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COVER NOTE

from:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	17 November 2008
to:	Mr Javier SOLANA, Secretary-General/High Representative
Subject:	Commission Staff Working Document accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Second Strategic Energy Review - An EU Energy Security and Solidarity Action Plan = Europe's current and future energy position Demand – resources – investments

Delegations will find attached Commission document SEC(2008) 2871 volume 1.

Encl.: SEC(2008) 2871 volume 1

COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 13.11.2008
SEC(2008) 2871
VOLUME I

COMMISSION STAFF WORKING DOCUMENT

accompanying the

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Second Strategic Energy Review

AN EU ENERGY SECURITY AND SOLIDARITY ACTION PLAN

Europe's current and future energy position
Demand – resources - investments

{COM(2008) 781 final}
{SEC(2008) 2870}
{SEC(2008) 2872}

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Part A
Europe's current and future energy position

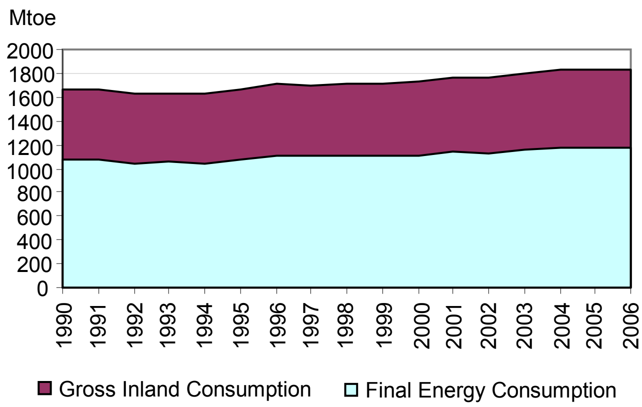
1. EUROPE'S CURRENT ENERGY SITUATION

1.1. Energy consumption

Energy consumption in the EU27 has stagnated over recent years. In 2006, according to the latest official data, gross inland energy consumption in the EU-27 was 1 825 Mtoe, while total final energy consumption, which excludes deliveries to the energy conversion sector and to energy industries themselves, was 1 176 Mtoe.

Figure 1

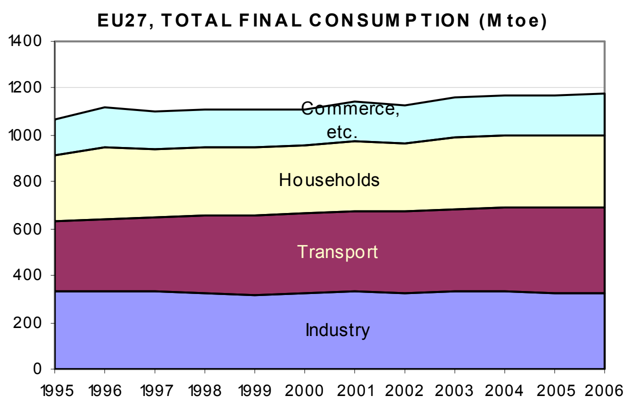
EU27, Gross Inland Consumption and Final Energy consumption (Mtoe)



Source: Eurostat

The transport sector is the biggest final energy consumer. The amount of final energy used by the transport sector exceeds the amount used by all other industrial sectors taken together. In 2006 transport consumed almost one third of final energy, while the other industries and households respectively accounted for 28% and 26%.

Figure 2



Source: Eurostat

Moreover, unlike in the other sectors, consumption in the transport sector, where fuels are the main inputs, continued to increase over the last decade. This trend in transport is associated with two factors: the accession of new EU Member States with competitive advantages in the road haulage sector and the subsequent expansion of road transport in these countries (Bulgaria, Czech Republic, Hungary, Poland, Baltic countries). In addition, some other Member States also experienced an increase in their transport sector, resulting in higher energy consumption (Ireland, United Kingdom, Denmark, Greece and Spain).

