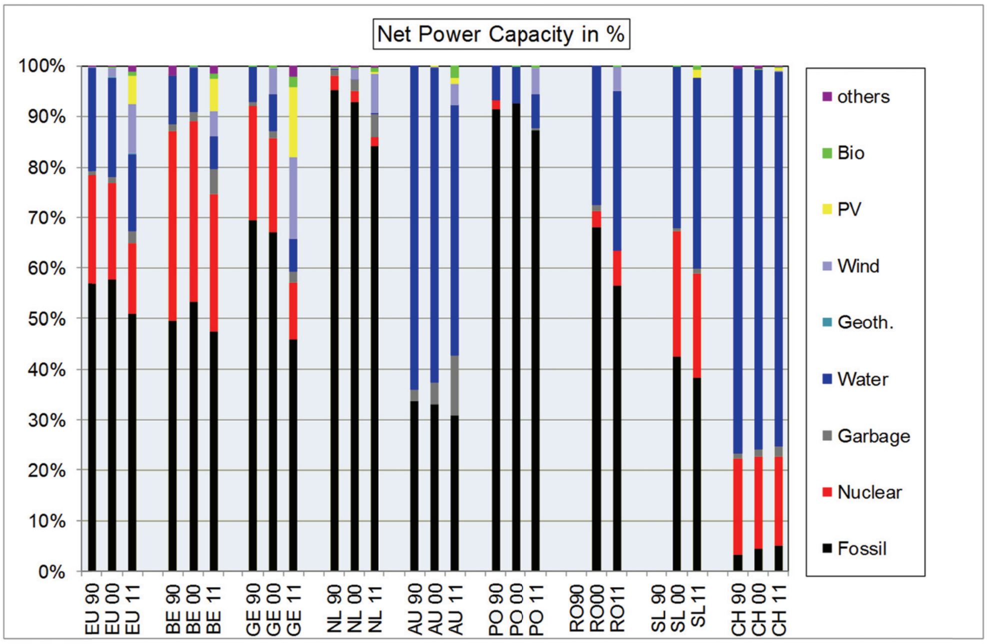

Figure 2-4: Changes in net the power capacity mix from 1990 to 2011

In Figure 2.5, a more detailed picture of the fleet mix of the EU28 is shown. In 1990, the generation capacities comprised basically fossil, nuclear and water power plants. There were practically no installations in wind, photovoltaic or biomass power plants. Ten years later, the wind installation contributed about 3 % to the fleet and, in the decade from 2000 to 2011, the renewables' share rose substantially: wind power plants from 3 % to 10 %, photovoltaic generators from 0 to 6 % and biomass power plants from 0 to 2 %.

The goal of the EU Commission is that in 2020 20 % of the total energy consumption is coming from renewable sources and in 2050 it should reach even 80 %.

All figures 2.1 to 2.4 show very specific situations in the selected countries. They all have their own and very special characteristics in the sources of primary energy for power generation and in consequence in the power consumption. Therefore, an identical approach within the EU for all member states for developing their energy system cannot be applied. Rather, each member state has to develop its own strategy. It seems that the EU Commission can only provide common goals and a common framework with respect to an internal market, to common technology development and common external relation to the primary energy exporting countries. This will be detailed in chapter 4.

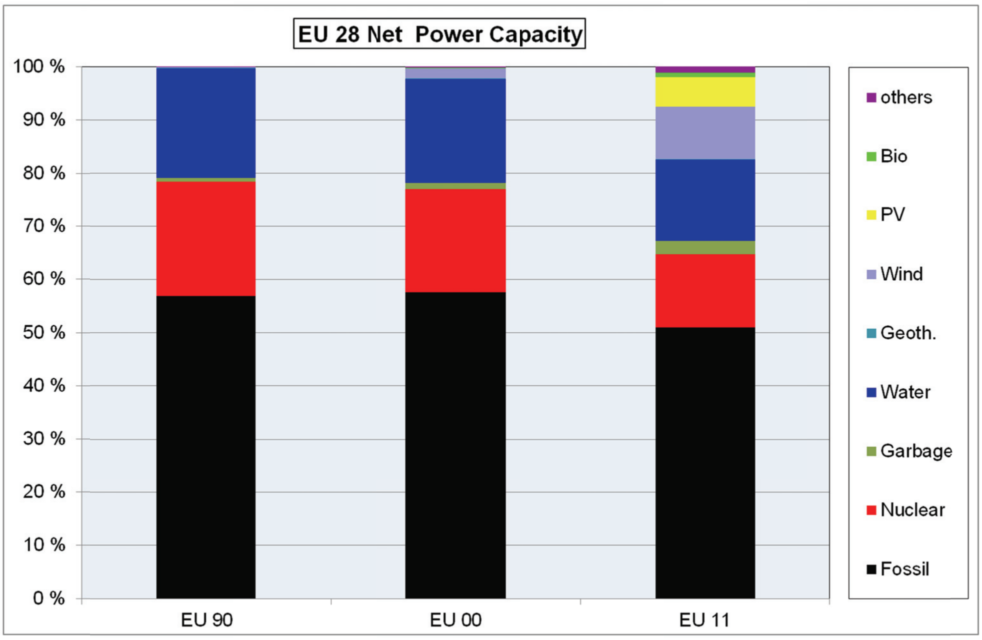

Figure 2-5: Net power capacity mix of the EU 28 from 1990 to 2012

Furthermore, the share of the EU countries of the worldwide reserves and resources in oil and gas are dramatically small.

2.2 EU plans

2.2.1 The Energy and Climate Package from 2007

After the Kyoto Protocol, signed in 1997 by most European countries, but expiring in 2012, a new international agreement to reduce emissions of greenhouse gases was to be negotiated at Poznan (Poland) and in Copenhagen in 2009. To play a leading role in these negotiations, the European Union wanted to develop as quickly as possible a common position in the fight against climate change, and thus implemented its own measures to deal with climate change.

At the meeting on 8 and 9 March 2007, the European Council adopted new environmental targets even more ambitious than that of the Kyoto Protocol. The plan included the so-called 20-20-20 targets, but actually it consisted of four proposals. The targets were:

- 20 % reduction of greenhouse gas emissions compared to 1990,
- 20 % share of renewables of the total final energy consumption,
- 20 % reduction of the total primary energy consumption compared to the estimation of 2007,
- 10 % share of renewables of the total fuel consumption.

2.2.2 Framework for climate and energy policy in the period 2020-2030

The European Commission presented in January 2014 a framework for climate and energy policy for the years 2020-2030. It proposes on the one hand, an EU greenhouse gas reduction target for 2030 in the amount of 40 % reduction compared to 1990, on the other hand a binding EU target for the development of renewable energies for 2030 in the amount of 27 %.

Energy efficiency should also remain an integral part of the future EU climate and energy policy. The Commission's analysis shows that a greenhouse gas emission reduction target of 40 % would require an increased level of energy savings of approximately 25 % in 2030. According to Commission calculations 400 to 500 billion Euro per Year for imports of fossil fuels can be saved in the EU when the energy reduction targets are between 30 and 35 % by 2030. Other essential parts of the Commission's proposals are:

- Reform of the Emissions Trading System ETS,
- Ensuring competition in integrated markets,
- Competitive and affordable energy for all consumers,
- Promoting security of energy supply.

2.2.3 Energy Efficiency Communication 2014

The Energy Efficiency Communication is a strategy that proposes mid and long-term objectives for the EU's energy efficiency policy by assessing a progress towards the 2020 energy efficiency target and proposing a new 30 % target for 2030. The EU proposes a new energy efficiency target of 30 % for 2030 in its Energy Efficiency Communication, released on 23 July 2014. The Communication assesses the EU's progress towards its 20 % energy efficiency goal for 2020 and analyses how energy efficiency could drive competitiveness and strengthen the security of supply in the European Union in the future.

Overall, it found that the EU will achieve with current measures energy savings of 18-19 % by 2020. However, if all the Member States work seriously to properly implement the already agreed legislation, the 20 % target can be reached without the need for additional measures.

Long-term benefits

Based on current achievements and maintaining the push towards energy efficiency, the EU's new 30 % target for 2030 can make energy cheaper, ensure security of supply, and improve the lifes of Europeans in a variety of ways:

- For every additional 1 % in energy savings, EU gas imports are expected to fall by 2.6 %, decreasing our dependence on external suppliers.
- More energy efficient buildings offer 'ancillary benefits' to people who live and work in them in addition to reducing their energy bills.
- Ambitious energy efficiency policies create new opportunities for European businesses such as construction firms and manufacturers of energy-using equipment.
- The new energy efficiency target is estimated to create more and more new jobs.

2.2.4 Energy Roadmap 2050

On 15.12.2012, the EU-Commission released the Energy Roadmap 2050 document based on a set of scenarios, leading to an almost carbon free energy system and the policy framework needed. This should allow member states to make the required energy choices and create a stable business climate for private investment until 2030.

The Commission claimed to have a European framework for the necessary policy measures to secure the right investments. The analysis is based on the four main decarbonisation routes (energy efficiency, renewables, nuclear and CCS). None is likely to materialize, but all scenarios clearly show a set of options for the coming years.

The Energy Roadmap 2050 release on 15.12.2011 listed some key outcomes such as:

- Decarbonisation of the energy system is technically and economically feasible
- Energy Efficiency and renewable energy are critical
- Early Investments cost less
- Contain the increase of prices
- Economies of scale are needed

2.3 Dependencies from third parties

One of the most crucial challenges of the EU energy policy is the dependency of its member states on energy sources out of the territory. This is especially true for oil and also for gas. In case of oil, nearly 84 % of the oil consumed in 2012 had to be imported from outside the EU. This value did rise in the last decade by nearly 10 % (!) and will rise further in the coming years. Figure 2.8 gives an overview of the EU and the selected member states. Romania has still valuable own resources, but the dependability is rising with the increase of demand due to industrialization and growing living standard.

Figures 2.9 and 2.10 show the same situation and only the absolute values are different. In case of gas, the EU had to import 70 % of its demand in 2012. From the selected countries only the Netherlands was an Exporter, all others had to import gas to a large extend with the exception of Romania which imported “only” 50 %.

Regarding solid fuels, i.e. basically coal, the dependency is much lower than for oil and gas. For the total EU 40 % of its demand has to be imported from outside of the EU. In 2001 Poland was a remarkable exporter of coal, in 2012 this export is nearly gone.

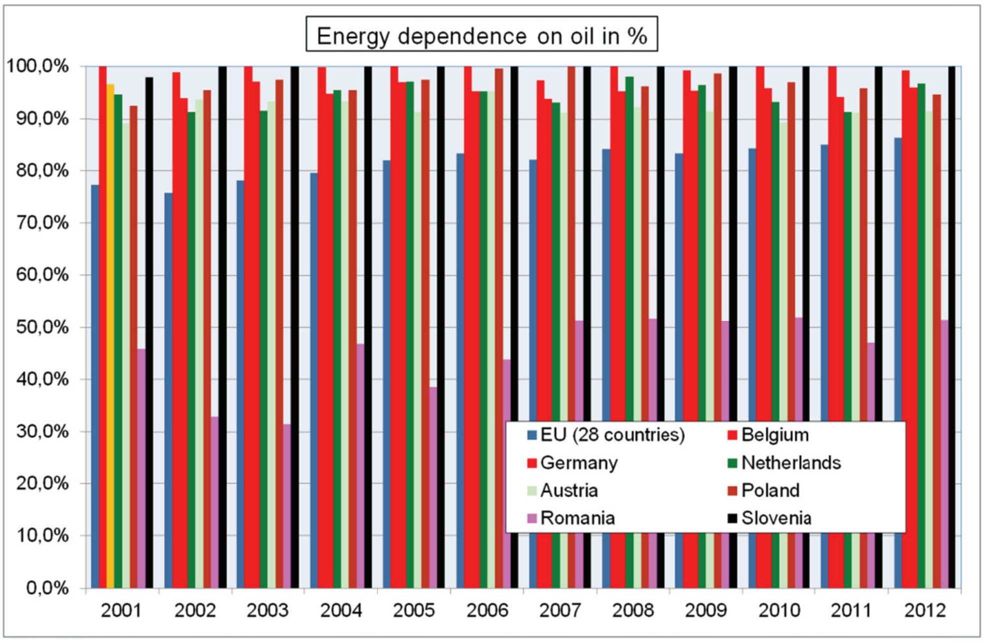

Figure 2-6: Dependence of the EU and selected member states on oil from outside EU areas

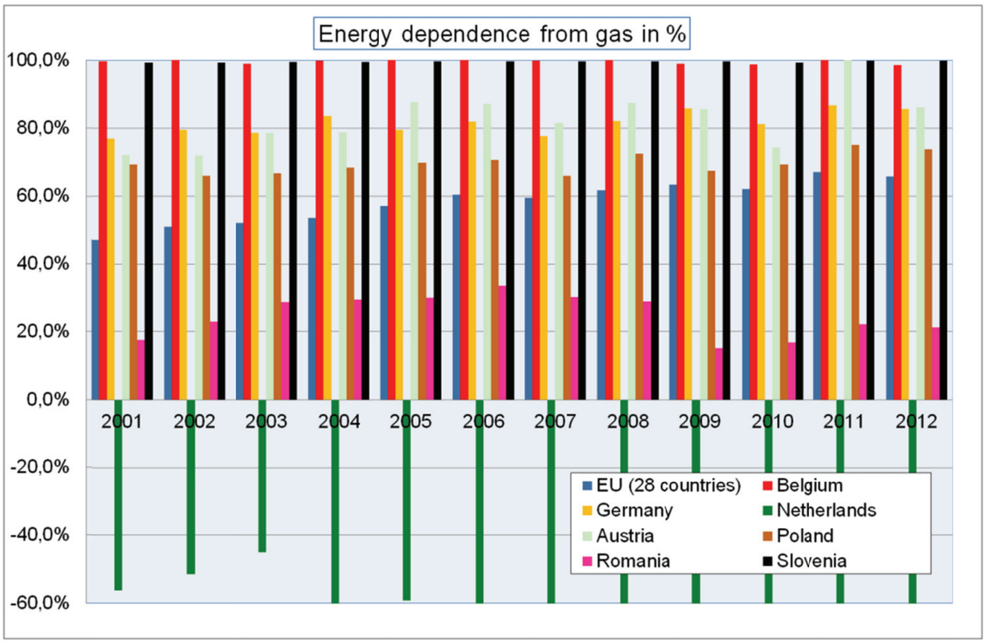

Figure 2-7: Dependence of the EU and selected member states on gas from outside EU areas

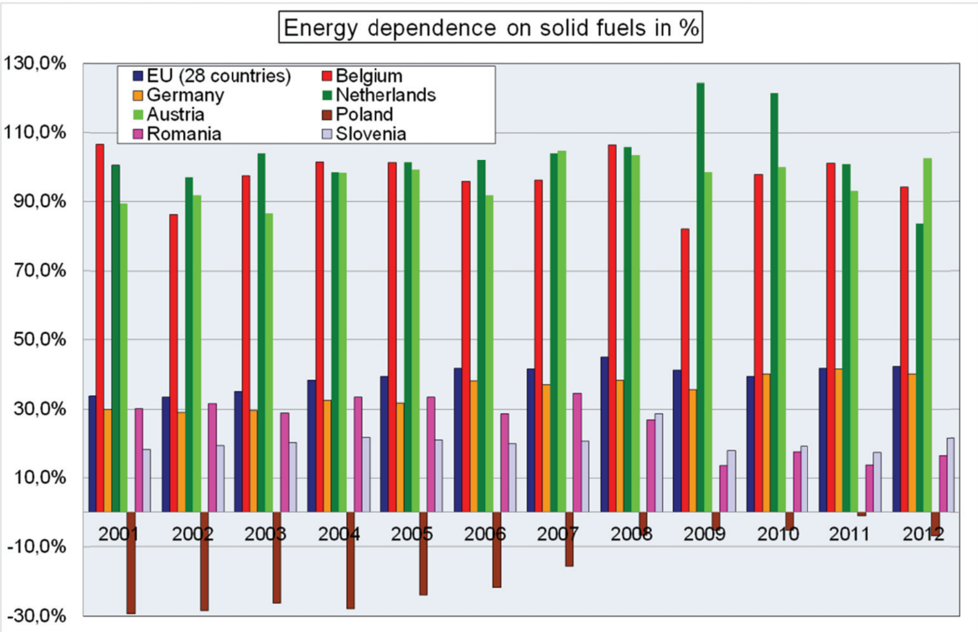

Figure 2-8: Dependence of the EU and selected member states on solid fuels from outside the EU area

3 National energy programs: A Selection

3.1 Austria

In the year 2009 an “Energy Strategy Austria”- Process was initiated by the Ministry of Economy and the Ministry of Environment, in which experts and all relevant parties participated. The Process is based on the “20-20-20 until 2020” directives of the EU. Here the targets for Austria are: 34 % renewable energy in the end-use, reduction of non ECT emissions by 16 % related to 2005 and increasing the energy efficiency by 20 %. In the electricity production, the renewable energy should reach a portion of 70.6 %. This strategic columns shall enable to reach the Austrian 2020 targets:

- Developing energy efficiency in end-use and reduction of the total energy demand until 2020 by 200 PJ (Petajoule) related to 2005. Here nearly “zero energy buildings”, efficiency in households and industry, efficient mobility especially development of electrical individual mobility, efficient use of primary energy and combined heat and power are seen as solutions.
- Renewable energy from hydropower, wind, photovoltaic, and biomass.
- Long term security of energy supply also related to costs and environmental effects. The energy infrastructure has to be developed in terms of the electrical transmission and distribution grid and the gas pipelines as well.
- Stabilizing the energy demand on the level of 2005 until 2020, this means at 1.100 PJ per year.

