PROJECT NO 518294 SES6

CASES

COST ASSESSMENT OF SUSTAINABLE ENERGY SYSTEMS

Observatoire Méditerranéen de l'Energie

WP1 Task 1

"The Drivers of Electricity Demand and Supply"

Version April 2007

1. DRIVERS OF ELECTRICITY DEMAND AND SUPPLY

This report provides an overview of the main drivers of the European electricity sector. The overview constitutes the background for the scenario analysis developed within the CASES project. The emphasis is on the most important supply and demand drivers in the electricity market, such as:

- Economic factors (growth rate, income, etc)
- Prices (electricity, fuel costs, etc.)
- Subsidies (for certain technologies, alternative energy sources, etc.)
- Structure of electricity demand
  - Demand level
  - Peak load & seasonal variation
  - Energy intensity
- Industry structure
- Potential for energy savings and DSM

Below we shall distinguish between drivers for demand and drivers for supply. We would, however, like to emphasize that some drivers impact on both the demand and supply side of the market, or, for example, impact supply via driving the demand.

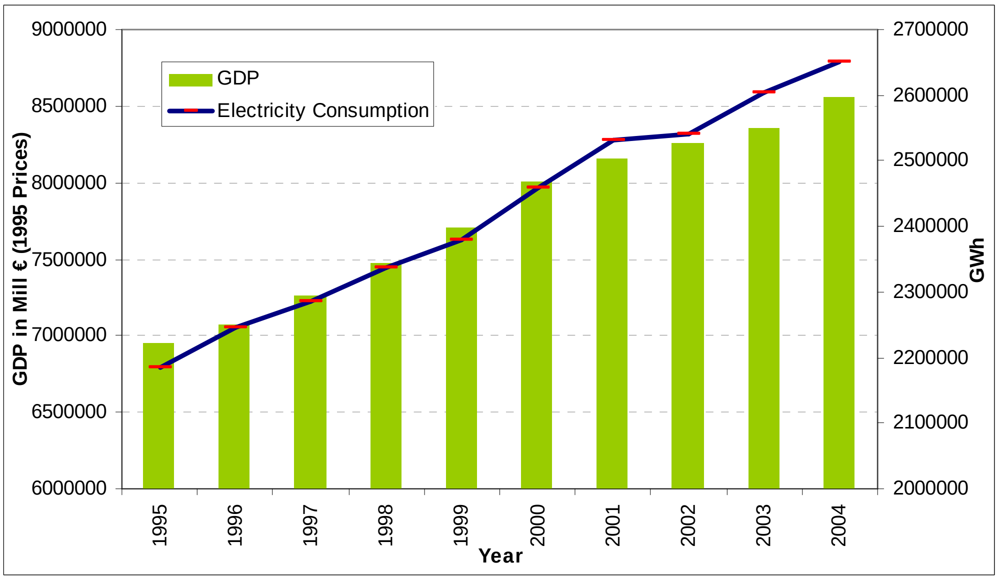
1.1. DRIVERS OF ELECTRICITY DEMAND

Generally, demand projections have to take two main aspects into account: Income drivers and price drivers. The income drivers are macroeconomic and demographic factors such as GDP growth, growth in household disposable income, population growth, growth in the number of households or the living space per capita, etc. Price drivers, on the other hand, are related to the price level for electricity and other energy sources that could substitute electricity.

1.1.1. Economic Growth

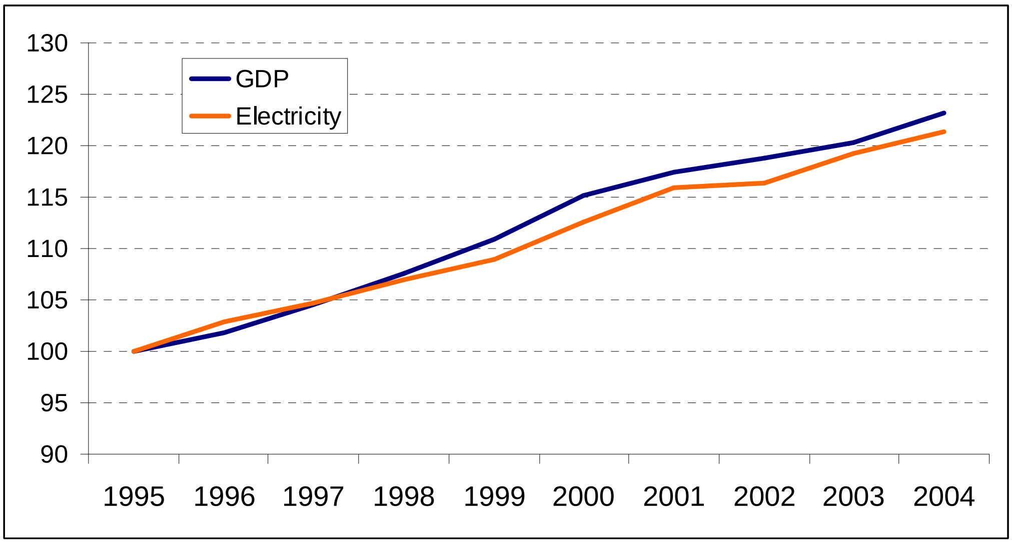
Economic growth is a key determinant of electricity demand. Although there is not a one-to-one relationship between GDP growth rates and electricity demand growth rates, there is a strong positive correlation. This means that electricity consumption typically increases with increasing GDP growth. This is illustrated in Figure 1.1, which shows the development of GDP and electricity consumption in the EU 15 from 1995 until 2004.