Energy consumption of the **commerce and other services sector** remained broadly unchanged. Although the services sector in both employment and value added grew at the strongest rate, consumption was kept stable through improved energy efficiency. Since heating and cooling comprise a large part of energy consumption in these sectors, a shift to new, modern, well-insulated office buildings has significantly contributed to this development, in particular in the new Member States.

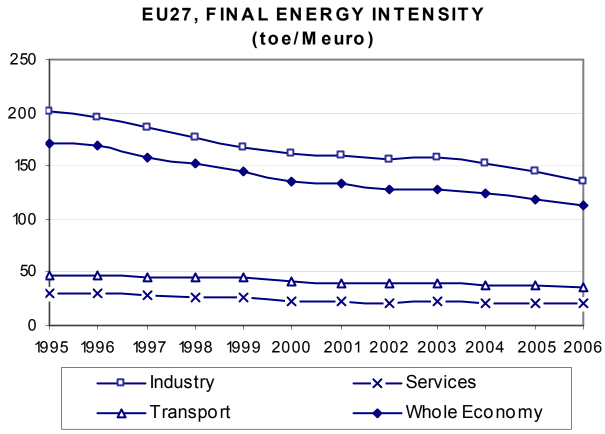
Apart from transport, energy consumption in the **industry sector** as a whole (excluding feedstock and petrochemicals) remained fairly stable. Industry restructuring in the 1990s, especially in Central and Eastern Europe, helped to prevent a rise in energy consumption. Restructuring also led to a major change in the energy mix, entailing a switch from solids to gas and electricity.

In the **household sector**, two opposing developments could be observed. A rising number of (smaller) households and improved living conditions that entail larger habitable space, more comfortable heating, more electric appliances and the installation of cooling equipment drove energy consumption up. On the other hand, new appliances typically consume less energy and new dwellings are better insulated. Taken together, these two effects tend to cancel each other out and household energy consumption over the last decade increased only marginally.

1.2. Energy intensity

Overall, energy intensity in the EU economy (i.e. tons of oil equivalent per million euros) improved **substantially**. Progress was mainly achieved through falling energy intensity in the industrial sector, while transport and services, which also showed a declining energy intensity trend, contributed to a lesser extent.

Figure 3

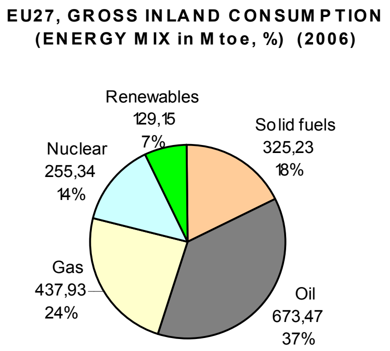


Source: Eurostat

1.3. Fuel mix

Oil remains the most intensively used product in the EU's fuel mix. In comparison to the 1990s, the share of oil in gross inland consumption has decreased only slightly – down one percentage point to 37%. The **gas and nuclear energy** share during the same period increased by six and two percentage points accordingly and in 2006 each comprised respectively 24% and 14% of gross inland consumption. The share of solid fuels in the same period shrank considerably (by ten percentage points) to less than one fifth of the total fuel mix.

Figure 4



Source: Eurostat

Renewables at the same time gained almost three percentage points. Half of this increase was achieved during the years 2000-2006, reflecting the effectiveness of EU policies aimed at reducing CO2 emissions and dependence on imports. However, the share of renewables still remains limited (7% of primary energy consumption[1]) and measures have been proposed by the European Commission to increase this share to 20% in final energy consumption.

The current fuel mix varies widely in the EU Member States. To a certain degree it depends on the domestic resource/production pattern: the UK, an important oil and gas producer, relies the most on oil and gas; Denmark, where indigenous production is dominated by oil, also consumes more oil; while countries having resources of solid fuels – Poland, Estonia – prefer those in their fuel mix. The share of nuclear is considerable in many of the countries that have opted for this energy source: France (42%), Sweden (35%), Lithuania (26%), Bulgaria (24%), Slovak Republik (24%) and Belgium (21%).