In the year 2010 each European member state had to finalize a “National Renewable Energy Action Plan” (NREAP), showing how the 20-20-20-targets will be reached until 2020. In table 3.1 the development of national targets in direction of share of Renewable Energy Sources (RES) are shown.

Table 3-1: Austria national 2020 targets in heating and cooling, electricity and traffic [NREAP-AT, 2010]

Target RES		**2006**	**2010**	**2015**	**2020**
heating & cooling	%	24.3	30.5	31.2	32.6
electricity	%	60.8	69.3	71.2	70.6
traffic incl. electricity	%	6.8	6.9	8.1	11.4
RES in brutto demand	**%**	**24.4**	**31.1**	**32.1**	**34.2**

The development of generation of electricity in direction of the relevant renewable sources according to NREAP-AT 2010 was changed according to a new Austrian Directive (“Ökostromgesetz 2012”), which brought a faster development of RES by additional subsidies (Table 3.2). Additionally, related to 2010 until 2020, a development of hydropower by 1000 MW/4000GWh, wind 2000MW/4000GWh, biomass 200MW/1300GWh and PV 1200MW/1200GWh will have a funding.

Renewable sources in electricity should reach as a mean value in the EU-27 member states a share of 34.5 %. Austria has with a share of 70.6 % the highest value in EU-27, followed by Sweden 62.9 %, Latvia 59.8 % and Portugal 55.3 %.

Table 3-2: Development of electricity generation from renewable sources according to NREAP-2010 and to new funding scheme of 2012.

Electricity generation		2005	2010	2020 NREAP	2020 (2012, new funding)
hydropower	MW GWh	7,907 37,125	8,235 38,542	8,997 42,112	9,235 42,542
geothermal	MW GWh	1 2	1 2	1 2	1 2
Solar PV & CSP	MW GWh	22 21	90 85	322 306	1,290 1,285
Wind	MW GWh	694 1,343	1,011 2,034	2,578 4,811	3,011 6,034
biomass	MW GWh	976 2,832	1,211 4,720	1,281 5,147	1,411 6,020
Total electricity	**MW** **GWh**	**9,600** **41,314**	**10,547** **45,383**	**13,179** **52,377**	**14,947** **55,883**

3.2 Germany

In August 2007, the Federal Government has decided on the “Integrated Energy and Climate Program (IEKP)”. This program comprises a total of 29 measures that are primarily intended to promote a more efficient use or supply of energy. The expansion of renewable energy is to be supported thereby.

In September 2010, the Federal Government has developed an energy concept that in addition to the 40 % target for 2020 also includes an 80 to 95 % reduction target by 2050, with intermediate targets for 2030 and 2040 as well as numerous other efficiency goals and targets for expanding renewable energies. This concept was updated in 2011 after the Fukushima disaster by phasing out of nuclear power. To check whether Germany is at an appropriate development path, monitoring is to be held every 3 years and the results to be submitted to the Bundestag. Like the IEKP, the energy concept also includes a number of measures.

Table 3-3 shows the planned climate change mitigation and development goals of the Federal Government in the areas of greenhouse gas emissions, renewable energy and energy consumption.

Table 3-3: Climate and Energy policy objectives of the Federal Government

	2020	2030	2040	2050
Reduction of greenhouse gas emissions (% cmp. to 1990)	40	55	70	80-95
Share of renewables of gross energy consumption (%)	18	30	30	60
Share of renewables of gross power generation (%)	35	50	50	80
Reduction of primary energy consumption (% cmp. to 2008)	20			50
Reduction of power consumption (% cmp. to 2008)	10			25
Red. of end energy consumption in traffic sector (% cmp. to 2005)	10			40

3.2.1 The Integrated Energy and Climate Program (IEKP, 2007)

The "Integrated Energy and Climate Program" (IEKP), passed in August 2007 and the decisions to be its concrete implementation of defined basic climate change targets for 2020:

- the reduction of the German greenhouse gas emissions by 40 % compared to 1990 as a contribution to global emissions;
- the share of renewables in electricity generation should be at least 30 %;
- the share of renewables in heat production should be 14 %;
- the expansion of biofuels, without the threat to ecosystems and food security

In addition, the goal is to double energy productivity compared to 1990 as part of the sustainability strategy.

3.2.2 The energy concept (2010/2011)

The Energy Concept 2050 redesigned the German energy supply completely. The goal is to become one of the most environmentally friendly and most energy efficient economies - at competitive energy prices and high level of prosperity.

The development of renewable energy sources as an alternative to nuclear power is the basic idea of the concept. The energy share of electricity generation from solar, wind & other shall be expanded to 40 to 45 % by 2025 and to 55 to 60 % by 2035. Even today, the renewable energies are the number 2 in the mix with about 23 %. However, a power supply, which is based on renewable energy sources, presents challenges: There are more, but smaller plants than before. Their power must be fed into the network and transported to the consumers.

In addition, a large part of the current wind power is generated in the future in the north and must be transported from there to southern Germany. The expansion of the large national transmission systems and distribution networks is an important concern. Renewable energy also means that more storage is needed. This is because solar, wind & other produce energy more volatile than large fossil power plants. Therefore, energy from peak hours must be stored, in order to use it in weak wind times and in the night. If that is not enough, there must be flexible power plants that can be ramped up quickly. In order to make renewable energy affordable and to make optimum use of storage and networks, the technology itself must be enhanced.

Energy research is therefore a fundamentally priority of the federal government. It is equally important to save more energy, especially during heating of apartments, houses, offices and in industry and mobility. The Federal Government therefore encourages the renovation and isolation of buildings and the purchase of electric cars.

Renewable energy

The Renewable Energy Sources Act (EEG) remains the main instrument for the expansion of renewable energy production. Already, hydropower, photovoltaic and biomass have become an important component in the mix. The Federal Government will continue to expand wind energy on land. The offshore wind energy in the North and Baltic Sea is supported by a new offshore program of five billion euros. The contribution by the electricity consumers for renewable energy, increased in 2014 to 6.24 cents per kilowatt hour. Also payments for renewable energies have been adjusted.

Networks

The German power grids are not designed for the transport of renewable energy. 24 projects have been classified as the most urgent by the federal government. Nearly a quarter of them have been completed - around 200 kilometers of power lines out of 850 kilometers planned to be built by 2015. The new Grid Expansion Acceleration Act ensures that planning procedures for high voltage lines across national boundaries can be shortened from 10 to 4 years.

The Federal Government has decided on further measures in December 2012 to accelerate the current network expansion. The centerpiece is the federal requirement plan, which contains all the necessary modernization of the next ten years. The federal requirements plan comprises 36 projects that are energy and economically necessary and particularly urgent. Nationwide, 2800 km new lines are planned and 2900 km of existing lines have to be improved and strengthened. The costs are estimated at ten billion euros, without any additional costs for underground cables. It is important to compare the life cycle costs of power lines and underground cables. The result of a calculation of the life cycle costs including the transmission losses for the power line and the underground cable, says often the life cycle costs underground cables can be cheaper.

Energy storage

Wind and solar energy does not always provide the same amount of power. To ensure the security of supply, advanced energy storages must be provided. The federal government will spend 200 million euro for research and development of energy storage.

Phase-out of nuclear power

Until the end of 2022, nuclear power will be phased out. A plan is provided when and which of the currently running nuclear power plants are to be taken out of operation.

Conventional Power plants

The nuclear phase-out can lead to bottlenecks in the winter periods. Gas and coal-fired power plants will have to absorb these bottlenecks. The network stability and fluctuations in power generation because of renewable energy sources operation will require use of conventional power plants.

In addition, the federal government wants to improve the promotion of combined heat and power (CHP) continuing up to the year 2020.

Energy efficiency

By 2050, the Federal Government aims to reduce the demand for primary energy by 50 percent. This can only be achieved if energy is saved in all areas. 40 percent of the energy, which is consumed in Germany, is for heating of buildings. The heat demand of the building stock should fall by 20 percent by 2020. By 2050, houses should be almost carbon neutral. For the current building renovation program, up to 1.8 billion euro shall be invested.

Electric cars

By 2020, at least one million electric vehicles should run on Germany's roads and by 2030, even six million. This is the target of the government’s electro mobility program. Anyone who buys an electric car, is expected to benefit. For ten years, the owners do not have to pay a car tax.

3.3 Israel

Israel is in an ongoing process of assembling a national energy program which has to be synchronized with several national programs that focus on utilities, water, economy and finance. To ensure a smooth implementation it also has to be coordinated with the policy of labor unions, numerous authorities and regulatory bodies. These complex scenarios, together with the growing demand, are key drivers to ongoing debates and conflicts. The discovery of natural gas (NG) reservoirs in the Israeli economic waters in 1999 and the successful explorations changed the energy programs that were accepted prior to the NG discoveries. It also opened a national discussion on how much of the Israeli natural resources might be exported.

Israel that had relied on fuel import has become a nation capable of providing its energy consumption for generating electricity without dependence on external sources. The governmental policy applied by the Ministry of Energy and Water Resources, states that power plants and large industrial factories are gradually converted to NG use. The establishment of a nation-wide conduction and distribution system of NG has commenced. This policy conflicts with previous decisions of shifting from fossil fuel to renewable energy; it halted many of the governmental supporting programs and endangers the prospects of some ongoing projects.

Israel's total installed capacity stands at about 13,000 MW (as of 2013) by IEC (Israel Electric Corp.) and additional 512 MW by private non-IEC suppliers. Actual usage is about 57,067,000 MWh. Of those, 0.87 % is produced by renewable energy. This figure should grow in 2014, as 134 renewable energy facilities have been approved for conditional licenses. By the end of 2014, 2.24 % of Israel's electricity is expected to come from renewable sources.

IEC is the sole integrated electric utility in Israel .The State of Israel owns approximately 99.85 % of the Company. One of the stated goals of the 1996 Electricity Law (replacing the 1954 law) is the encouragement of competition in the electricity sector, and government decisions have set a target of increasing the generation of electricity by independent power producers to 20 % of the country’s installed generating capacity. It suggests that IEC will be split into several power production companies to increase competition.

On September 18th, 2008 the government decided to promote energy efficiency measures in order to reduce electricity consumption. As part of this decision, the government had set a guiding objective - to reduce electricity consumption by 20 % until the year 2020.

The enforcement mechanism would supervise electrical appliances and energy systems, and ensure their compliance with the required efficiency levels. It is advisable to offer financial incentives for socio-economic disadvantaged populations, in order to encourage the replacement of old and inefficient electrical appliances with new and efficient ones.

The Smart Grid is one of the main drivers of the future development of the world energy networks. The Israel Electric Company (IEC) has installed advanced control and supervision systems in the transmission and distribution segments. Traditionally, Israel was considered a micro grid, with local goals of leveling electricity demand peaks.

In 2012 a project of laying a 2,000-megawatt submarine power line, dubbed the Eurasia Interconnector project, would ensure that nations including Greece, Cyprus, Israel and others in Europe and the Mediterranean basin have a regular power supply. Greece and Cyprus have agreed to an Israeli request to lay a power cable to Europe via the two Mediterranean nations. This is the first stage in a process that would bring Israel electricity from mainland Europe. At 540 nautical miles (1,000 kilometers) long and lying at a maximum depth of 2,000 meters, the cable would be the longest in the world.

In 2013, Israel, Jordan, and the Palestinian Authority were set to ink an agreement to build a pipeline from the Red Sea to the Dead Sea, part of an initiative that would produce millions of cubic meters of drinking water for the parched region and slake the critically dwindling Dead Sea. It has an additional potential for several hydro-electric power generation plants. Natural Gas pipeline to Turkey and the plan to sign a 15-year deal to export 2.5 trillion cubic feet of gas to a Spanish-owned liquefaction facility in Egypt, are introductory projects to export Israeli gas. These projects indicate that Israel is becoming an integrated junction on the global smart grid.

Renewable Energy

The Ministry of Energy and Water Resources is working to ensure the development and expeditious integration of renewable energy sources in Israel. The main technologies likely to be practical for Israel's electricity sector are:

- **Solar energy**: Israel has lots of sunshine with excellent potential as an energy source. Tender for the construction of two thermal solar power stations with a total capacity of 250 megawatts and a photovoltaic power station with a capacity of 30 megawatt is in the final stages of preparation. In addition, hundreds of megawatts of installations have been constructed to date.
- **Wind energy**: for geographic reasons, there is little potential for the exploitation of wind energy in Israel. There are currently several wind turbines operating on a limited scale. Wind turbine farms are being considered for additional sites.
- **Biomass energy**: can be generated from municipal and agricultural solid. There are schemes of various sizes operating in Israel that generate and utilize biogas, and tariffs are regulated.

In 2002, the Ministerial Committee for Social and Economic Affairs set a target of 2 % of electricity generation for consumers coming from renewable energy sources as of 2007, increasing by one percent every three years up to a level of 5 % of total electricity generation in 2016 and 10 % by 2020. Accordingly, the Public Utility Authority – Electricity published premiums for the generation of electricity from renewable energy sources.

In 2007, the Israeli Government passed a resolution to remove barriers in the energy sector and to encourage electricity generation by private developers, construction of power stations based on renewable energy sources and a transition to the use of natural gas for generating electricity.