Figure 1.1: GDP Growth vs. Electricity Consumption EU 15



Source: Eurostat

Figure 1.2: GDP vs. Electricity Consumption EU 15, annual growth rates

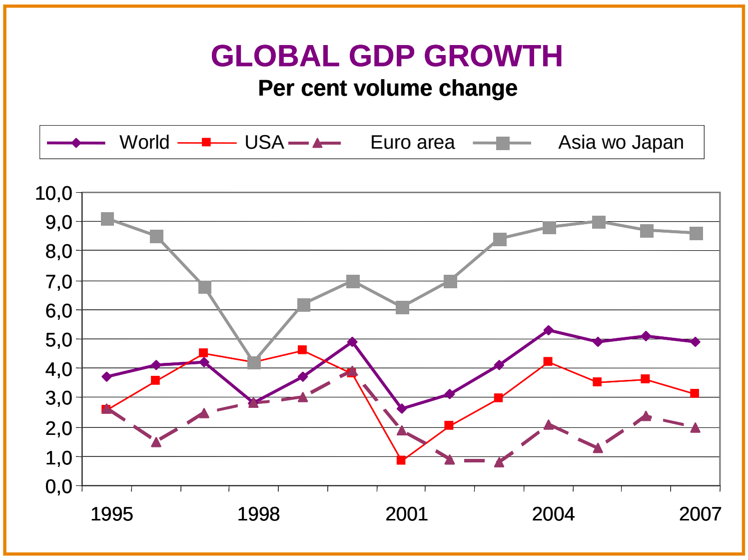


Source: Eurostat

GDP growth indicates increased economic activity and available income, both of which are correlated positively with electricity consumption. For example, increased industrial output contributes to GDP growth and is the key income driver in the industrial sector. Household energy consumption is not only a function of the number of households and the level of heating and cooling comfort, but also of the level of consumer expenditure, which is correlated with GDP growth. Another example is service sector consumption, which is related to the commercial floor space, which in turn is a function of the service sector growth. Figure 1.2 shows that electricity consumption in the EU 15 has grown by slightly less than the GDP growth over the decade from 1995 to 2004. The average electricity consumption growth rate has been almost 2.2 %.

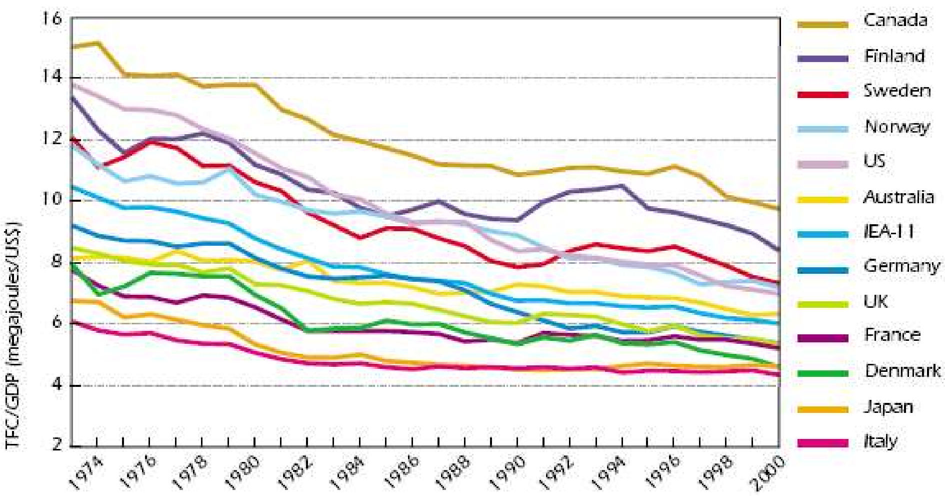
In a global context, European growth rates are expected to be modest in the short term, although higher than in 2002-2003 (1.2-1.3%). The growth rates in the figure relates to the Euro area. It should be noted that higher growth rates are expected for the new EU member states. According to the reference scenario in the IEA Global energy outlook (2006), the expected growth rate for the transition economies is 4.5% in the 2005-2015 period and 3.5% 2015-2030, as opposed to around 2% for the OECD area. An overview of recent and projected growth rates globally is given in Figure 1.3.

Figure 1.3: Global GDP growth



In the longer term, the key question may be how strong the correlation between GDP growth and electricity demand will be, rather than expected GDP growth. Historically we have seen a decline in the energy intensity of the economies, and this applies to the electricity intensity as well. According to the IEA Global energy outlook (2006) the ratio of energy demand to GDP growth has gradually declined over the last three decades, and since 1990 has been at around 0,5% to a 1% increase in GDP (expressed in purchasing power parity terms).