1.4. Import dependency

The EU-27 is a net energy importer, despite ever improving energy intensity rate. EU's indigenous energy production is depleting. This import dependency is not a problem as such but requires appropriate policies**.**

The EU's energy production satisfies less than half of its needs, with import dependency reaching almost 54% in 2006. Oil comprises the bulk of total EU energy imports (60%) followed by imports of gas (26%) and solid fuels (13%). The proportion of imported electricity and renewable energy is negligible (less than 1%).

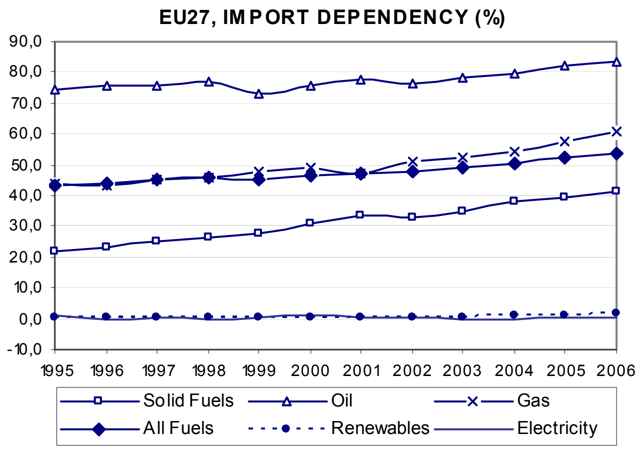
[1] 8.5% of renewables in final energy consumption.

The European Union in 2006 imported 608 Mtoe of **oil**. Most of the oil imports come from OPEC (38%) and Russia (33%), while Norway and Kazakhstan respectively provide 16% and 5% of oil imports to the European Union. The EU produces less than one fifth of its total oil consumption.

Looking at the EU as a whole, the situation is better in the **gas** sector, since domestic production (mostly taking place in the Netherlands and the United Kingdom) satisfies about two fifths of consumption needs. Gas is mainly imported from four big suppliers: Russia (42%), Norway (24%), Algeria (18%) and Nigeria (5%).

Sources of **coal** imports are also less concentrated – the largest suppliers are Russia (26%) and South Africa (25%), followed by Australia (13%), Colombia (12%), Indonesia (10%) and the United States (8%).

Figure 5



Source: Eurostat

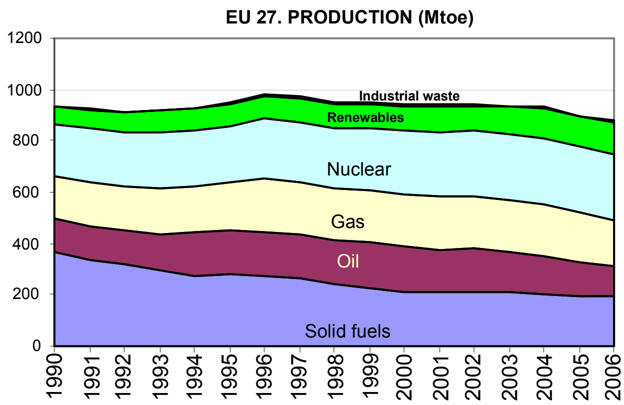
Although overall energy import dependency in the EU is high and continues to increase, the situation **varies significantly from country to country**. Denmark is the sole country which is completely energy independent, while for some countries, like Poland and the United Kingdom, import dependency ratios are quite low (close to 20%). At the other extreme, Ireland, Italy, Portugal and Spain have import dependency ratios exceeding 80%, while small island countries like Malta and Cyprus (due to their geographical situation) along with Luxembourg are fully dependent on energy imports.