In 2009, the Government set an electricity generation target from renewable energy sources of 10 % of the country's energy needs in 2020, and calls for the building of power stations based on renewable energy sources in the southern regions, of at least 250 megawatts each year. An interim target of 5 % of electricity consumption coming from renewable energy sources by 2014 was also set.

In July 2011, the Israeli Government reaffirmed the targets set in 2009, and established quotas for the generation of electricity from solar energy, wind energy and energy based on biogas, biomass and solid waste sources. To this end, the Ministry received an allocation of NIS 10 million (~ 2.400.000 EUR) to incentivize specific projects such as commercial demonstration installations.

The Public Utilities Authority - Electricity (PUA) published an economic mechanism originally used to encourage individuals and companies installing RE was the Feed-in-Tariff (FiT), accompanied by a series of quotas for installations.

3.4 The Netherlands

3.4.1 Introduction

In the Netherlands, a general Energy Agreement for Sustainable Growth was reached in 2013 and signed by forty organisations, including central, regional and local government, employers' associations and unions, nature conservation and environmental organisations, and other civil-society organisations and financial institutions.

The parties to the Energy Agreement will strive to achieve the following objectives:

- saving in final energy consumption averaging 1.5 % annually. This is expected to be more than enough to comply with the relevant EU Energy Efficiency Directive;
- in this context, a 100 peta joule (PJ) saving in the country's final energy consumption by 2020;
- increase in the proportion of energy generated from renewable sources from 4.4 % currently to 14 % in 2020, in accordance with EU arrangements;
- further increase in that proportion to 16 % in 2023;
- at least 15,000 full-time jobs, a large proportion of which will be created in the next few years.

The Energy Agreement also aims to strengthen the economic structure and to contribute to future sustainable growth and to find the right balance between energy reliability, sustainability and affordability.

With petrochemicals, greenhouse horticulture and transport accounting for a major share of the Dutch economy the Netherlands has a high per capita energy consumption. It imports a considerable amount of energy, and consumes about a third of what it imports. Much of this imported energy is exported abroad in the form of crude oil and oil products. Compared with many other European countries, the Netherlands have a relatively large reserve of fossil energy carriers. Assuming that the quantity of natural gas produced in the Netherlands remains stable over the next few years, at the present rate of consumption the Netherlands has approximately twenty years' worth of reserves in its gas fields.

The Netherlands' energy supply is tightly intertwined with Europe and the rest of the world. The parties to the agreement are fully aware of this international context, the relevant trends in the international supply of energy, and the potential of EU frameworks for achieving sustainable growth. Climate change is an international issue, and the present Energy Agreement therefore also includes measures that are to be implemented within the European context (for example improvements to the EU Emissions Trading System or ETS).

3.4.2 Ten basic components of policy

Saving energy

Saving energy is a key point and is the first basic component for achieving a sustainable energy supply. Saving energy contributes to environmental objectives, reduces the energy bill, improves the competitiveness of Dutch businesses, and boosts employment. The parties' aim in the Energy Agreement is to achieve an annual saving of 1.5 % in final energy consumption. This is expected to be more than enough to comply with the Energy Efficiency Directive. The parties have agreed on a package of measures that is expected to save some 100 PJ by 2020. The arrangements for saving energy focus both on the built environment and on increasing energy efficiency in industry, agriculture, and the rest of the commercial sector.

Scaling up renewable energy generation

The second basic component of the policy involves scaling up renewable energy generation. This demands a strong focus on various resources such as onshore and offshore wind power, various types of local energy generation such as solar energy, and the use of biomass.

Renewable energy accounted for 4.4 % of total energy consumption in the Netherlands in 2012. Biomass accounts for more than 70 % of all renewable energy, and wind power for slightly less than 20 %. Other sources – hydropower, solar energy, geothermal energy and ambient heat – make only a small contribution. Electricity generated by wind turbines, hydropower plants, solar panels and biomass accounted for more than 10 % of all electricity consumption in 2012, approximately a half percentage point more than in 2011. The share generated by wind turbines rose by 5 % in 2012 owing to an increase in capacity. The share accounted for by biomass remained virtually static. Solar energy generation more than doubled, but it still represents no more than 2 % of the overall production of renewable electricity.

Renewable sources of energy continued to provide just over 3 % of the Netherlands' heat in 2012. Consumption of renewable energy in the transport sector rose from 4.6 % in 2011 to approximately 5 % in 2012.

The main policy measure stimulating the use of renewable energy is the "SDE+" scheme (SDE stands for "Sustainable Energy Incentive"). The scheme covers the difference between the price of grey energy and the price of sustainable energy for a 5, 12 or 15-year period, depending on the technology used.

The parties will pursue the Dutch Government's objective of generating 16 % of the country's energy from renewables. The basic premise is a cost-effective rollout that provides certainty for investors, creates additional employment, triggers innovations that reduce costs, and contributes to boosting the competitiveness of Dutch companies in this sector. Combined with ambitious energy-saving measures, the parties hope that this approach will allow them to achieve the target of 16 % renewables by 2023 and 14 % by 2020.

The main components of large-scale renewable energy generation include:

- Scaling up offshore wind power to 4450 MW, operational in 2023. The existing and planned offshore wind power capacity comes to a total of some 1000 MW. In addition to this, a total of 3450 MW will be contracted for by means of phased procurement procedures commencing in 2015 and increasing as follows: 450 MW (2015), 600 MW (2016), 700 MW (2017), 800 MW (2018), and 900 MW (2019). This assumes that the cost of offshore wind power will be cut by some 40 % in the years ahead. This will take the form of tenders, in which this cost decrease is a critical criterium.
- In the case of onshore wind power, there will be investment within the frameworks agreed with the provinces in order to achieve 6000 MW by 2020. Wind farm investors will introduce a participation model enabling local residents to participate actively in the planning and operation of wind farms. For the period after 2020, additional capacity will eventually be sought within the frameworks discussed with the Association of Netherlands Provinces (IPO).
- Renewable energy generation from the various other sources will be tackled ambitiously. There are a number of factors other than financial ones that limit the scaling up of renewable energy. It is crucial to tackle these factors if progress is to be made.
- The parties agree that promoting the use of biomass by coal-fired power stations will not exceed the level of 25 PJ. In the context of the best possible use of biomass and strict sustainability criteria, methods will be elaborated for how the 25 PJ restrictions on biomass, the type of support, and the possible use of a procurement procedure can be given shape within the SDE+.
- An offshore network will be constructed where this is more efficient than connecting wind farms directly to the national high-voltage network. Responsibility for this will be allocated to TenneT TSO.

Decentralised energy generation

Diversification is a growing and significant trend in energy production. More and more businesses and consumers are taking steps to meet their own energy needs. A drop in the price of solar panels has made this more financially attractive for consumers, who also appear to want control over their own energy supply. A vibrant range of private and local initiatives is developing, including district heating companies, electric-transport projects, solar-energy collectives, energy generated from waste, biomass fermentation plants, wind-energy operators, and energy-neutral building projects.

What unites these initiatives is that they are focused on sustainability and alternative sources of energy. Although limited in scope, these new forms of energy generation are growing rapidly. The major power companies have also made important investments in renewable energy; specifically wind energy, biomass co-firing, and hydropower.

Energy transmission network

The energy transition will have far-reaching consequences for the networks whose task is to bring together supply and demand. The fourth basic component of the Energy Agreement ensures that the energy transmission network is ready for a sustainable future. The parties have agreed that they will prepare thoroughly for this changing future so that changes can be made quickly when they are necessary and desirable.

Measures that will make the energy system (gas, electricity and heat/cold storage) more flexible include the following:

- The development of smart grids and of demand-side management in order to shift the pattern of demand.
- The development of storage capacity to encourage electric transport and the infrastructure of charging stations it requires. Another possibility is to convert electricity into gas, which can then be stored. Such measures could make power-to-gas and/or dual firing more attractive.
- It is crucial to conduct experiments to study the impact on the energy infrastructure.

In the context of European cooperation, the Dutch government, energy companies, grid managers and businesses have committed themselves to:

- Closer international cooperation within the pentalateral Energy Forum, with other countries in the North Sea region and bilaterally with Germany. Such cooperation is needed to properly coordinate national plans for the large-scale generation of renewable energy and the related commercial and grid development.

- Promoting an effective, supportive regulatory EU framework that will provide for a sound investment climate in Europe. That will require the scrupulous implementation of measures under the EU's Third Energy Package.
- An effective regional approach towards integrating the electricity and gas markets. The investments needed in production facilities and grids will also require the efficient deployment of capital and resources and a large enough return on investment to attract investors.
- Transparent procedures in international projects, in particular when issuing permits and inviting tenders for large-scale offshore wind farms and the construction of cross-border grid infrastructures. The focus on a more European regulatory framework will encourage more coherence in investment and a more effective cost-benefits analysis per investment.

EU Emissions Trading System (ETS)

As the fifth basic component of the Energy Agreement, a properly functioning EU Emissions Trading System (ETS) is a crucial factor in the long-term transition to a sustainable supply of energy.

Energy generation from fossil fuels and coal-fired power stations

Up to 2050, fossil fuels will remain an important component in the energy consumption, even though the Energy Agreement focuses on achieving a reduction in CO_2 emissions of 80 to 95 % by 2050, with renewables accounting for 16 % of energy generation by 2023. Gas-fired power stations will continue to be important in the northwest European electricity market.

In this sixth basic component, the parties have agreed that the capacity of the coal-fired power stations built in the 1980s will be minimised as part of the transition to the sustainable supply of energy (in connection with the arrangements concerning renewable energy in the second and third basic components). More specifically, this means that three coal-fired power stations will be closed down with effect from 1 January 2016, and that the two remaining power stations (Maasvlakte I and II) will close on 1 July 2017.

If the power stations referred to above have been shut down by the dates mentioned, the exemption for electricity production in the tax on coal will be reintroduced on 1 January 2016. The connection between these arrangements as set out in the Energy Agreement will be anchored in separate agreements between central government, individual companies, and the environmental movement.

To achieve an entirely sustainable energy supply system in the long term, the capture, use, and storage of CO_2 (“CCS”) will be unavoidable. CCS can be applied both by industry and by gas and coal-fired power stations. Central government will take steps to produce a long-term strategy regarding the role of CCS in the transition to such an entirely sustainable system.

Mobility and transport

The seventh basic component of the Energy Agreement consists of mobility and transport measures intended to make traffic and transport more efficient and mobility more sustainable. The parties have agreed on ambitious targets, namely a 60 % reduction in CO_2 emissions by 2050 (compared to 1990), with a reduction of 25 Mton (-17 %) in 2030 in direction to attain that target.

Employment opportunities

The Energy Agreement will produce significant employment opportunities in the installation and construction sectors and in the longer term in the renewable energy sector; this is the eighth basic component of the Energy Agreement. The aim is to capitalize on these opportunities and in the period from 2014 to 2020 to create at least 90,000 additional full-time equivalents.

Energy innovation and energy export

The ninth basic component focuses on energy innovation and energy export. The aim is for the Netherlands to be in the top 10 of the cleantech rankings by 2030. That will be possible by excelling in smart sustainability solutions as a result of an inviting climate for investment and growth for both existing and new cleantech companies.

Funding programme

The tenth basic component will be an extensive funding programme focusing on freeing up the enormous amount of investment needed for the transition envisaged in the Energy Agreement. Agreement has been reached with financial parties and various umbrella organisations (the Dutch Banking Association/NVB, the Dutch Association of Insurers, and the Federation of the Dutch Pension Funds) on an approach that will make it attractive to invest in energy saving and renewable energy. A funding programme will also be designed to improve the financing feasibility of major renewable energy projects. The programme will also focus on smaller and often decentralised projects that find it difficult to create an effective financing structure.

3.5 Poland

Poland, as a member of the European Union, is involved in creation of the common EU energy policy, and also in implementation of its main objectives in specific national conditions with taking into account the protection of the customer's interests, owned energy resources and technological conditions of production and transmission of energy.

Industry is still the economic sector in which there is the greatest demand for energy, however it decreased from approx. 38 % in 2000 to 30.5 % in 2011. Energy-consuming industries are responsible for about 60 % of the total industrial consumption. A significant increase in demand occurred at the same time in the transport sector (from 16.8 % to 25.4 %). The share of household consumption varies, within the limits of 27 – 29 %, while the share of agriculture fell down from 7.7 % to 5.2 %.

In 2012, the electric power installed in the national power system was 38 029 MW, of which 26 263 MW came from the system power plants. Electricity production was approximately 162 TWh, while electricity consumption accounted for approx. 160 TWh and it was higher (by 0.76 TWh) in comparison with 2011.

The generation of electricity is based on hard coal (49.9 % in 2011) and brown coal (33.3 % in the same year). However the fastest growth is observed in area of renewable energy resources: from 8.0 % in 2011 to 10.4 % In 2012. Usage of natural gas also increased from 3.6 % to 3.9 %.

Hard coal is mined out in two regions: the Upper Silesia and Lublin Coal Basin. Balance of coal mining in 2012 amounted to approx. 79 million tons. The total geological resources of coal in Poland stands at 68.3 billion tons, including the level of balance resources of 48.3 billion tons.

In 2012 there was mined in Poland about 4 297 million m3 of natural gas which is about 30 % of the domestic consumption. Recoverable natural gas resources in Poland for December 31, 2011 amounted to approx. 92 billion m3.

The annual fuel consumption in Poland amounts to approx. 22 million tons. Majority of the demand is covered by in-country production, which is mainly based on imported crude oil. Poland is dependent on the supply of this raw material of approx.25 million tons per year. In-country production covers 2 - 3 % of total demand only.

Taking into account the specificity of the Polish energy sector, the basic directions of Polish energy policy are as follow:

1) Improvement of energy efficiency,
2) Increasing security of fuel and energy market,
3) Diversification of electricity generation structure by introducing nuclear energy,

4) Development of renewable energy sources, including biofuels,
5) Increasing competition in the energy market,
6) Reducing the impact of energy on the environment

1) The first issue of the new energy policy is to improve the energy efficiency. It is defined as a priority and a key for the rest of the strategy. Strategies of keeping zero economy growth and consequent reduction of the specific energy consumption to the level of the EU-15 are the main objectives of the policy. In 2012, Ministry of Econimy developed regulations implementing the Energy Efficiency Act, which allowed the President of the Energy Regulatory Office to call for tender for efficiency certificates in 2013.

   In addition, the Ministry will stimulate the development of high efficiency cogeneration (process encouraging a reduction in fuel consumption for energy production, and thus - reducing emissions and reducing fossil fuel consumption), to support investments in energy conservation and research. For the effective friendly energy use, information and education campaigns will also be conducted.

2) It is planned to increase security of fuel and energy production based upon own resources, mainly hard and brown coal. This would ensure the independence of the Polish power and heat generation terms from foreign suppliers and enable sourcing of raw materials from indigenous sources. Also, the development of cross-border connections is planned.

   In addition, it is assumed to create a stable outlook for investment in generation and transmission infrastructure. Operators will be obliged to detail planning: network development plans, location, capacity and cost of connection.

   It is also planned to change the legislation defining the liability of the local government for the preparation of local plans for heat, electricity and gas fuels.

3) Ministry of Economy has especially pointed on diversification of electricity generation and is going to enter the Polish nuclear power program as the third pillar of the policy in next years. For the first plants of this type, it is necessary to prepare an appropriate legal infrastructure, organization and ensuring conditions for the construction and operation of nuclear power plants based on proven, safe technologies.