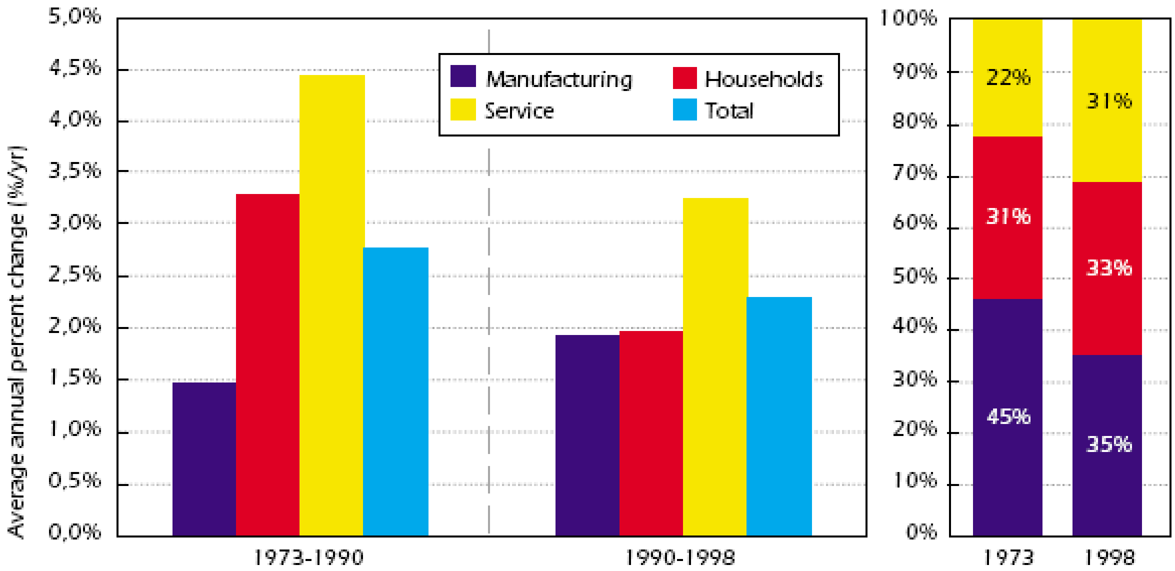
Figure 1.4: Total Final Energy Consumption per unit of GDP



Source: IEA (2004): 30 years of energy use in IEA countries

Figure 1.4 shows that the energy intensity of the IEA economies vary, but that there is a clear downward trend. In other words, the energy intensity of the economies is declining over time.

Figure 1.5: Average electricity consumption growth rates per sector in the IEA-11[1]



Source: IEA (2004): 30 years of energy use in IEA countries

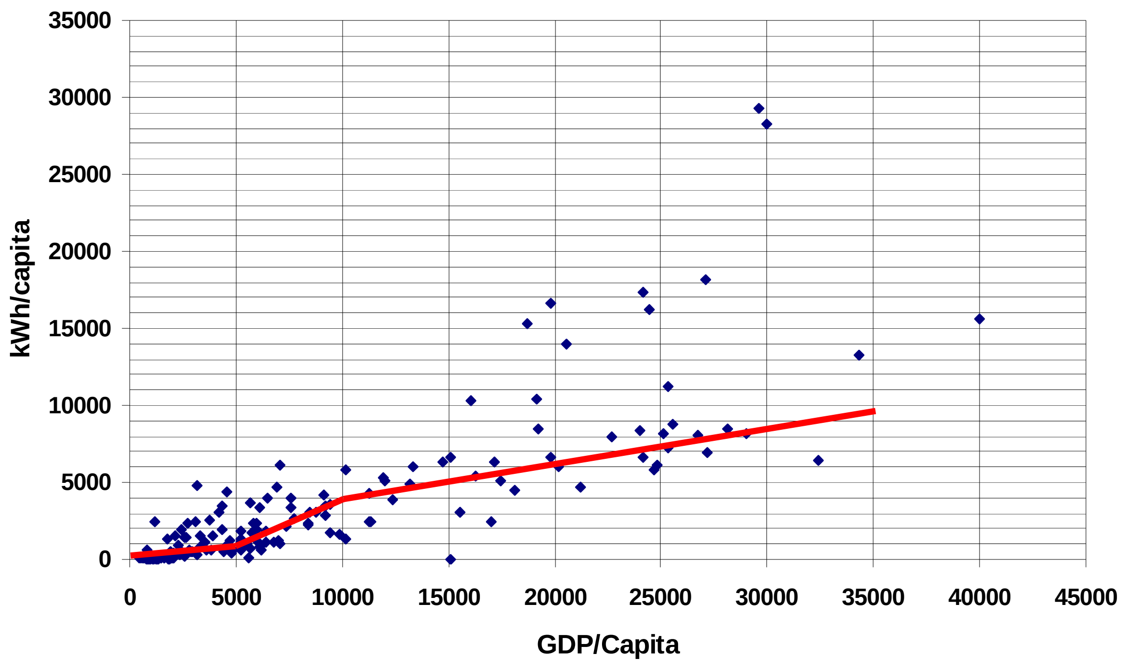
According to IEA (2004), residential electricity demand growth has primarily been driven by increased use of electric appliances. "Big appliances" such as dishwashers and refrigerators dominated the growth to the early 1980's, while much of the recent growth is due to the use of "miscellaneous" appliances, such as home electronics and kitchen gadgets. Much of the strong growth in the service sector can be attributed to the rapid growth in electricity use for cooling, ventilation, lighting and various kinds of office and network equipment.

Although total energy use in manufacturing declined between 1973 and 1998, electricity demand grew. This means that the importance of electricity in the manufacturing energy mix has increased significantly, though the share of manufacturing in total electricity demand has fallen.

As far as developing countries are concerned, the S-shaped curve often characterizes the increase in electricity demand. In other words, as per capita income increases a lift-off point is reached where commercial energy demand (and electricity in particular) grows much faster than the rate of growth in GDP. As per capita income increases so the growth rate starts to slow down - this in part reflects a level of saturation in some markets (see Figure 1.6).