The overall picture masks the very high import dependency on one supplier for certain countries. Estonia, Latvia, Lithuania, Bulgaria, Slovakia, Ireland, Sweden and Finland are completely dependent on one supplier for gas imports, while Greece, Hungary, Austria are more than 80% dependent on the same (monopoly) supplier. Moreover, Lithuania, Hungary, Slovakia and Poland are nearly fully dependent on one oil supplier (more than 95%). Estonia, Latvia, Lithuania and Cyprus are also almost completely dependent on a single supplier for coal.

1.5. Indigenous production

The EU's energy production has been declining, especially from 2004 onwards. In 2006, EU indigenous production is 880 Mtoe, out of which nuclear energy comprises the largest share (30%), followed by solid fuels (22%), gas (20%), oil (14%) and renewables (14%), although the contribution of the latter is expected to increase significantly in the future in line with the ambitious EU policy targets. Declining energy production implies that the EU's import dependency will further increase.

Figure 6

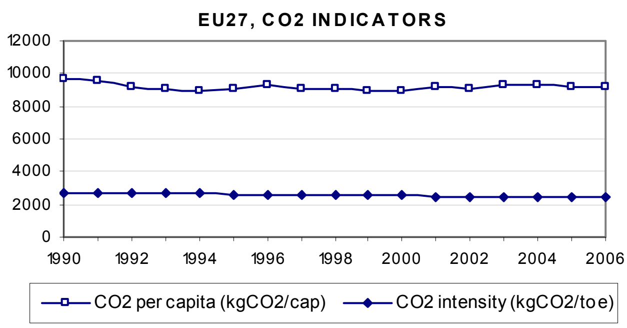


Source: Eurostat

1.6. CO2 intensity

The EU emitted 5 143 Mt of CO2-equivalent in 2006, 7.7% less compared to 1990 levels[2]. Following a period of industrial restructuring in Central and Eastern Europe at the beginning of the 1990s, GHG emissions picked up again after 2000. Energy-related CO2 emissions represented 77% of the GHG emissions in 2006. CO2 intensity, measured as kgCO2 per ton of oil equivalent, has been slowly but steadily declining and in 2006 fell to 2498 kgCO2/toe.

Figure 7



Source: Eurostat

Energy industries generated the highest amount of CO2 emissions (37%) in 2006, followed by transport (23%), manufacturing industries and construction (15%), and the residential sector (11%). Between 1990 and 2006 CO2 emissions from transport increased by 26%. Transport is the only sector that showed an upward trend during this period.

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2 Total emissions of all greenhouse gases, expressed in CO2 equivalent, excluding LULUCF (land use, land use change and forestry)

Among the biggest emitters in 2006 were Germany (21% of CO_2 emissions), the United Kingdom (13%), Italy (11%), France (9%) and Spain (8%). However, in terms of CO_2 intensity, which gives an indication of the CO_2 content of the fuel mix, high levels have been attained in Malta (5 912 kgCO2/toe), Greece (3 882 kgCO2/toe), Cyprus (3 711 kgCO2/toe), Poland (3 386 kgCO2/toe), Ireland (3 259 kgCO2/toe), Estonia (3 088 kgCO2/toe) and Denmark (3 040 kgCO2/toe).

2. EUROPE'S FUTURE ENERGY DEMAND

2.1. Future pathways

In formulating the future EU energy policy it is necessary to conduct a thorough analysis of possible developments in terms of the EU's energy demand. This chapter examines Europe's future energy demand under two main scenarios. Demand in 2020 is projected according to current trends and policies (baseline) and in the case of taking action (New Energy Policy) to achieve agreed EU targets on climate change mitigation, namely a reduction of 20% in greenhouse gas emissions compared to 1990, along with a 20% share for renewables in the final energy demand by 2020, and to bring about a substantial improvement in energy efficiency.

In the light of these scenarios, overall developments are described and their impact on EU energy security and on 2020 objectives is assessed.