4) Direction to increase the use of renewable energy sources is in accordance with the objectives of the climate package. By 2020, the plan is to achieve 15 % the share of renewable energy sources in final energy consumption and 10 % share of biofuels, especially of second generation in the transport fuel market. The Ministry will support the development of agricultural biogas plants and wind farms on land and sea, also through a system of co-financing from European funds and environmental protection.

5) Increasing competition in the energy market is the next main road designated by the energy development strategy. Ensure stable operation of the market through the implementation of relevant provisions, preventing excessive price increases and protection of vulnerable customers are the main reasons associated with the policy increase the competitiveness of the market.

6) The last issue that was taken into consideration in the Polish energy policy until 2030, is to reduce the impact of energy on environment. Proper ways for reduction of CO_2 SO_2, NO_X emissions were identified. The approach would permit the fulfillment of international commitments, while reducing the need to introduce significant changes in the structure of production. It is planned to create a management system for national limits on emissions of greenhouse gases and other substances will be introduced acceptable product emission factors. In addition, the Ministry will develop a system to dispose of the proceeds from the auctioning of CO_2 emission allowances. It is also planned to support the technology development of carbon capture and storage (CCS), as well as the implementation of the obligations arising from the new ETS Directive.

The Polish Energy Policy until 2030 is focused primarily on security of energy supply, energy efficiency and legislative processes that shape the functioning of the sector. The information in this field, prepared by the Ministry of Economy, was accepted by the government on excepted on 30 December 2013.

In August 2014, the Ministry of Economy has prepared an update version of existing document entitled "Polish Energy Policy until 2050." It was addressed to the public consultation now. The document indicates three operational objectives which are designed to achieve the main objective of ensuring the energy security of the country; increase the competitiveness and efficiency of the national economy and reducing the impact of energy on environment. Poland should strive for energy independence and therefore indigenous resources of hard and brown coal will stabilize country's energy security. On the other hand, when it comes to brown coal was concluded that it is important to maintain the protection of deposits of strategic planning, so as to guarantee the possibility of their use in the future. The direction of clean coal technology development will be one of the main reasons of economic efficiency of electricity generation based on coal.

The leading sustainable scenario assumes the continuation of current trends and implementation the decisions taken in the development of Polish energy sector. The two auxiliary scenarios have a character of analytical options. The first of them - a nuclear scenario - provides the dominant role of nuclear energy in the energy balance Polish, and another - gas + renewables - is based on the assumption launched in Poland on a large scale exploitation of natural gas from unconventional sources and the development and dissemination of technology, the production of energy from renewable sources.

Within the scenario of sustainable structure of the Polish energy balance is to be diverse in terms of raw materials and the share of the various media will be shaped evenly at approx. 15 - 20 % with the exception of solid fuels, whose share will continue to be dominant. The sustainable scenario also provides a balanced introduction to the nuclear power plants, generating new sources of natural gas and increased use of renewable energy sources, including a micro-sources and development of the energy sector prosumer, as well as the increased use of biofuels in transport.

The nuclear scenario assumes an extension of an ongoing nuclear program, ensuring the share of electricity produced from nuclear power plants in the energy balance at the level of 45-60 % significantly higher than currently expected. As highlighted in the design implementation of this scenario requires high capital expenditure incurred on the implementation of the nuclear program in an enlarged scale. However, these expenditures would be noted largely by offset of the relatively low cost of obtaining fuel (uranium and nuclear fuel cycle services) and a reduction in costs associated with the accumulation of carbon dioxide (CO_2). The share of other energy carriers is balanced on a similar level. Hard coal and brown coal cover level of 10 -15 %, oil of approx. 10 - 15 %, natural gas of up to 10-15 % and renewable energy sources at approx. 15 %.

3.6 Romania

3.6.1 Introduction

The Romanian and European Union (EU) energy evolution and geo-political realities require the development of a new energy strategy (2015-2035), by revising the existing one. in order to establish "the optimal energy scenario" it is needed to enabling securing energy supplies, a more efficient and secure operation of the National Power System (NSP), a more efficient electricity market, preparation conditions for the participation of the electricity market in the European common market and the decrease of dependence on imports. The consultation process reveals that the revised Energy Strategy should be based on the following main principles, respectively:[1]

- keeping a diversified and well balanced energy mix;
- increasing the energy security by replacing the aged generation capacities and by efficient use of our indigenous energy resources, including coal (still an important source for Romania);
- developing nuclear energy, essential to achieve Romanian decarbonisation targets;
- providing the use of the energy efficiency potential;
- encouraging the involvement of local capital in investments in the energy sector and building an attractive and predictable environment for investors;
- cautions, cost-effective and sustainable approach for the development of renewable energy with an emphasis on sustainable biomass potential;
- clear rules for vulnerable consumers in the context of the energy price increases;
- consolidating the management of the state-own companies of the energy sector.

3.6.2 Primary Energy Resources

Non-renewable energy resources

- Lignite reserves of about 1490 mil. tons (276 mil. toe);
- Hard coal reserve about 755 mil. tons (422 mil. toe);
- Oil reserves about 74 mil. tones (72 mil. toe);
- Natural gas reserves about 185 billion m3 (159 mil. toe);
- Existing and exploitable uranium are reserve provides the natural uranium demand natural up to 2017, used for the operation of two nuclear power plants at Cernavodă.

[1] Energy Department. Set of principles underlying the new energy strategy for 2014-2035. Bucharest 2014.

Renewable energy resources

Renewable energy resources (National Action Plan for Renewable Energy Resources - PNAER - 2010) with estimation of annual potential:

- solar energy
- thermal, 60 PJ
- photovoltaic, 1.2 TWh
- wind turbine, 23 TWh
- hydraulic energy, 32 TWh from which under 10 MW, 6 TWh developed 54 % nowadays;
- biomass and bio-gas, 318 PJ
- geothermal energy, 7 PGJ[2].

Romania will remain partially dependent on imports of primary energy. Romania has a dependency on energy imports of 21 % (was 18-20 % in 2009-2013), while the European average is 53.8 %. Thus, the potential of our country, in conjunction with regional position, provides an important perspective of development[3].

3.6.3 Energy Generation and Consumption

Consumption

The gross energy consumption per capita (1,8 toe/capita) of Romania, is about two times lower than the EU average consumption. Annual domestic generation of primary energy is about 28 mil. toe. Gross consumption of primary energy annually is about 38 mil. toe. The difference of about 10 mil. toe shall be covered by imports or by additional generation in the country. In 2010, the primary energy consumption registered was 34.2 mil. toe.

According to the PNC (National Prognosis Commission) until 2017, Romania has forecast an average economic growth of 2,64 %/year and, according to Eurelectric Power Statistics (December 2012) of 2,7 %/year in the period of analysis respectively from 2012 to 2030. In 2020 electricity consumption will be 20 % higher than 2013 and in 2030 by 42.5 %. Inputs made in 2013 and 2014 are lower than projected in this optimistic vision. Heat generation for industry and district heating is achieved by thermal plants (TP) and power plants (TTP). After 1990, consumption mainly decreased due to reduction of the industrial consumption. About 80.000 housing units, with about 3 million apartments, and 7 million residents and a large number of institutions and companies are supplied from the heat centralized systems.

2 *GD nr. 1.069/ 2007. “The Romanian Energy Strategy for 2007-2020”..Cap.1. pg.4,5,6.*

3 *Energy Department. Orientations strategic in energy sector of Romania, in perspective year 2030. Bucharest 2014.*

Power Generation

Evolution of power generation for the period 1999-2009 is presented in Table 1. During the first part, it has been an increase in generation, leading in 2006 to be 24 % higher than in 1999, followed by a reduction of 9 % in 2009, lower than in 2006. After 2009, there is a slight increase.

Table 3-4: Evolution of electricity generation between 1999-2009 [TWh] Source: Energy Department

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Gen.	50.71	51.93	53.86	54.93	56.64	56.48	59.41	62.69	61.67	64.95	57.50

Status of the power plants from the National Power System

Thermal Power Plants

About 80 % of thermal power plants in Romania were commissioned in the period 1970-1980, exceeded their life span. Power units belonging to plants, because of the technologies of the 60s-70s and because of the wear, have low performance, around 30 % efficiency, except for some rehabilitated coal-operated units that reach 33-35 %. These efficiencies are 65-70 % of the modern units' efficiency with supercritical and ultra supercritical parameters.

Following the rehabilitation works completed or in progress, as well as the planned new units by the year 2025 - 2030, the thermal power sector will have an output of approx. 6500 MW.

Hydro-power plants

Hydro-power plants with an installed capacity of 6346 MW represent about 33 % of the total available installed power within the NSP. The annual generated power is about 17.5 TWh. The degree of the technical convertible energy potential (36 TWh/year) is about 50 %, while the economic convertible energy potential (30 TWh/year) is about 60 %. There have been rehabilitated through modernization, power plants of 1200 MW. The rehabilitation program for hydro-power plants until 2020 involves hydro-units rehabilitation with capacities of 2400 MW. From this generated power, 1090 MW power units are under rehabilitation and these works will be completed by 2015.[4] Construction of plants with an installed capacity of about 500 MW is in progress. For NSP safety and reduction of CO_2 emissions, it is necessary the execution and commissioning of Tarnita-Lăpustesti pumping station, with a power 1000 MW (4x250 MW). For the period 2015-2030 the hydro-power sector will have a power of about 6500 MW.

[4] *Energy Department.* 14. *Orientations strategic in energy sector of Romania, in perspective year 2030. Bucharest 2014.*

Nuclear power plant – Cernavoda NPP

Nuclearelectrica owns at Cernavoda NPP, 2 nuclear plants with a power of 706,5 MW each, equipped with CANDU 6 reactors that use natural uranium as fuel and heavy water as coolant and moderator. For the period 2015-2030 the nuclear sector will have a power of 1413 MW or more. Between 2030 and 2050 the nuclear industry should continue to have an installed capacity of at least 1413 MW. This program is necessary to maintain the operation of existing utilities: nuclear fuel factory, heavy water plant and site work already performed at U3 and U4 at Cernavoda NPP, for strategic and socio-economic reasons.

Electricity generation using renewable power sources

The total installed electric power capacity of RES, which have received support through green certificates system in 2013 is 4417.66 MW.This 4417.66 MW of installed and put into operation in RES, so far, 63 % are wind power plants, 23 % are photovoltaic power plants and 12 % are hydro power plants.

Table 3-5: Electricity generation using renewable power sources – Data source: Transelectrica

Type of resource		2008	2009	2010	2011	2012	2013
Wind power plants	MW	6,91	14,16	370,27	826,04	1.822,04	2.782,55
Photovoltaic power plants	WM		0,08	0,10	1,01	49,33	1.022,04
Hydro power plants	MW	40,41	74,36	75,94	380,84	425,64	530,03
Biomass power plants	MW	-	8,08	23,33	25,25	39,82	82,95
Total	**MW**	**47,31**	**97,47**	**469,55**	**1.233,13**	**2.336,82**	**4.417,66**

Daily RES average was 1900 MW wind, 100 MW solar and 34 MW biomass which represented 27 % of total electricity generation.

Renewable energy (targets), especially for 2030

National efforts are targeted towards achieving the objectives agreed at EU level in the field, respectively for the 2020 horizon. The RES national target of 24 % was already accomplished in 2014.

There are serious concerns regarding the capacity for Romania to contribute to achieving the EU target of 27 % by 2030, as proposed by the European Commission. The new energy strategy (2015-2035) must establish Romania's contribution to CO_2 reduction program for 2030 and based on this, its preliminary contribution for 2050 Energy mix.

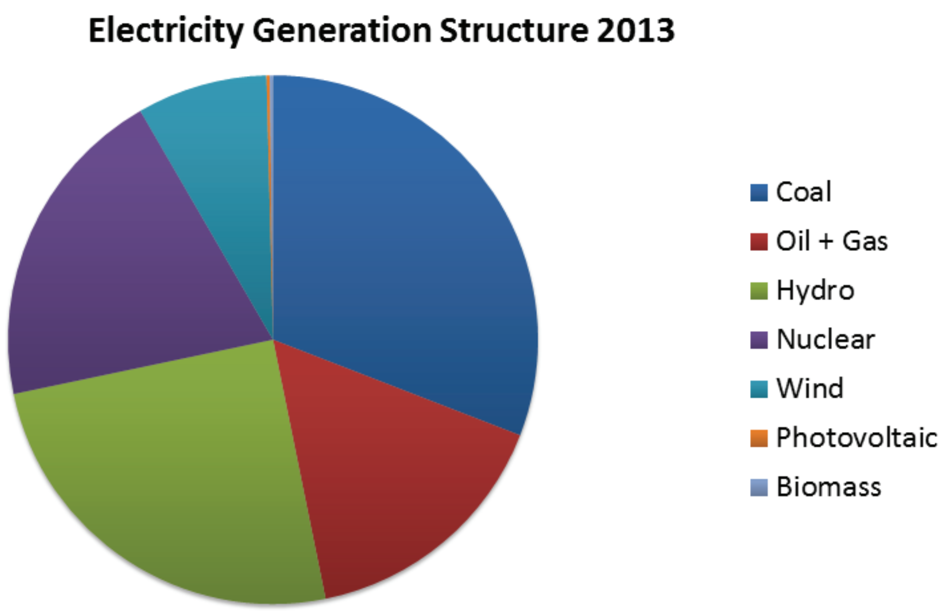

Figure 3-1: Electricity generation structure in 2013 (Source: Energy Department)

The optimal energy mix shall be determined by the new energy strategy, allowing efficient operation of the electricity market, secure and efficient operation of the NSP. The generation structure result is: about 54 % without CO_2 emissions and about 46 % with CO_2 emissions.

3.6.4 Security of supply

The indigenous energy resources (both conventional and unconventional) will have a substantial contribution to the Romanian energy security; also, the potential of the Black Sea gas resources and shale gas will be taken into consideration in order to reduce Romania's energy imports. Nuclear energy will continue to play an important role in ensuring the security of supply. The high potential of hydropower and renewable energy resources is an advantage in providing security of energy supply.[5]

The National Power System represents the basic infrastructure, used by participants in the electricity market, increased interconnection with neighboring countries and electricity market coupling, will contribute to the increase of energy security; also, reinforcement of national grid, aimed to overtake important energy flows coming from RES and the nuclear sector are foreseen. The EU energy policy, set out in the Energy Strategy distribution of fuel, power and heat.

[5] *Ibidem*

There is a strong need of investments in three areas[6]: production (the replacement of old capacities); balancing the system (to face the high increasing deployment of RES); energy interconnection (one of the national priorities is the energy interconnections with the Republic of Moldova); transport and distribution.

3.6.5 Energy efficiency

Energy efficiency is the most cost effective way to reduce emissions, improve safety and decrease the energy bill.

The strategic objective of National Strategy for Energy Efficiency (G.D.1613/2004), is reducing energy intensity (consumption) by 40 % by 2015, compared to 2003 and primary energy saving by 2.12 million toe / year.

The target goal of the National Action Plan for Energy Efficiency (2007-2010) and (2011-2014), is a reduction by 13.5 % by 2016 (with an annual average of 1.5 % for the period 2008-2016) and 2.8 mil. toe., in relation to the consumption during 2001-2005, of 20,84 mil. toe. The intermediary target for 2010 was set to 0.94 mil. toe corresponding to 4.5 %. Between 2004 and 2010, it was achieved a decrease of consumption by 2,223 mil toe, The representative synthetic indicator of energy use efficiency at national level is energy intensity, By investing in the energy sector so as to increase energy efficiency is sought on the potential national energy savings, reducing energy losses, estimated at 27-35 % of primary energy resources (industry 20-25 %, 40-45 % buildings, transport 35-40 %).