[1] Australia, Denmark, Finland, France, Germany, Italy, Japan, Norway, Sweden, United Kingdom and USA.

Figure 1.6 Relationship between GDP per capita and electricity consumption per capita



1.1.2. End-user prices and subsidies

In addition to growth factors, the demand for electricity depends on the price for electricity and the price of alternative goods. In general, the higher the price for electricity, the lower the overall consumption level will be (ceteris paribus). This reduction in consumption can be a result of energy savings, profitable energy efficiency measures, or substitution of electricity for other energy sources. For example, electric space and water heating can be replaced by other kinds of space and water heating such as district heating, oil, coal or gas. In general, it is mainly in heating, cooking and industrial processes that electricity may be substituted with other energy sources. For a range of appliances (e.g. computers) and industrial processes electricity cannot be substituted by other fuels.

Furthermore, subsidies for certain types of energy consumption, as, for example, financial aid for investments in pellet ovens, heat pumps or solar panels, can influence the demand considerably, as they change the relative prices for different energy sources, including electricity. Other subsidies, like support for better insulation of buildings, may reduce the overall level of energy consumption within households or office buildings.

It should also be noted that, regarding the prices for electricity, it is important to not only consider domestic prices, but also international prices. This is illustrated by the fact that some power intensive industries are considering moving the production facilities to, for example, China, where electricity is cheaper compared to domestic European electricity. Hence, even if electricity cannot be substituted, the price level for electricity may still influence the overall consumption. Such effects will generally take some time to take full effect because investment decisions have to be made and carried out.

End-user prices are not only a function of the wholesale electricity price, but also of the distribution tariffs, the transmission tariffs, supply service margins and government consumption taxes, including VAT.

1.1.3. Peak load and seasonal variation (effect vs. energy)

Electricity cannot be stored – it has to be consumed at the same time as it is produced. This means that demand varies from instant to instant, from hour to hour, and from season to season. Therefore, we may say that electricity demand consists of demand for energy generally, measured in kWh, but also for instant energy, or effect capacity, measured in kW (i.e. kWh/h). In order to meet demand, the system must have the ability to generate the demanded energy over a certain time period, but also the effect capacity to meet demand in peak hours.

Therefore, all factors that influence the demand profile (both over the course of the year and over the course of the day or week) are important driving forces behind demand that determine peak and off-peak prices. In continental Europe, for example, the installation of air-conditioning has lead to increased summer peak prices, while in the Nordic countries the peak prices typically occur in the winter time, when the demand for space and water heating is high.

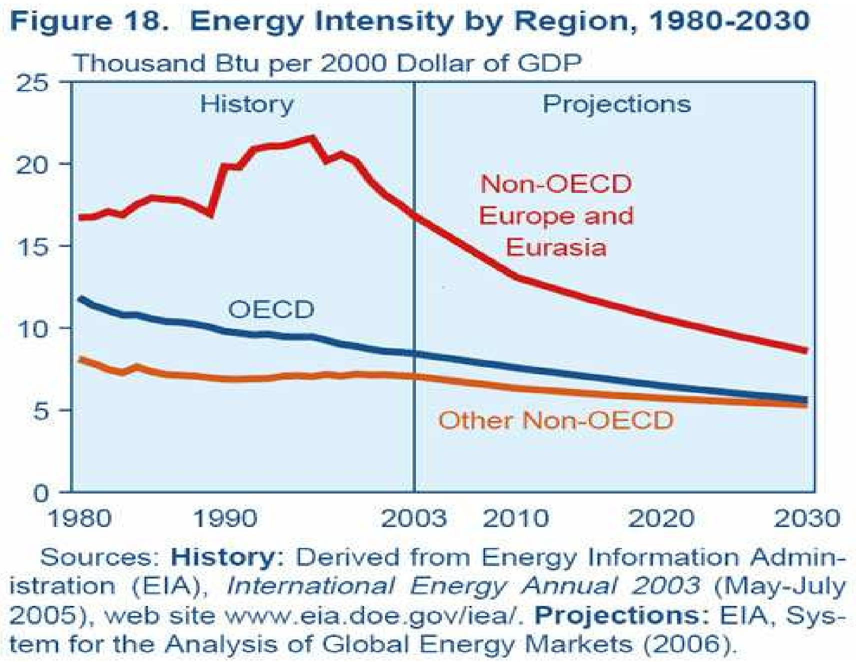
In addition, there is a demand for flexibility, i.e. generation that has the ability to rapidly change generation level in order to keep the system balanced. This demand is mostly automated or coordinated by system operators. The need for such services in a system depends on a number of factors such as the composition of demand and supply structures, and the ability to trade, i.e. the size of the trading area.

The demand profile and the need for flexibility do not only affect the cost of generation, but also the environmental impact of electricity generation.

1.1.4. Energy intensity, energy savings and DSM

As mentioned, the energy intensity of the European economies has declined over time, and this trend is expected to continue. This is partly due to energy – and electricity – being less important in the overall production processes than in the past. Europe is becoming less industrialized, and is developing into a more service intensive economy. This is in particularly true for the accession countries, where old production processes are shut down or replaced by more efficient means of production. An illustration of the historic development of energy intensity is given in Figure 1.7.