3.6.6 Environment

According to the national inventory, of emissions of greenhouse gases achieved by our country in 2012, GHG emissions related to energy sector in 2010 accounted for about 70 % of the total. To comply with future energy national development priorities including using its own coal resources, our country has taken all laws to promote technology to CO_2 capture and geological storage (CCS). Through the strategic document for year 2050, EU refers to a reduction in emissions from the energy sector by 93-99 % compared to emissions in 1990. For 2050, it is desired that 100 % of the energy mix to be achieved through technology based on low carbon. A realistic program is that of extending the lifetime, of the U1 and U2, and commissioning of U3 and U4, to deadlines that allow an available capacity of at least 1413 MW. The final scenario will be set-out in the new Energy Strategy (2015-2035).

[6] *Energy Department. Orientations strategic in energy sector of Romania, in perspective year 2030. Bucharest 2014.*

3.6.7 Strategic orientation for medium and long term

Based on the new energy strategy, the Romanian proposals for EU energy strategy 2030 and preliminary proposals for EU energy strategy 2050 may be underlain. An energy mix is estimated for 2020-2030, comprising: coal (25-30 %), hydro (25-30 %), nuclear (20-25 %), renewable (15-20 %) and natural gas/ hydrocarbons (8-10 %). In this preliminary version of the energy mix, about 65 % of electricity generation (hydro, nuclear and renewable) is CO_2-free. The remaining 35 % of generation will be, on coal and gas with reduced CO_2 emissions through the development of large coal-fired units with supercritical and ultra-supercritical parameters and combined cycle gas units. It is estimated that after 2030, the CO_2 capture and storage facilities can be commercially used. Through the installation and commissioning of these facilities the CO_2 emissions in power plants will be reduced.

The energy mix will allow:

- secure operation of NPS and providing reserve power for ancillary services
- increase in efficiency accomplishment of emission reduction targets for 2030 and further;
- economic exploitation of over 75 % of economic hydropower potential of Romania and indigenous coal and lignite resources exploitation over time
- substantial increase in energy independence; in case of natural gas exploitations in the Black Sea and possibly some shale gas, only after clarifying the environmental issues and exploitation acceptance, remain dependent only on imports of uranium

3.7 Slovenia

Elements of the future Slovenian national energy plan

3.7.1 Introduction

Life requires energy, but all its resources cause various nearby effects. It is agreed that fossil fuels produce various emissions that are detrimental to the environment. The EU member states agreed to achieve two goals: reduction of greenhouse gasses and conservation of energy in everyday use. That in turn requires a significant change in the structure of the energy resources used. Countries and the EU as a whole are faced with the existing energy structure which varies from country to country. Therefore, the measures to be taken could be significantly different.

The basis for energy measures towards a sustainable energy system in Slovenia is the following:

- Use of country's available energy resources,
- Increase efficient energy use,
- Support efficient renewables,
- Strive for low carbon energy use.

For that purpose, an agreement should be reached with the industry regarding its plans of economic development as well as the national plans for development and restructuring of the transport and heating/cooling systems, which are the main targets of the efforts to reduce fossil fuels use. Among them, natural gas is viewed as a transient energy source.

3.7.2 Current State

Slovenia is a net oil and gas importer. Electricity production is based on a balanced mix of 34 % hydro power, 20 % nuclear, and 37 % coal, the rest is supplied by natural gas and small scale renewables. 20 % of further nuclear production is supplied to Croatia by a long term contract.

Currently, the electricity consumption reaches up to 13 TWh. A new lignite coal plant unit entered operation in 2014 and takes care of load-frequency control along with the hydro-power plants ensuring quality of electricity supply and stability of power system operation. It is scheduled to operate until 2045. There are two wind power plants installed and together with other renewables reach 1260 MW of installed power.

Until 2014, the renewables, especially PV production was heavily subsidized via feed-in tariff scheme, which was ultimately drastically limited due to a lack of funds. Thermal power plants are, except for the new one, scheduled to be eliminated from operation and one has been already shut down.

The network is in a relatively good condition with strong 400 kV tie-lines to the neighboring countries. Only a 400 kV line to Hungary has to be built and plans for it are almost prepared.

The distribution network needs refurbishment and replacement of ageing elements. The renewables will require significant change in mode of operation using of smart technologies (smart grids) to control the energy injection from new distributed renewables.

3.7.3 Main components of the Energy Plan

Basic Goals

Several factors will influence the growth of consumed electricity. Among them are: electric mobility, changes in metal-processing heavy industries, and energy saving plan in consumers regarding heating and hot water supply. Two target dates have been set: 2035 and 2055.

By the year 2035: To decrease the greenhouse gases emission by 40 % compared to 1990 status, improve the energy efficiency by 35 % compared to 2005, achieve 30 % of renewables in final energy consumption.

By the year 2055: To decrease the greenhouse gases emission by 80 % compared to 1990 status, ascertain low carbon generation of electricity, reach 100 % energy efficiency of the renewable energy resources compared to 2005 status, reduce the carbon emission by 70 % compared to 2005 status, and sustain heating with low carbon resources.

In addition, the energy dependency on import is one of main concerns. Change of energy consumption patterns may bring significant reduction of energy sources imports and offer new perspectives for developing additional industrial development and improving the employment.

Energy efficiency and energy saving

Energy efficiency is a key factor helping reduction of energy consumption and energy imports. The measures will be taken in all sectors: generation, transport and general use of energy by changing the attitude and cultural aspect towards energy.

The structure of energy carrier change will lead to higher electricity consumption. The heat pumps, industrial use of electricity, and e-mobility will contribute their share. Renewables will be scaled up to meet that demand.

Heating systems

About 40 % of energy is currently spent for heating and industrial use. The heating systems will be scrutinized and paid attention to. Insulation of buildings will further reduce the use of heating energy.

By 2055, 100 % of heating is planned to be supplied by low carbon systems. Individual heating systems as well as remote heating networks will be supplied by biomass, heat pumps, geothermal energy and residual heat from the industrial processes.

The plan encompasses thermal insulation on government buildings. Incentives will be given for thermal insulation of other buildings. A significant energy saving may be reached with the heat pumps in household use of hot sanitary water.

Electricity and energy carriers

Fossil resources

Use of fossil energy carriers will be reduced and finally abandoned. New investment in fossil technologies won’t be allowed any more. Two thermal power units are in the process of being shut down and one of them is only foreseen to be used for tertiary reserve for a short period.

After 2055, use of coal i.e. lignite in existing power plants will be forbidden. Accordingly, the domestic extraction of coal and lignite will stop.

Use of natural gas is somewhat more acceptable regarding the GHG emissions and is still important in the industrial production. It will be used to support the electricity generation from renewable energy due to its variable and uncertain generation. Until 2055, natural gas will be used in district heating and heavy loads traffic. Some domestic natural gas reserves will still be used.

Up to 2035, heating oil use will be halved. In 2055, the oil usage will be terminated.

Renewables

Two goals have been adopted: 30 % of the final energy consumption will be covered by renewables by 2035, and 100 % of renewables potential will be reached by 2055. The share of renewables is foreseen in all segments of energy use. Among them are all segments, which do not disrupt the food chain. Promoted will be hydro power plants, hydro thermal energy, photovoltaics, wind energy, biogas and biomass.

Efforts will be given to exploit all potential of our rivers by 2035. For full exploitation of renewables, legal and other aspects will be adjusted to achieve equilibrium in environmental, economic and social development by adequate political measures. The introduction of net metering is promising.

Nuclear

Nuclear energy plays a significant role at reducing the carbon emissions in production of electricity. Its use is planned after the life span end of the existing nuclear plant. It is planned to prolong its operation for another period up to 2055.

It is of vital importance to assure the safe operation of the existing plant. Furthermore, a proper strategy will be adapted to responsible and economic treatment of the radioactive waste.

Mobility and transport

Currently, about 40 % of energy is spent in traffic, coming from imported oil. By use of alternative sources, as for instance electricity and gas, the reliability of supply may be improved significantly and GHG reduced accordingly. For that purpose, they will be reduced by 30 % by the year 2035. Furthermore, the goal is to ensure 100 % electric mobility in personal and public transport by 2055.

It is planned that natural gas use will be stimulated in transport. Electrification will be carried out in the railway system, and low carbon fuels will be used in other transport sectors.

Networks

The power transmission system is relatively well interconnected; two more interconnecting transmission lines are planned. The distribution network will undergo significant adaption by taking over almost a half or electricity production, which will be achieved by introduction of smart network techniques.

One of the problems is quality of delivered electricity. Ancillary services are of main concern after phasing out the thermal plants.

Energy market

For the formation of internal EU market, serious effort is needed to remove all obstacles regarding different energy concepts, highly subsidized electricity prices, which distort the market, different energy resources and different member countries policies needed to supply electricity to the consumers at an acceptable price. One of the main problems seems to be the difficulties with energy corridors and their acceptability by the population.

Current action

The goals set in the energy development concept require a set of measures to be formed and thoroughly executed by the government, which is faced with relatively fast process of energy carriers' use transition. The process requires significant changes in the structure of energy carriers use. RES introduces a strong fluctuation in quality of supplied electricity, and accordingly, with its prices in different member states and EU parts. The government is faced with high level of investment in renewables in form of feed in tariffs and problems in the energy carriers' changes since the market did not and does not remunerate any additional investment in renewables and there is a little help from private funding.

The common energy system is envisioned, which has to take into account high differences of the electricity production structures in the member countries. Their convergence across the member states requires a lot of time, governments' efforts, and profound changes in mode of operation of electric power systems requires a high quality of delivered electricity, for instance.

However, the problem is an additional component of the consumer's price, which makes a double or triple value of the electricity market price. It is pertaining to the cost of government spending for renewables, which have practically no private investment counterpart. As it appears, the market is devoted more or less to filling the money to the private pockets since it does not return to investing in the power industry.

Under said conditions, the government is facing the following problems in order to achieve reduction of GHG emissions:

- Enabling to utilize the country's own resources in era of ever dropping subsidized renewable energies prices.
- Setting the proper feed-in tariff for a specific renewable in a context of rapid developments of generation technologies (electricity and carbon storage, higher efficiency of photovoltaics, more acceptable nuclear generation of electricity, etc.).
- Securing the quality of electricity under ever changing production conditions.
- Funding the adaptation of distribution networks and deployment of smart grids technologies.
- Employing industry in the new technologies,

These factors will influence the future's development of the country's energy concept.

3.8 Switzerland

The new Energy Strategy of Switzerland

Following the accident in the Fukushima nuclear power plant, the Swiss government decided to phase out nuclear energy and the five nuclear power plants in Switzerland once they reach the point of maximum operational safety. At the same time, energy consumption and energy-related CO_2 emissions are to be reduced and the share of renewable energy increased – without compromising the hitherto high safety of supply and affordable energy supply in Switzerland. Truly a very high goal!

The current situation

The net electricity production has been reasonably stable for years. It was around 66 TWh in 2012, which corresponds approximately to the Swiss annual consumption. In winter, however, production is unable to meet consumption which is higher than in the summer months. This is why Switzerland has to import electricity during the winter. 60 % of the local electricity production is renewable, mainly hydropower. The total yield of energy from solar, biomass, biogas, wind and waste amounted to only 3 %. Approximately 37 % of the net electricity production is supplied by the five nuclear power plants; the rest is generated by conventional thermal power and district heating plants.

How to implement the new Energy Strategy

The Swiss government, the Federal Council, has drawn up three different scenarios to implement its goals by 2050, the phasing out of nuclear energy, the reduction of final energy and electricity consumption, and the increase of the share of renewable energy and reduction of energy-related CO_2 emissions.

Scenario 1 "Business as usual" focuses on measures and indicates which energy demands and energy offers result after the nuclear power plant exit. Energy policy measures and laws remain unchanged.

Scenario 2 "New Energy Policy" shows the development of the energy consumption and electricity production (including phasing out of nuclear energy) with the goal of reducing CO_2 emissions by 2050 to 1–1.5 tons per capita. (Today: over 6 tons)

Scenario 3 "Political action" shows how concrete political measures of the energy strategy have an impact on energy demand and electricity supply.

In 2012, Switzerland imported around 87 TWh and exported 89 TWh of electricity, while the gross domestic consumption amounted to approximately 63 TWh. These figures show that Switzerland is closely linked to the continental power grid as an electricity hub (trade and transit). The existing high burden on the transmission network has already led to production constraints; the transmission capacities at the borders have been exhausted. The high voltage grid must be partly renewed and expanded, mainly because of the German developments with an extremely large increase in the supply of electricity from renewable energy with significant variations. In addition, the four pumped storage plants under construction or planned require corresponding transmission lines. The new installations increase pump power from today 1.7 GW to 6 GW. This additional power can contribute significantly to the temporary storage of fluctuating, renewable energy in the future.

Central measures for scenario 2

- Increased efficiency of electrical appliances and electrical equipment and systems through stringent efficiency and use instructions. Efficiency potential estimated 25 – 30 %.
- Target-setting process with industry and service companies to exploit the potential for efficiency with financial incentives.
- Reduction of the total energy consumption of buildings of 25 TWH by 2050 and of electricity by 12 TWH by energy renovation of buildings, self-sufficiency of heat and electricity, prohibition of boiler and electric heaters, substitution of fossil heaters etc.
- Massive expansion of new renewable energy and hydropower
- Tightening of emission standards for motor vehicles and promotion of electric vehicles.

Measures for scenario 3

- CO_2 reduction targets by 2035 including electricity production and district heating - 44 %

- Electricity demand by 2035 –15 %
- Increasing the CO_2 tax of CHF 70 per ton in 2020 to Fr 540.- in 2035
- Increasing the power output by 11 % in 2020 to 31 % in 2035

Political process

Currently, the government bill is discussed in the Energy Commission of the National Council. There were many amendments that caused a delay of about half a year. In autumn 2015 the National Council (People's Chamber) has discussed the Commission's request and decide. Subsequently, the same procedure will be performed in the Senate (council of state). In the spring 2016 both commissions had decided to spend SFr. 120 Mio. for extension big hydro powerplants. They also will spend Sfr. 30 Mio. from the CO_2 Fund (Yearly earning about SFr. 450 Mio) for building geothermal heating power plants and spend money for developing geothermal electricity power plants.

Approved amendment of the Commission of the National Council

- Instead of supporting small-scale hydroelectric power plants, new large-scale hydroelectric power plants will receive start-up funding.
- Other changes have not been published. The negotiations are not public.

Fundamental comments

The bill includes very ambitious targets, which are very difficult to achieve. In cooperation with the ETH Zurich, the "Swiss Academy of Engineering Sciences SATW" carried out a study concerning the government’s energy strategy. The aim was to clarify by means of model calculations whether the three scenarios of the Federal Council provide a reliable power supply in Switzerland. The result – to be found under satw.ch, energy study 6.2014 – clearly affirms this, provided that electricity imports are possible. Since a decrease in current consumption by 15 % by 2035 is highly questionable, the authors also calculated the base of the IEA with an increase in consumption of 50 % by the year 2050. With this assumption, Switzerland has to import 30 % of their electricity consumption in 2050. Whether this will be possible cannot be predicted with certainty.