Figure 1.7: Energy Intensity Developments

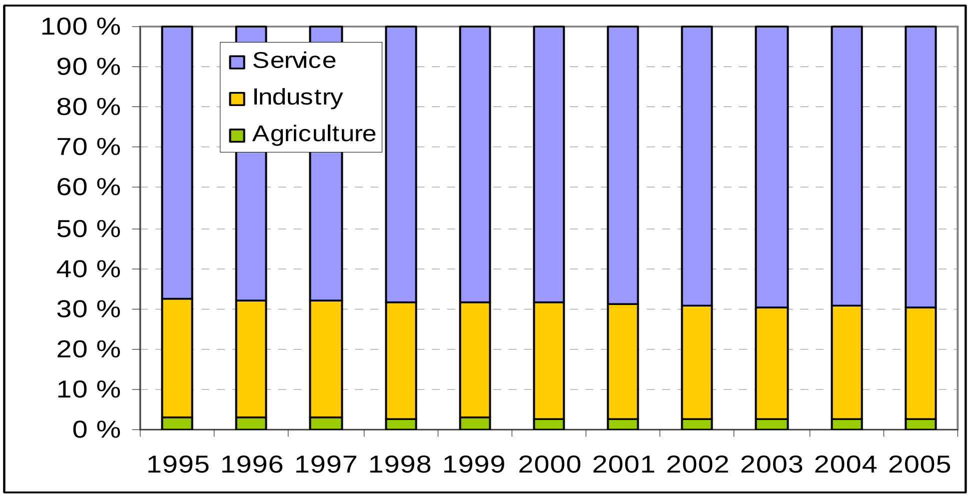


Regarding both energy intensity (electricity intensity) of an economy and demand profiles, it should be noted that both can be significantly influenced by energy savings or other demand side management measures (like demand response or load profile management).

1.1.5. Industry structure

A driver very much related to energy intensity is industry structure. As mentioned above, the focus of economic activity in Europe is shifting from industry towards the service sector. The agricultural sector already accounts for only a small part the European GDP. This is also illustrated in Figure 1.8, showing that the trend of an increasingly important service sector also continued over recent years.

Figure 1.8: GDP Composition of EU 25



Source: Eurostat

1.1.6. Technological development and energy conservation

New technologies that help to save energy and "optimize" energy consumption can also have a significant impact on the demand and the demand profile. For example, one aspect that may change the consumption profiles, are hourly meters, the cost of which has declined considerably over the last years. In Sweden and Finland, for example, distribution companies have started to install hourly meters for end-users. This opens up the opportunity for increased hourly demand response, i.e. the short-term reaction of demand to short-term (hour-by-hour) price fluctuations.

1.1.7. Other policy factors

Policy measures can raise awareness and alter preferences. For example, the EU and its member states have recently been putting a stronger emphasis on global warming issues. This does not only impact the supply side via, for example, CO_2 quota trading, but also the demand side, as it raises awareness for energy preservation and energy efficiency. In general, awareness and information campaigns could also impact the demand.

We would like to emphasize, however, that direct incentives (via, for example, subsidies) are likely to have the most significant impact on the demand side, and usually work better than pure awareness or information campaigns.

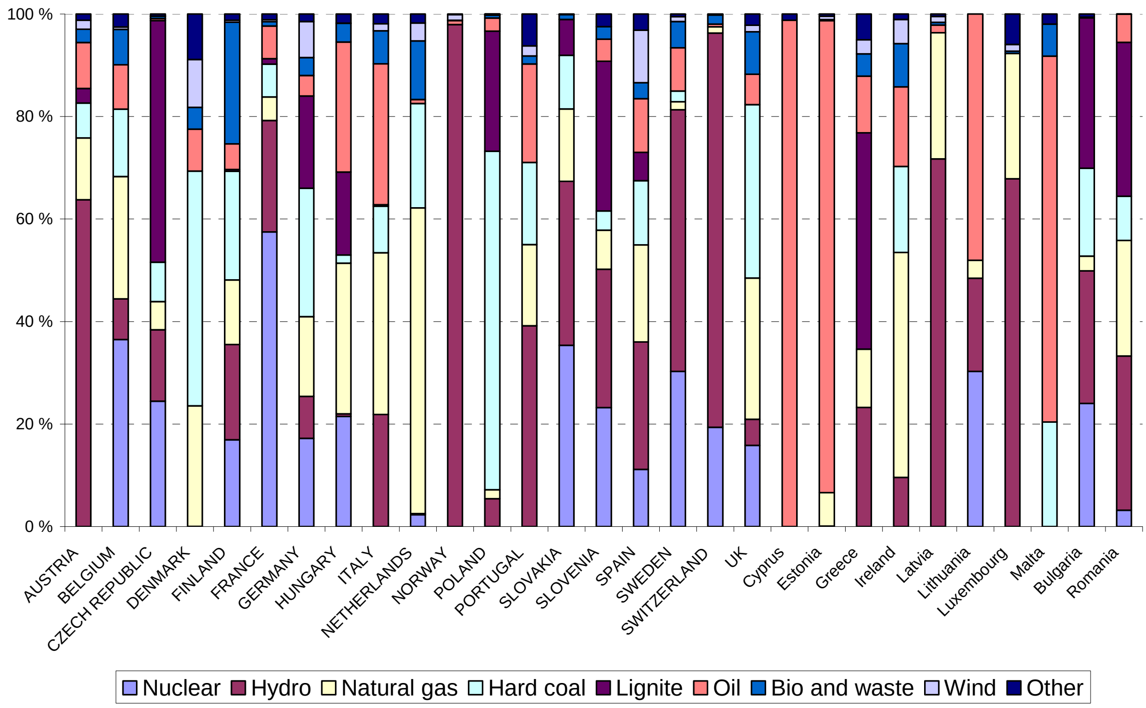
1.2. DRIVERS OF ELECTRICITY SUPPLY

Electricity is supplied from a vast number of power plants throughout Europe. Traditionally, the cost of transporting electricity over long distances has been very high, and electricity generation and supply have been considered important parts of national infrastructure.

Electricity can be generated from a wide variety of fuels and by means of several different technologies. The domestic and regional endowments of energy resources vary between countries and have been decisive for the variety of electricity supply structures that we see in

Europe today. This is illustrated in Figure 1.9, showing a distinct variation in the composition of electricity generation among the European countries.

Figure 1.9: Composition of electricity generation capacity in Europe



Source: Platts

Total gross electricity production in the 29 European countries represented in the figure was 3.12 million GWh in 2003. The largest producers are Germany, France, UK, Italy and Spain. Germany accounts for more than 15% of the total capacity and the five countries together for more than 60% of the capacity in the EU-25.

Investments in new power generation are naturally determined by the profitability of the different options, but are at the same time heavily influenced by policies. The most important investment drivers include, for example, fuel prices (and expectations thereof), availability of resources, demand growth, the current structure of the generation park (including age), and technological developments. The main policy areas affecting power generation investments are, for example, environmental policies, security of supply policies, public opinion and NIMBY issues.

Historically, national policies and indigenous fuel supplies have formed the electricity supply structure in the European countries. In recent years EU policies are becoming more and more important. EU policies regarding energy taxation, market liberalization, renewables obligations and the EU emission trading scheme (ETS) are all shaping the framework for investments, and tends to create a much more harmonized investment regime than ever before. This does not mean that national policies no longer matter, but the space for national subsidies and specially adopted policies is limited. The increase in trade and development towards an integrated market also contributes to lessen the impact of nationally adopted policies.

The most important EU Directives affecting capacity development are the renewables Directive and the emission trading Directive:

The Renewables Directive (Directive 2001/77/EC) has been in place since 2001.[2] The directive aims to increase the EU's share of electricity produced from renewable energy sources to 21% (up from 15.2% in 2001), thus contributing to reach the overall target of 12% of energy consumption from renewables by 2010. Although many member states are struggling to reach their national goals, the European Parliament and environmental groups have now called for even more ambitious targets for 2020.

The Emission Trading Directive (Directive 2003/87/EC) lays out the framework for the ETS which has been in operation since January 1, 2005.[3] The system allocates tradable emission allowances to installations within electricity and heat generation, and some industry sectors. The second trading period coincides with the Kyoto period (2008-2012), in which the EU countries collectively are committed to cut emission by 8% compared to emissions in 1990. Recently, the EU Commission has stated the EUs intention of cutting emissions by a minimum of another 20% after 2012, and by as much as 30% if other countries take on ambitious emission reduction targets.

1.2.1. Fuel Prices

Fuel prices, including CO_2 prices, play a role in the short-run, when it comes to the allocation of resources and the decision about which units to run, and in the long-run, when it comes to investment decisions. Hence everything that drives the fuel prices (in the long-run) also drives the investments in new generation.

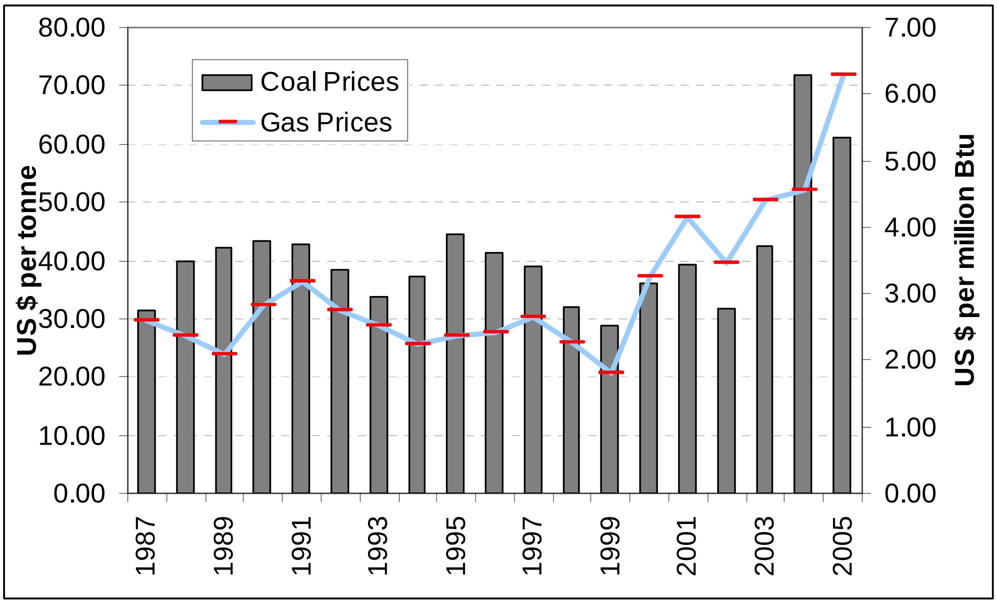
Oil does not directly play a significant role in electricity generation in the future, but may still affect costs via the link of the gas price to the oil price.[4] The most important price ratio is that between gas and coal. The development of gas and coal prices is shown in Figure 1.10. The introduction of the EU ETS introduces a cost on CO_2 emissions. Generally that increases the cost of coal power generation more than the cost on gas generation. To what extent the allowance price is sufficient to shift the choice of fuel for new electricity generation capacity depends on the emission cap imposed on the ETS sectors and the allocation of free allowances to new generation capacity. Technology-specific allocation mechanisms, where coal power gets more allowances than gas power (and CO_2 free capacity gets none), reduces the relative cost impact of the ETS on coal power generation. This, however, may change in the future.