3.9 Differences and commonalities in the member states’ programs

The task force made a survey on the national energy programs of their home countries. The main result of the survey is that there are big differences in the current situation of producing electricity in the individual countries (see Figure 3.2).

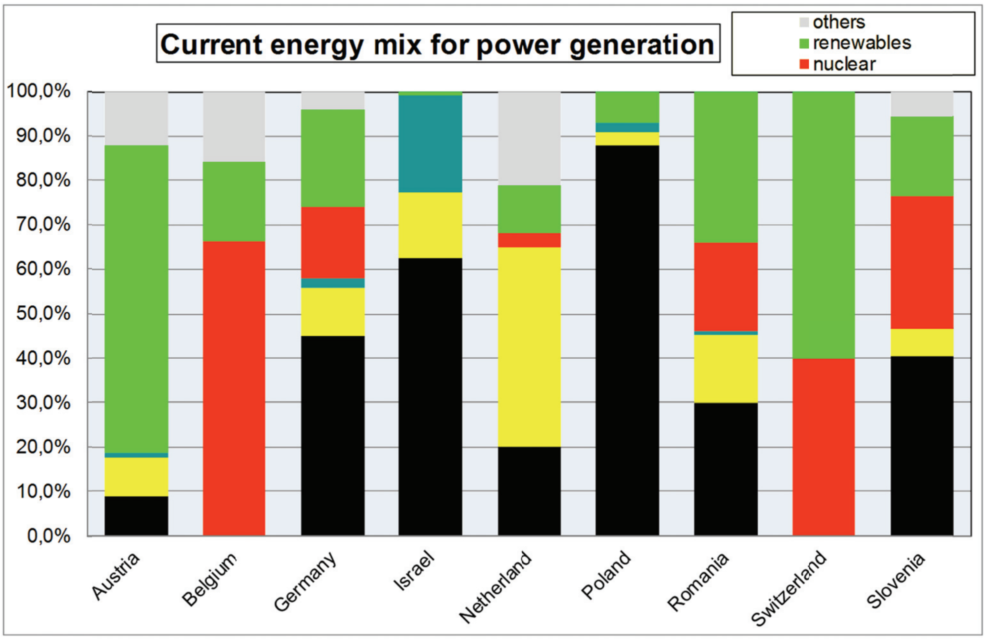

Figure 3-2: Result of the questionnaire

Although we have investigated only 8 of the 28 countries of the EU, the picture for the rest of the EU member states would not be very different. And the survey also shows clearly that there are quite different strategies in these countries for the next and the further future of their energy supply approach. Of course this is partly the consequence of their past, their geographical situation and their political will. But it also shows that for the EU it is extremely difficult to establish a common EU energy program to be accepted by all member states.

Since in all countries of the EU the classical resources in primary energy will come – at least on longer term - to an end except for nuclear, the basic direction of all countries will point to renewable resources to secure their energy supply. Main resources will be water and wind power and solar energy, to a smaller extend also bio mass. In the future geothermal resources may play some role in the energy mix for producing electricity. But this is not given jet. But geothermal resources are and will play a big role in producing efficient heat energy and cooling (substitution of air condition systems) with borehole heat exchanger and§ heat pump

Figures 3.3 and 3.4 show the potential of solar and wind energy in Europe. While the wind potential is much bigger in the northern parts of Europe, especially on the North sea, the Baltic sea and the Irish sea (Figure 3.3), the radiation of the solar power is strongest in the southern regions of the European continent (see Figure 3.4).

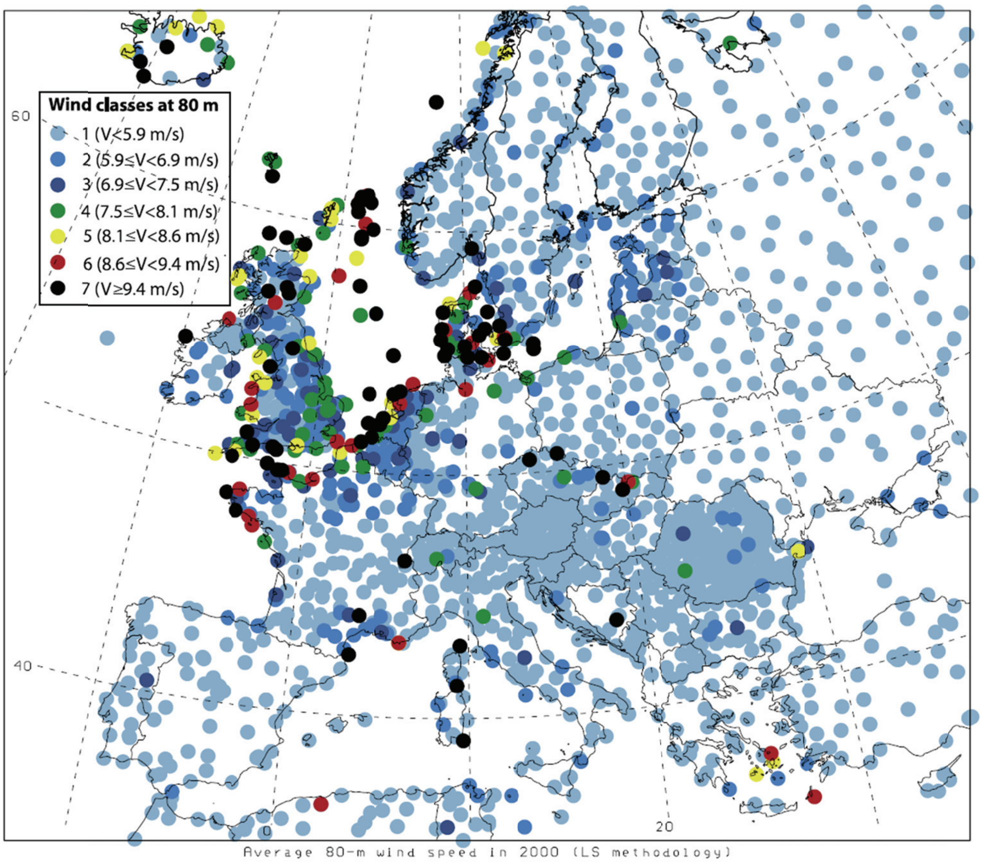

Figure 3-3: Wind power potentials in Europe (Cristina L. Archer and Mark Z. Jacobson, Evaluation of global wind power, Stanford 2005.)

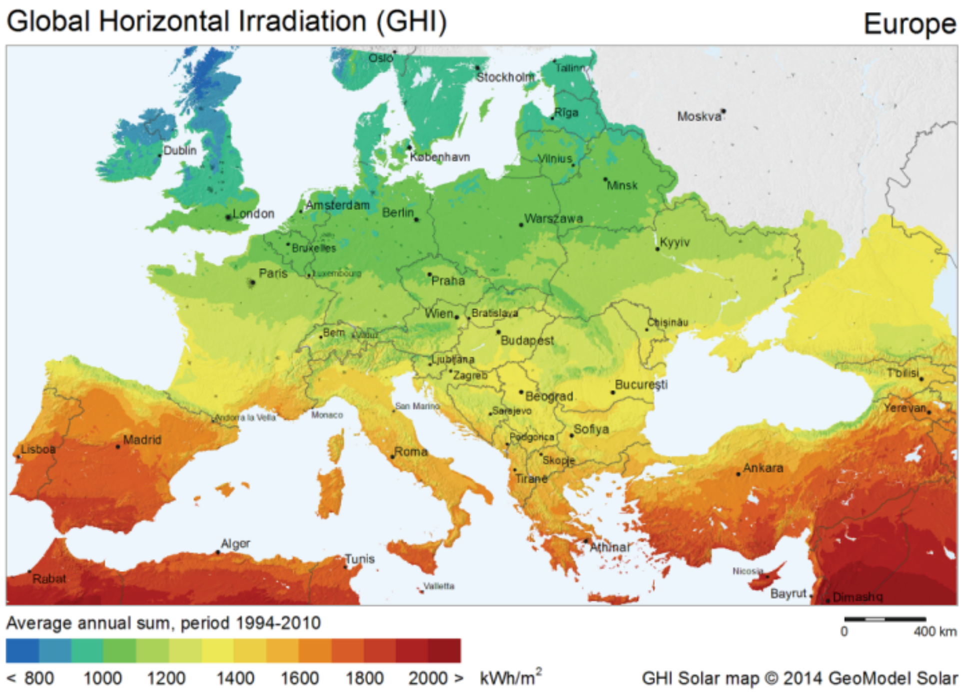

Figure 3-4: Solar energy potentials in Europe (GHI Solar Map © 2016 Solargis)

There is the idea of regional agreements to save fuel consumption for power generation. For example Austria has huge hydro-power resources and no coal, in contrast Poland has large coal reserves. By considering a joint electrical production of both countries the fuel consumption and the emission can be reduced reasonable.

Based on the above data and on the maps of wind and solar energy, the option of horizontal zones shows advantages. The north has larger wind power production while the south has larger solar energy potential. Regional transmission and smart management allows resource leveling.

This can be an approach for a new European energy policy.

4 Key Elements for Europe's future energy policy

4.1 Priority Setting

In 2007, the European Union's (EU's) council adopted energy goals aiming to reduce greenhouse gas emissions by 20 % (rising to 30 % if the conditions are right), to increase the share of renewable energy to 20 % and to make a 20 % improvement in energy efficiency. This targets aim at reducing primary energy consumption and improving the EU's energy independence. However, these goals will be hard to achieve by 2020. In 2011 the European Commission (EC) defined an energy strategy for the period after 2020, which is structured around 5 priorities:

1) Environment (implementing a low carbon system)
2) Strengthening security of energy supply
3) Increase energy efficiency in the sectors buildings, transport, industry, energy supply, products, (limiting energy use and energy losses in Europe, to define strict standards)
4) Efficient use of energy resources

This order aligns to the political and public opinion.

In contrast the ranking of the Task Force in a technical point of view is the following:

1) Energy resources
2) Efficiency
3) Security
4) Environment

Energy Resources and energy efficiency should be the key components of the European energy policy. Ensuring the supply of Europe with essential resources and to improve the energy efficiency can increase the security of supply and reduce the greenhouse gas emissions. From that the points 3 and 4 are consequences of the both first points.

4.2 Efficiency

4.2.1 Efficiency plan: to set efficiency goal

Energy efficiency plays a vital role in transition to renewable energy supply:

- The potential of renewable energy from hydropower, wind, photovoltaic, biomass and geothermal sources is limited by area and environmental consideration.
- Renewable energy has lower and higher periods of generation and needs stronger grids and has higher demand for ancillary services.
- Renewable energy has higher total system costs.
- Renewable energy needs short term and long term storage capacities.

Energy efficiency helps to reduce the energy demand and thus helps to reduce the investment costs and limits the environmental impacts. The European Union had in history and now some directives in direction of efficiency, here are the latest:

- Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives2004/8/EC and 2006/32/EC.
- Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.
- Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products.

The directive comprises a broad field of efficiency measures:

- Buildings renovation. The national stock of residential and commercial buildings shall be renovated by 3 % of the total floor area every year. Public bodies shall play an exemplary role in their buildings.
- From 2014 to 2020, a saving of 1.5 % of the annual energy sales to final consumers of all energy distributors or retail energy sales companies are expected.
- Energy audits and energy management systems shall be introduced in industrial and SME's.
- Metering has to be introduced for electricity, natural gas, district heating and cooling as well as for domestic hot water supply.

The households themselves stand outside of these measures and has no individual efficiency targets. But by the eco-design directive, only efficient appliances and other end-use equipment will be on the market available, bringing efficiency in the sector of end-use.

One problem in end use-efficiency is the rebound effect. Here a new efficient equipment is introduced, but the old inefficient is still used in parallel, causing higher energy demand. Incentives for less equipment of higher efficiency are also needed in future.

4.2.2 Electrical efficiency potentials

In 2005, a task force of VDE was set up to research the potential of efficiency increases in all electrical applications in order to save electrical energy. The aim of the VDE Task Force was firstly to identify technological options for improving energy efficiency in the various current applications, and secondly, to assess their quantitative saving effect.

For this purpose, the potentials for improving efficiency in the various sector of consumption like industry, transport, household and commercial, trade and service (CTS) were estimated on the basis of the current and future technological advances.

The application sectors are subdivided into the areas of process heat, space heat, mechanical energy, lighting, information and communication applications (I & K). The prognosis for 2015 and 2025 includes in addition to the improvements in power efficiency, also the decline in electricity consumption in the respective applications with the same functionality, quantitative changes in the number of equipment and systems in the respective periods, change in the power demand of a device or system by changing the scope of its functionality and new power applications (e.g. drives for heat pumps). That means, among other things, that in some areas of the power application, in spite of improved power efficiency, the absolute electricity consumption continues to rise significantly when the amount of devices and systems increases. If the aim of the policy is to reduce the consumption of electric energy, then it also means limiting the amount of power-consuming equipment and installations may be limited. This may lead potentially to a conflict with the economic interests of the country!

From the starting point in 2005, the study estimated the volume trends by 2015 or 2025. For example, in 2025 there might be 4 PCs per a household instead of 2 PCs in 2005, i.e. an increase of 50 %). In addition to the volume growth, the development of the electrical efficiency of the respective areas of application was estimated in each sector. It was also considered that substitutions take place, which will have an impact on the electricity consumption. For example, an oil or gas heating is replaced by a heat pump that requires an electric drive. Also recognizable new applications were included in the forecast. Air conditioners were not used in the middle or northern Europe in the past. But this will probably change in the future due to the level of living comfort and due to the climate change. For this, you can use a ground-coupled heat exchanger and instead of using air conditioners you directly pump this about 13 degree cold fluid in the heat cycle of the house. This kind of house cooling is nearly free of charge.

Including these aspects, Table 4-1 was prepared. Professionals from each application sector forecasted the probable changes in terms of quantity, efficiency, substitution and new application.

Table 4-1: Potential efficiency improvement and quantity increases in percent per decade for Germany in all electrical applications

Sector / Application	**Quantity change 2015**	**Quantity change 2025**	**Efficiency change 2015**	**Efficiency change 2025**	**Ultimate eff. goal 2015 1)**	**Ultimate eff. goal 2025 1)**
Industry						
Process heat	3,00 %	5,00 %	-4,00%	-8,00 %	-6,00 %	-16,00 %
Space heating						
Mech. energy	0,40 %	0,40 %	-5,00 %	-16,00 %	-8,00 %	-32,00 %
Lighting			-40,00 %	-10,00 %	-60,00 %	-20,00 %
ICT	0,00 %	0,00 %	-20,00 %	-10,00%	-30,00 %	-20,00 %
Transport						
Process heat	---	---	---	---		
Space heating	---	---	---	---		
Mech. energy			-5,00 %	-5,00 %	-7,00%	-10,00 %
Lighting			-40,00 %	-10,00 %	-60,00 %	-20,00 %
ICT	0,00 %	0,00 %	-20,00 %	-10,00 %	-30,00 %	-20,00 %
Household						
Process heat			-10,00 %	-10,00 %	-15,00 %	-20,00 %
Space heating	-5,00 %	-5,00 %	-5,00 %	-5,00 %		
Space heating	29,0 %	29,20 %			-10,00 %	-10,00 %
Mech. energy	28,90 %	28,90 %	-10,00 %	-25,00 %	-15,00 %	-50,00 %
Lighting			-40,00 %	-10,00 %	-60,00 %	-20,00 %
ICT	15,00 %	15,00 %	-20,00 %	-10,00 %	-30,00 %	-20,00 %
CTS						
Process heat	3,00 %	5,00 %	-2,00 %	-4,00 %	-5,00%	-10,00 %
Space heating	-5,00 %	-5,00 %	-5,00 %	-5,00 %	-10,00 %	-10,00 %
Mech. energy			-5,00 %	-15,00 %	-8,00 %	-30,00 %
Lighting			-40,00 %	-10,00 %	-60,00 %	-20,00 %
ICT	10,00 %	10,00 %	-20,00 %	-10,00 %	-30,00 %	-20,00 %

1) Economically and technically possible

On the basis of this input, the absolute power consumption in Germany was calculated in TWh. The results are summarized in Fig. 4-1.