[2] "Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market."

[3] "Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC."

[4] Historically, European gas prices have been linked to oil via long-term supply contracts. The gas market is however changing, and this link may be weaker in the future.

Figure 1.10: Fuel Price Developments

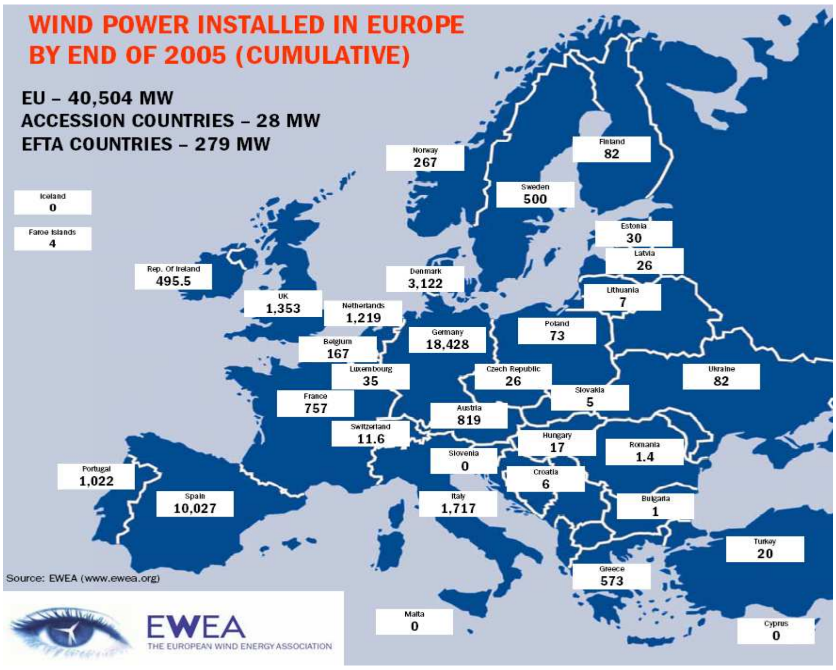


Source: BP Statistical Review of World Energy June 2006

1.2.2. Subsidies and Renewable Policies

Subsidies play an important role when it comes to the composition of the generation side. In particular the financial support and subsidies for certain technologies have significant impact on the supply structure. For example, the high feed in tariffs for wind power in Germany lead to vast investments in wind power, even though Germany does not provide the most advantageous wind conditions. In Norway, on the other hand, the support for wind power has been very limited, leading to only marginal installation of wind power, despite its favorable wind conditions. An overview of installed wind power in Europe is given in Figure 1.11.

Figure 1.11: Installed Wind Power Capacities in Europe



Source: EWEA

In general, the support schemes have to be seen in the context of the EU renewable directive which requires member states to provide some 21% of electricity from renewable sources by 2010.

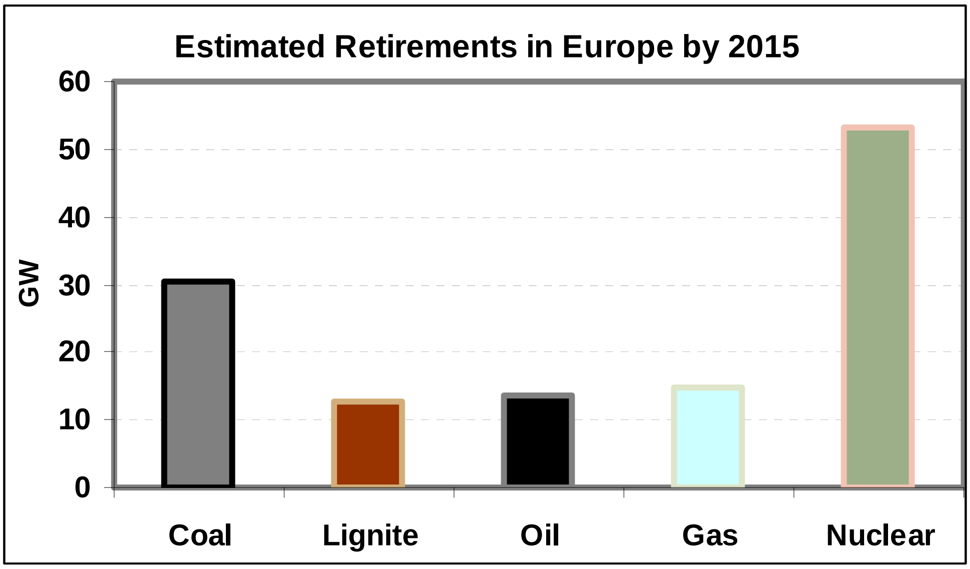
In this context the establishment of a CO_2 quota market and the Kyoto protocol also play an important role. In general, it is important to see how certain targets for renewable are to be achieved. While Germany, for example, uses feed in tariffs, other countries, like the UK or Sweden, use more market based solutions like the renewable certificate obligation scheme or the green certificate market.