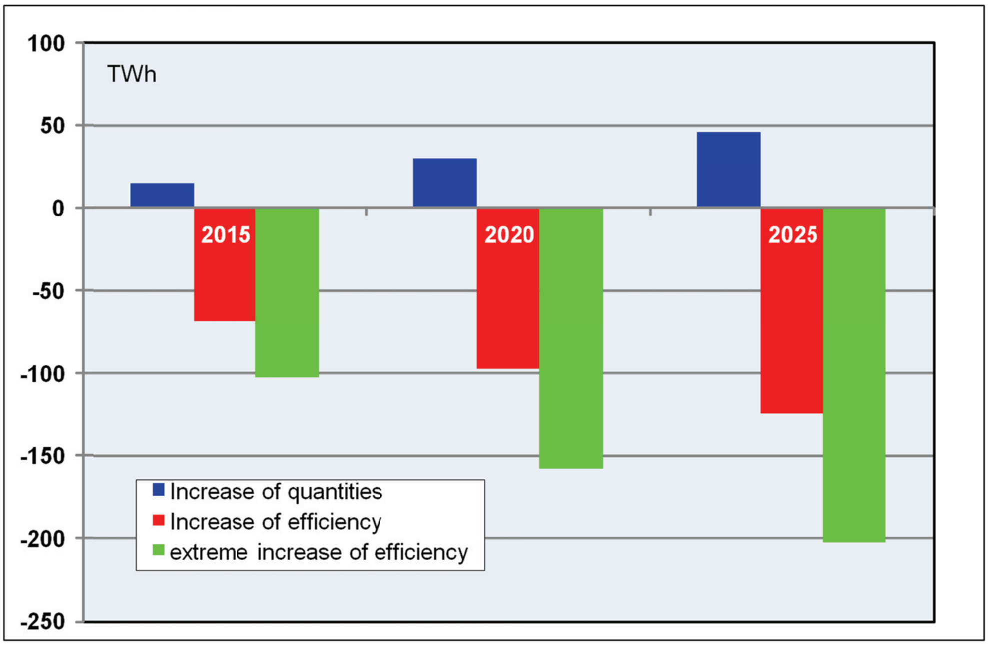

Figure 4-1: Efficiency improvements and quantity of equipment increases in TWh compared to 2005 in Germany

To achieve those improvements, extraordinary efforts have to be made:

- Significant technical improvement of electrical energy-consuming equipment, systems and processes,
- At the same time, immediate savings in power consumption in industry, households and CTS, not just power efficiency improvement,
- Providing incentives to do so,
- Educate consumers and thereby change of their habits and behaviour,
- In the event that the objectives are not achieved on a voluntary basis there may be legal actions required.

All measures should be divided into short and medium term actions to harvest rapidly the "low hanging fruits". Firstly, voluntary and market-oriented measures should be initiated that reward consumers immediately. Regulatory measures are, however, to be implemented only when the market and the voluntary nature does not produce the desired result. This may, inter alia, be requirements for minimum efficiency / maximum consumption, as well as a modernization duty. Alternatively, a corresponding progressive taxation of consumption can be introduced, which will have the same effect. The nationwide introduction of an energy certificate for energy-efficient appliances and equipment, including the main consumption figures can make an important contribution to the shift in consciousness.

By benchmarking, the objectives are to be evaluated regularly and readjusted if necessary. It should start with smaller but consistent steps, which are then continuously increased. The state must proceed in his field with a leading role and the corresponding trigger massive investments to increase energy efficiency and to the direct saving of energy in its areas of responsibility. In general, the energy consumption must be visualized wherever it is possible.

In public institutions, industrial and commercial companies, energy officers should be introduced (similar to a safety officer). If necessary, both functions may be exercised in a personal union to limit the effort. The energy officer has the task to analyse, to register, and to optimize the energy flows.

The study listed some important contributions to the technological improvement of efficiency in equipment and systems:

a) Space heating

- heat pump systems, with borehole (Ground-Coupled) heat-exchanger for heating and cooling
- solar thermal systems with the corresponding pump,
- applications of combined heat and power in particular in the tertiary sector, such as schools, hospitals, swimming pools,
- electronic controls and monitoring of consumption,
- regulated converter-controlled high-efficiency pumps instead of old circulators
- intelligent automation in the field of space heating,
- Intelligent energy management,
- use of waste heat,
- use of local and district heating systems.

b) Mechanical energy

- avoidance of mechanical actuators,
- retrofitting of old motors to premium-efficiency motors,
- introduction of controlled drive technology, where meaningful,
- intelligent drive systems, for example in pumps and fans, which only work when they are really needed,
- accelerated replacement of old fans by high-performance drives,
- energy-minimizing optimization of the complete chain of industrial production processes.

c) Information and communication technology:

- optimization and possibly limitation of the standby function where not required for basic operation

- New energy-saving data storage methods and procedures for server farms in the Internet or in the intranet

d) Lighting:

- electronic ballasts,
- energy saving light bulbs, where it make sense,
- optimization of public lighting, particularly of roads lighting (use of high-efficiency lamps, restricting the operating hours),

e) Process heat:

- energy optimised use of hybrid technologies,
- energy-optimized tuning of process steps,
- energy management systems,
- improved process monitoring systems,
- use of waste heat.
- local storage of electrical energy

A higher-level load management in the private sector, in industry, in business and in public institutions may also provide an important contribution to the optimal use of the fluctuating supply of renewable energy (wind, power, photovoltaic). The above list is not exhaustive. Especially important is the systematic optimization of all areas and processes in industrial, households and CTS in terms of energy use and energy saving. Only the widespread use of energy-optimized devices, systems, equipment and processes brings the desired volume effect.

To achieve real progress in efficiency the states and the industry must heavily invest in new measures. The public sector is called upon to invest in appropriate R & D for basic technologies to improve energy efficiency.

5 Concept of Regions

Balancing of regions instead of balancing (member) countries

Optimization of balancing (a region is a number of countries, which fit generation wise optimally together)

Europe is now in the startup period in direction of intensive renewable energy supply. The member states of the EU have different targets in emission reduction, renewable energy development in the end-use sector and in renewable electricity development. Furthermore, there are different traditions in power generation:

- Nuclear power generation (FR)
- Coal based power generation (PL, CZ)
- Coal, gas and nuclear generation (DE, SE)
- Hydro power (N)
- Hydro and gas with shift out of coal (AT)

Table 4.3.1 shows for some selected EU member states the targets for the share of renewable energy in electricity generation. Today the member states develop programs for balancing of electrical energy by measures in their territories.

Germany for example has to increase its renewable share from 10.2 % to 38.6 % until 2020. The renewable share will be very different in Europe.

Renewable electricity especially from wind and solar power represents a fluctuating in generation pattern with short generation periods and high units installed power. For balancing of generation, the following technological or market methods can in principle be used:

- Pumped hydro power plants. For storage they represent ideal storage capacities with high efficiency of 80 % and no emissions. The potential in Europe is limited especially for long term storage.
- Power-to-gas. This technology is today still under development and shows high costs of about four to five times, compared with pumped hydro storage and less efficiency.
- Stationary batteries in buildings or mobile batteries in electrical cars. Their capacity depends on the availability and the investment costs and is until 2020 probably not available in sufficient capacity, seen from the electrical energy system. But you have nearly no transmission losses, compared to centralized storage systems.

- Cooperation of Energy Regions. Here, energy exchange over the transmission grid offers a solution. In case of high renewable generation in a member state, the electricity is exported to neighboring states with lower share of renewable electricity. Flexible thermal power stations in these countries can compensate their fluctuating power in this case. In periods with low renewable generation, these thermal power plants can be used for balancing too.

Cooperation of Energy Regions seem during the transition period of EU member states to be the most cost efficient method for balancing, as only the grid has to be developed in direction of transit capacities. As the electricity market will comprise a larger number of consumers, the price of renewable energy will not drop down so dramatically as in limited national areas with high amount of surplus production and highly subsidized.

Table 5-1 gives a view in population and development of renewable electricity in some selected EU member states. As an example, Germany will have, according to its subsidized renewable development plan, beginning from 2020 periods with high over production followed by periods with lower renewable generation. Poland, the Czech Republic and Hungary for example have a significant number of inhabitants and lower targets for RES.

Table 5-1: Characteristic values of neighboring member states in EU

EU Member State	inhabitants	electricity demand	portion ren. electricity	portion ren. electricity
	Millions	TWh/a	2005	2020
Germany	81	560	10.2 %	38,6 %
Austria	8,1	65	59.8 %	70,6 %
France	66	543	13.5 %	28,5 %
The Netherlands	17	110	6.0 %	37,0 %
Poland	38,5	152	0.0 %	19,1 %
Czech Republic	10,5	81	4.5 %	13,9 %
Hungary	10	40	4.3 %	10,9 %
Entso-E (EU-34)	**525**	**3.400**		**34,5 %**

Poland has partly old coal fired power plants, with lower efficiency and has a plan to replace them by new ones

These plants can be replaced either by high efficient units or by flexible ones. High efficient power plants have higher efficiency but lower flexibility. In future, thermal power plants are needed, which allow high power gradients, low minimum load and have their best overall efficiency not at full load but at periods with partial load, which is in reality the standard situation.

Two scenarios can be compared:

- Replacement of all power plants by high efficient, which will increase the mean efficiency in Poland from 36 % (estimated) to 45 %. This will reduce the CO¬2 emissions by 22 % (Table 4.3.2).
- Installing new gas fired combined cycle power plant will reduced CO_2 emissions by 68 %, which will bring high dependence on gas imports at higher costs.
- Installation of flexible coal fired power plants, showing a lower mean efficiency of only 42 %. Cooperation with neighboring states with high amount of renewable electricity generation will reduce the full load hours (here by 60 %) and bring also significant reduction of emissions. This will need to develop the transmission grid with sufficient grid capacity between the neighboring countries and resolve of RES subsidizing question.

Table 5-2: Influence of power plant refurbishment on emissions in Poland

Status coal power plants in Poland	Full load hours h/a	mean efficiency	Relative CO2-potential
2014	6,000	35 %	100,0 %
Installing new coal technologies	6,000	45 %	78,4 %
Installing new gas combined cycle	6,000	60 %	31,8 %
New flexible coal power plants and 60 % RES import	2,400	42 %	42,9 %

The cooperation between countries shows the following needs and advantages:

- Need for building sufficient transmission capacities.
- Flexible operation of thermal power stations.
- As flexible power plants have lower full load hours, the fixed costs will approximately double the total generating cost. As these plants perform ancillary services by their flexible operation, they should have a fair generating price.
- Avoiding periods with strong over generation, will help to stabilize the price of renewable energy.
- In total, the emission balance will show reduction as the renewable capacities can be used by consumers in neighboring countries and the capacities of very expensive storage capacities can be reduced.

This example gives an insight in the advantages of cooperation by energy regions and shows the limitation of pure national concept.

6 Breakthrough technologies for the future

Reports that forecast energy demand and supply are based on GDS figures, reserve estimates, power generation investments, and compliance with local and global strategy. Key factors that are difficult to predict, by most economic analysts, are technological breakthrough developments and innovations. These developments, in the field of energy, may be divided into two major categories: developments that improve existing processes and developments that open new venues of storage, supply and generation. Breakthrough developments may change dramatically many of the published outlook scenarios. Some R&D addresses gigantic projects that need an international collaboration to materialize; they suggest global scale supply opportunities with major unpredicted impact.

Ongoing technological developments can be further divided into two categories: related to fossil fuel processes, and to sustainable renewable energy production.

Enhancement examples of existing practices that use fossil fuel include: a new generation of heat recovery steam generators (HRSGs), enhancements to boiler efficiency with reduced emissions (CO2 and NOx), pipe redesign to enable faster start of the generation process, etc. Reducing the risks of extracting hydrocarbons from unconventional sources - tight oil and shale gas, in particular - are changing the economic dynamics.

Power and utilities companies are benefiting from advanced analytics tools – to boost efficiency, save money, ensure reliability, and provide better service to customers. The key is a combination of in-memory database technology capable of facing the so-called "data tsunami" inundating utilities, primarily from smart meters and other intelligent devices being deployed across power, gas, and water systems.

Carbon capture project that would significantly reduce the amount of CO2 released from coal-fired power plants grabbing it and pushing it into the ground to force oil out. This technology could decelerate coal plant closures in oil-rich areas.

Advanced nano-engineered materials create efficiencies across the value chain and will have a multitude of impacts. Consider some examples:

- Oil and gas production – Nanotech particles make pipelines durable, nanocoatings help equipment resist corrosion. Nanoballs prop shale fractures open to optimize oil and gas flow reducing water and chemical requirements.
- Electricity transmission and distribution – Highly conductive carbon nanotubes can cut energy loss from transmission lines. Smaller, faster, and cheaper nanosensors will help utilities detect operations issues in real time.

And some examples related to Renewable Energy:

- Electricity storage – Nanotechnology is contributing to the development of high capacity affordable energy storage and helps mitigate renewables' intermittency. Nano-infused electrodes increase batteries' storage capacity, and materials like carbon nanotubes will eventually be used to produce ultra or super capacitors that store energy more efficiently. Recent work on "liquid batteries" that promises to store power on a massive scale, and cheaply. Advance in grid-level battery storage could revolutionize renewables and take a bite out of gas demand.
- Hydrogen Storage - A team of scientists at Lawrence Berkeley National Laboratory (DOE) have discovered a new material called air-stable magnesium nano-composites which can help in storing hydrogen without complex methodology.
- Electricity generation – Using nanocomposites in wind turbine design improves blade performance by maintaining strength and stiffness. Nanolubricants with friction coefficients near zero maximize system efficiency in wind and conventional power generation turbines. Several evolving nanotechnologies reduce the size and enhance the efficiency of solar panels, such as thin film graphene and nanowire coating.

There are many ideas to improve renewable energy generation: kite-like airborne turbines spinning at high altitudes sending power down via nano-tube cable; Enhancement in the field of bio-fuel, converting waste heat to electricity, is just few examples.

Nuclear power plant accidents such as the Chernobyl or the Fukushima disaster resulted in a tendency of reducing nuclear power generation. However nuclear power plants, which produce low-carbon electricity at stable and competitive costs, constitute an element of the solution to global warming and a means of delivering power to emerging and developed countries. Further development of nuclear technology is needed to meet future energy demand. Nuclear fusion is one of the most promising options for generating large amounts of carbon-free energy in the future. Fusion, the process that heats the Sun, results from atomic nuclei collide together and release energy. Fusion scientists and engineers are developing the technology to use this process in tomorrow's power stations.

Fast neutron reactors are a technological step beyond conventional power reactors. They offer the prospect of vastly more efficient use of uranium resources and the ability to burn actinides which are otherwise the long-lived component of high-level nuclear wastes. Generation IV reactor designs are largely FNRs, international collaboration on FNR designs is proceeding with high priority.