1.2.3. Technological Developments and Structure of Generation Park

A very important driver for electricity supply is technological development. Over time, some technologies may become competitive compared to others, while others are driven out of the market. This also includes developments in nuclear technologies, with a new generation of nuclear plants to be under development now. “Clean Coal” technologies and carbon capture (sequestration) could make coal plants competitive in the presence of high CO_2 prices.

Another important aspect is the current composition of the generation park, including technologies and age. Those factors determine how much has to be replaced and what upgrades are needed in order to have a sufficient supply.

Figure 1.12: Retirements



Source: ECON estimates (based on Platts data and lifetime estimates)

1.2.4. Market Design and Market Structure

A very important driver for power supply is market design. Here, most notably, the EU internal market directive has had a considerable impact on Europe's power markets.[5] This directive required member states to deregulate the power markets and open them to competition, and also for competition and increased trade between countries. This also includes the requirement to split network activities from other activities. In this respect it should be noted that third-party-access is a pre-requisite for a functioning market. The market structure and the degree of market power also impact pricing policies and investment decisions.

Against this background it should also be noted that the EU is not satisfied with the progression of the internal market within the EU. In its latest document on Europe's energy policy, the EU again emphasizes the importance of a functioning internal market and the importance of competition.[6] In the same document they even suggest a complete unbundling of network activities from other activities in order to ensure Third-Party-Access and a level playing field for market participants.

It may be worth noticing that, before deregulation, there was excess capacity in many countries. This excess capacity has now been absorbed by higher consumption and a lack of new investments. This has lead to capacity concerns, as some fear that the current market design and structure do not provide the right incentives to provide sufficient investments. Security of supply concerns are rising on the policy agenda, and may in time impose changes in the market structure and the view on deregulation and competition issues.

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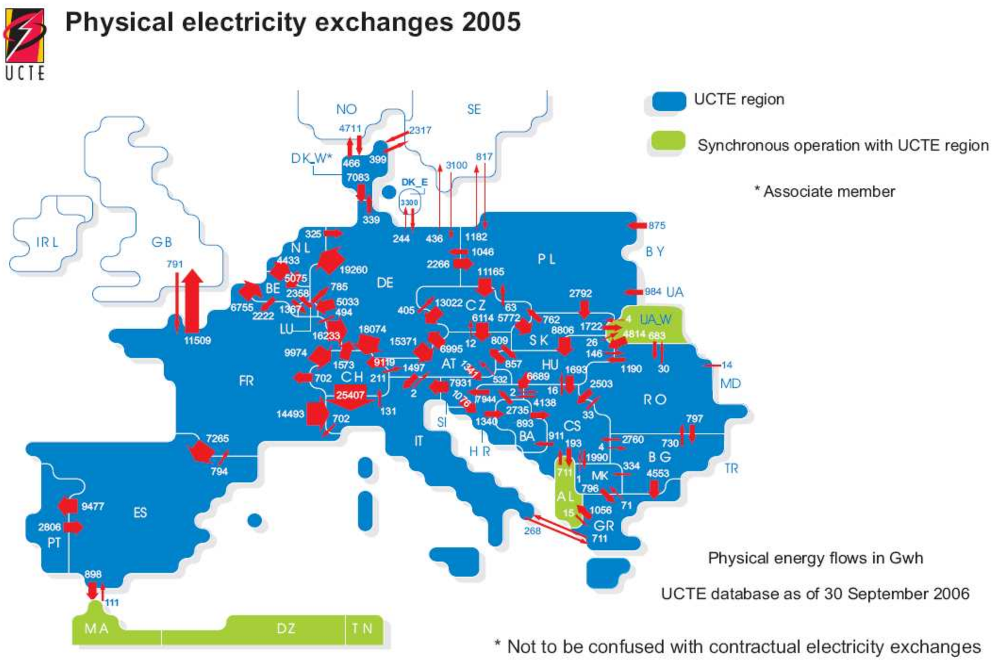
[5] The directive also applies to the gas markets, and does hence also affect end-user prices for gas.

[6] Communication from the Commission to the European Council and the European Parliament (2007); "An Energy Policy for Europe".

1.2.5. Connectivity of Markets

Strongly related to the issue of market design and competition between countries is that of the connectivity between markets. As the EU would like to see a working competition between countries, the connectivity of markets is of crucial importance. This is, for example, mirrored in the Trans-European Energy (TEN-E) guidelines aiming at the installation of an electricity and gas network that is linking the fragmented national networks. Security of supply is another reason behind the TEN-E guidelines. An illustration of the physical electricity exchange as of 2005 is given in Figure 1.13.

Figure 1.13: Cross border exchange 2005



Source: UCTE

1.2.6. Availability of Resources and Security of Supply

The availability of resources plays an important role in the energy mix. Germany, for example, had indigenous coal (and lignite) resources, leading to a strong role of coal (and lignite) in German power generation. Norway, in contrast, had vast hydro potential, which lead to Norway’s electricity generation coming to some 99% from hydro (including large reservoirs and run-of-river plants). In the Netherlands, or the UK, gas plays an important role in electricity generation, due to domestic resources (though they are diminishing).

Closely related to the availability of resources is the security of supply issue. Recent issues with Russian gas supply reminded the EU of its vulnerability when it comes to energy supply. The debate about nuclear power does not only go in the direction of reduced CO_2 emissions, but also in direction of security of supply.