The Generation IV International Forum (GIF) was created to develop nuclear technology in order to meet future energy demand. The 4 goal areas to advance nuclear energy into its next, "fourth" generation are: sustainability, safety and reliability, economic competitiveness, and proliferation resistance and physical protection. GIF defined a Technology Roadmap and the necessary R&D to allow for the deployment of Generation IV energy systems after 2030. GIF selected six systems as Generation IV technologies: gas-cooled fast reactor (GFR), lead-cooled fast reactor (LFR), molten salt reactor (MSR), sodium-cooled fast reactor (SFR), supercritical-water-cooled reactor (SCWR), very-high-temperature reactor (VHTR).

Solar power continues its growth, in addition, PV solar panels prices continue to drop. Technical developments add efficiency to the process. Combined with energy storage it becomes a reliable source of power. However, the absorption of solar radiation by the atmosphere and shortage of land near populated arias inspired some solutions that sound like science fiction. Collecting the Sun’s energy in space where it constantly shines and transmit it down to Earth wirelessly has been around and studied since the end of the 60s. Early studies by NASA were followed in 1998 by the “Space Solar Power Concept Definition Study” and in 1999 by the SERT. In parallel, Canada and Japan initiated studies on space solar power like ESA with the “Space Exploration and Utilisation” study by DLR in which the European Sail Tower Solar Power Satellite (SPS) concept based on laser power transmission was developed.

In 2003/2004, broad scale introduction of terrestrial and space based solar power in Europe was performed (ESA Advanced Concepts Team), it was followed in March 2007, by the US NSSO, and at the same year, URSI published a report assessing SPS microwave power transmission interaction with environment, radio astronomy, telecommunications and human health. In its October 2009 report aimed at assessing the use of SBSP to supply power on demand for military application, the US NRL also concluded that SBSP concept was technically feasible. In 2011, the International Academy of Astronautics published the report "Space Solar Power - The First International Assessment of Space Solar Power: Opportunities, Issues and Potential Pathways Forward".

Some of these projects are capable of supplying most of the energy needed for the entire earth population.

This short review does not intend to cover the entire potential in breakthrough technology on the energy market. It aims is to indicate that 20, 30 and 40 years forecast must be aware of the dramatic impact by the exponentially growing research and development effort.

7 EU long-term basic concept for electricity supply

Since two decades the world of power generation in Europe is changing. Renewable resources are playing a more and more important role. This started in Spain and Germany with Wind and PV powered generation units. But in the recent years also the other member states invest in renewable generation. In UK, huge wind parks are erected and even in France the only nuclear generation is step by step replaced by renewable and gas power stations. In Germany and Switzerland, the nuclear generation will come to an end in the next decades. The replacement will be by wind, solar, biomass und geothermal power units.

This trend is accelerating since Europe has only limited fossil and nuclear primary energy resources and is dependent in a high degree from third parties and therefore Europe is susceptible to blackmail. The Ukraine conflict is a good example of this situation, when Russia is threatening with not supplying oil and gas or increasing the prices to a not acceptable level.

Europe has a high potential of renewable resources. In the south, the sun power can be utilized, in the northern countries and in the offshore regions wind power can be used to generate electricity. In addition the potential of geothermal power is until now practically not used.

In contrast to the concentrated power generation concept with big power station with fossil resources in the past, the new power generation units are much smaller and decentralized. So the power generation scheme of the future will dramatically change and will be highly decentralized.

7.1 The cellular approach

7.1.1 New principles of network planning

The future of the electric power, supply system will be highly decentralized and a very large number of smaller units will be included. So, there already are more than one million, mostly small generation plants in the Federal Republic of Germany, which have to be integrated into existing networks with still a high number of large generating units. It raises the question of how the structure of the electrical power supply system will look like when the number of decentralized (renewable) producers continues to rise even more.

A model for a new design could be the automation technology. At this discipline, a massive shift towards decentralized intelligent units took place in the recent decades. All units were operated interconnected in a communication network.

For planning and operation of such structures, two principals have prevailed, which could be helpful for designing electrical grids of the future:

The first principle: The optimal structure is achieved if one observes the structure of the control system.

The second principle: Data and information are processed in a hierarchy.

In automation technology, we have learned that one should perform any processing at the lowest possible level of the system. If one shifts the processing to a higher level, this can quickly lead to capacity constraints or time delays.

Applying the two principles outlined above for automation systems on the energy supply systems of the future, this means:

Production and consumption of energy are to be balanced at the lowest possible level.

This principle is already used to describe so-called microgrids, which operate in island mode.

7.1.2 The cellular principle

The basic idea of this new approach is the concept of autarkic electricity cells, which are implemented on all levels of the energy supply system. This means that multiple cells in a plane map on the next higher level again in a single cell and are treated according to the same basic principles. So it would be to possible that the structure of power supply system is oriented to local conditions and local administration levels such as house, street, district, town / city, county. It is important to mention that the power cell itself follows a multi-modal approach, that is, all used energy types such as electricity and heat are considered in the cell.

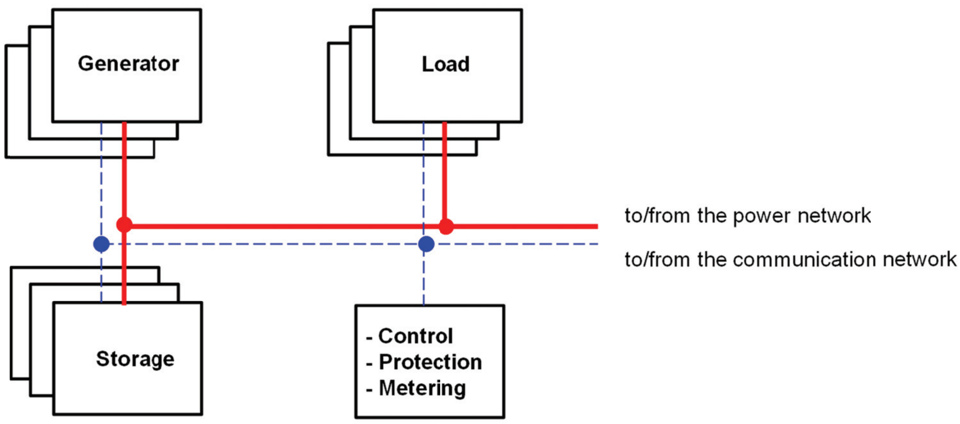

Figure 7-1: Principle structure of the autarkic energy cell

Figure 7-1 shows the basic structure of a power cell. Each cell may have its own generating units and loads, as well as one or more local storage units using different technologies. In addition, conditioning converter facilitate the conversion between different forms of energy in the balancing group.

The control and monitoring, including the necessary protection functions will be handled in the cell computer. This computer manages both the existing facilities and all communication links to adjacent cells and the next higher level. Subsets of facilities are possible. So a conventional installation of a family house could only include the unit "load". Control and monitoring would be resolved as previously

The energy cell reproduces itself to the outside with only a few parameters (Figure 7-2). For load management, this can be the power values, which are required or provided in the next observation interval. Questions on confidentiality of data must be solved conceptually.

The new basic principle, i.e. the balancing of generation and consumption at the lowest possible level might have significant impact on the expansion and upgrading of existing networks. And it might influence the construction of new networks.

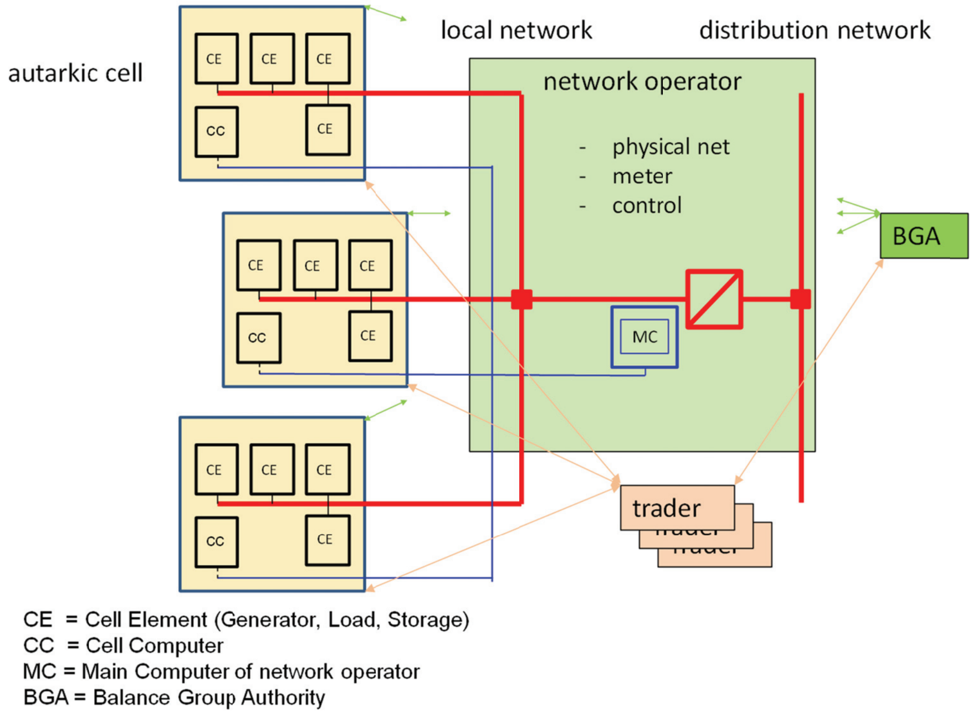

Figure 7-2: The autarkic cell approach within the new network scheme

7.2 Implications on a cell based energy / electricity supply system

The consequence of a cell based approach is a partly new design of the power network. There are implications which are quite different to the traditional network design approach.

Since a large amount of the secondary energy (electricity, heat, etc.) is generated locally it is reasonable to consume the energy on the local level and not to transport it on long distance. Consequently, the balancing of generation and consumption should be achieved locally using the local storage facilities for the balancing task if needed. If this is not possible on the lowest level than the next higher cell level will help out. In the same direction demand side management (DSM) is aiming. DSM is firstly cell oriented and is not ordered from a central authority.

Since the energy transport is always on the lowest possible level, the new emphasis in power networks activities is on the distribution level. The distribution networks have to be strengthened and adapted. Power flow is not anymore from the higher to the lower voltage level. Since a lot of the power is generated on the low voltage level in the future it has to be transported repeatedly in the opposite direction from the lower to the higher voltage level. In general the distribution and also transportation networks have mainly the task of balancing in this new approach. Besides its balancing task, the transport networks still have their original task of transportation when linking big wind farms to consuming centers which might be far away. For example, in Germany the big wind based generation units in the northern parts of the country and off shore facilities have to be linked to the consuming centers in the southern regions of the country.

Big industry aggregations and parks are forming their own cell which will work mainly autarkical. Surplus in generated electricity is offered to the market, while in case of shortage, energy has to be bought from the market. But in general, these complexes have the goal to produce their secondary energy demand by themselves and balance generation and consumption on their own.

The energy traders will have also in the future their traditional role in marketing electricity on a local, regional and even Europe wide level. This task may even be extended because of the rapidly increasing number of generators. The traders have to carry out their task always in coordination with the balancing group authorities. These balancing authorities and also the network operators are under the supervision of a regulator.

The network operator’s task is changing: he does not have any generating capacity, he is only responsible for the power system linking the cells, but he could also be responsible for the associated communication resp. control network. But this (which system, information?) task could also be carried out by another operator. In addition, the power operator has to run and to control all meters at the interface between the cells and the power network and all equipment for the balance group automation. Since he is a monopolist he has to be supervised by the regulator.

One very important requirement of a power cell is that it can run in an island mode and has a black start capability.

Having this new approach in mind, it is safe to say that the traditional hierarchical electricity supply system from high voltage level (transportation) to low voltage level (distribution) is somehow partially inverted: a part of the intelligence is migrating from top to toe. The basic idea is that all the organizing tasks are done at the lowest possible supply system level while in the past they were concentrated mainly on the highest level. The basic current regulation mechanisms will further apply on the cell level, but have to be adapted and automated in detail since the main challenge is the big data challenge.

8 EUREL recommendations

8.1 Findings

- Energy mix of the member states is extremely different,
- Energy strategy of the member states is technically and politically very different,
- The resource base is quite diverging, as example:
  - France: mostly nuclear,
  - Austria: mostly renewables,
  - Romania: coal, oil and gas, water, nuclear in nearly the same share,
  - Poland: mostly coal,
- The EU is politically in a very critical situation,
- The integration forces are weak, while disintegration ambitions are getting stronger,
- Energy and especially electricity could be an integrating element for EU´s future. Electricity is and will be in the Future the most important Energy .

8.2 The proposed concept of the EU internal power system

Where do we have to go from here?

Common European electricity system (UCTPE interconnection) successfully existed for decades operating from Portugal to Greece. A governing body of UCPTE has been established taking care of rules in order to obtain secure and stable power system operation and to deliver electricity of required high quality.

Political introduction of electricity market changed that profoundly. Numerous new bodies have been established and a long series of EU directives and rulings followed. The result was a warped and segmented electricity market, less stability in power system operation, practically no investment into the power system, and with much higher electricity prices for consumers.

For that effect, the renewable resources contributed a considerable portion, too, since their introduction to the power system they has been very poorly managed. For the electricity market, a lot has been expected from the private funding, which turned to be practically non-existent. Therefore, the entire burden fell on the member states governments with the mentioned consequences since they did not base their decisions on professional engineers' judgement.

EUREL decided to analyse the current electricity system situation seriously threatening by the GHG emissions and due to directions of the EU Commission setting goals to achieve a low carbon society in a reasonable time span. Basic goals have been set in this report including proposed solutions regarding the power system transition along with financial measures to attain the desired reduction of GHG emissions.

a) Basic goals:

- Intensive reduction of GHG,
- Increased efficiency is the key element of a future EU energy strategy,
- Strong expansion of the renewable energy is the main goal,

b) Proposed solutions:

- A new cell based approach as a fundamental element for electricity supply is mandatory for long term evolutionary development:
- Energy balance should be on the generation level or on the lowest possible level,
- Introduction of active, autarkic electricity cells as base elements of the strategy,
- The regions concept may help to overcome the structural differences of various member state energy supply patterns,
- Shift of energy automation intelligence from top to toe, i.e. to the lowest possible level,

c) Power system transition

- No available long term, only seasonal electrical storage technologies available, at least for the next future,
- The conventional sources will support the transition to the low carbon environment:
  - Coal will be phased out in shortest time possible,
  - Gas will support the transition period to the low carbon society,
  - Nuclear energy may help operation of the system in cases of low renewable potential in some member states,
  - Conventional sources supporting the system operation must be subsidized or available on the market to supply ancillary services,
- The proposed concepts ask for a reduced construction of the transport networks,
- The distribution network will have to be enhanced by the IKT technologies and by physical expansion.
- New regulation mechanisms must be adapted for the proposed new production/ supply model:
  - Power system codes for the bulk generation and transmission system,
  - Distribution system code covering the power cells and distribution network
  - Empowered Energy Agencies to regulate the energy transition scheme to achieve the desired goals.

d) Financial effort to support the new approach

- Startup financing for new technology is needed,
- New business models are to be developed.
- CO2 goals will be reached more or less automatically.

This new decentralized concept, based on information and telecommunication technologies, exploiting the automation intelligence can lead to a new and common European energy policy, which could be accepted by the member states regardless their current status. Moreover, the regional concept across the national borders would be a further integration force for the EU.

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