Box 1

Main assumptions underlying the different scenarios

The results of the scenarios used in this document are derived from the PRIMES model run by the National Technical University of Athens (E3MLab). PRIMES is a partial equilibrium model of the energy system providing projections on energy demand, supply and transformation including on power generation capacities up to 2030[3]. It is complemented by a series of specialised models and databases. PRIMES ensures that energy demand and supply behaviour, energy prices and investments are determined endogenously. The prices for fuel are determined exogenously (see below).

Except from the policy assumptions, all other assumptions (technology, economic structure, demographic development, etc.) remain unchanged between the Baseline case and the New Policy case. Both scenarios start from common projections, notably on economic growth (2.2% on average up to 2020), based on short-term forecasts of the Commission and macro-economic modelling drawing on DG ECFIN work[4].

The Baseline includes current trends and policies as implemented in the Member States up to the end of 2006[5]. The New Energy Policy scenario assumes vigorous implementation of new policies to make substantial progress on energy efficiency for reaching other energy and climate targets. The 20% RES and greenhouse gas targets are assumptions for the New Energy Policy. It does not include action on non-energy related greenhouse gases, such as methane or NO2, or use of the JI/CDM option previously used in the scenarios supporting the climate energy package adopted in January 2008.

3 For a description of PRIMES, see Annex 1 Part A or "European Energy and Transport – Trends to 2030 – update 2007" at the following address: http://ec.europa.eu/dgs/energy_transport/figures/trends_2030_update_2007/index_en.htm.

4 For detailed macro-economic and policy assumptions, see Annex 1 Part A. Detailed macro-economic assumptions are also included in the above publication on Trends to 2030.

5 This scenario and the underlying assumption and results are explained in detail in the publication "European Energy and Transport – Trends to 2030 – update 2007" available from http://ec.europa.eu/dgs/energy_transport/figures/trends_2030_update_2007/index_en.htm

In the Baseline scenario, the price of CO2 equals 22 €/t. With the New Energy Policy, the carbon price is equal to 41 €/t of CO2 and is determined endogenously in order to reach the 20% emission reduction target under moderate energy prices.

Given the uncertainty concerning crude oil prices[6], both the Baseline and New Energy Policy cases are described by giving ranges for 2020 depending on a moderate or high oil price environment. The moderate price environment means an oil price of 61$ (2005) /barrel in 2020[7]. The high price environment would have an oil price in 2005 money of 100 $/barrel in 2020[8].

2.2. Overall developments

Changes in primary energy demand, the evolution of individual fuel sources and of the EU's energy production give an overview of possible energy futures of the European Union. The EU energy situation in 2020 sets the scene for political decisions to be made (urgently) today.

2.2.1. Primary energy demand and energy intensity

Meeting the energy demand is the basic requirement of energy security. An analysis of future primary energy demand, also known as gross inland consumption, is therefore essential. The level of the future demand is influenced by various factors, including energy prices. The impact of demand-side developments is generally measured by the evolution of energy intensity, which refers to the quantity of energy necessary to produce one unit of GDP[9]. In the context of the baseline and the New Energy policy, energy savings equal energy efficiency improvements, as GDP remains unchanged between the scenarios.

Under baseline conditions the primary energy needs in 2020 continue to grow, compared to the current situation, although at a lower rate than in the past. Given current trends, the EU's consumption rises between 5% and 9% depending on the oil price, with the higher increase in the case of moderate oil prices. Gross inland consumption would therefore reach in 2020 a level of between 1 900 and 1 970 Mtoe. Fuel needed for the transport sector remains the main driver. Transport consumption rises by 17% - 21% by 2020, with the lower limit reflecting developments under high oil prices.

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6 The oil price increased from 60 $/barrel in March 2007 to almost 150 $ in mid July 2008 before falling back to about 90 $ at the time of writing this report.

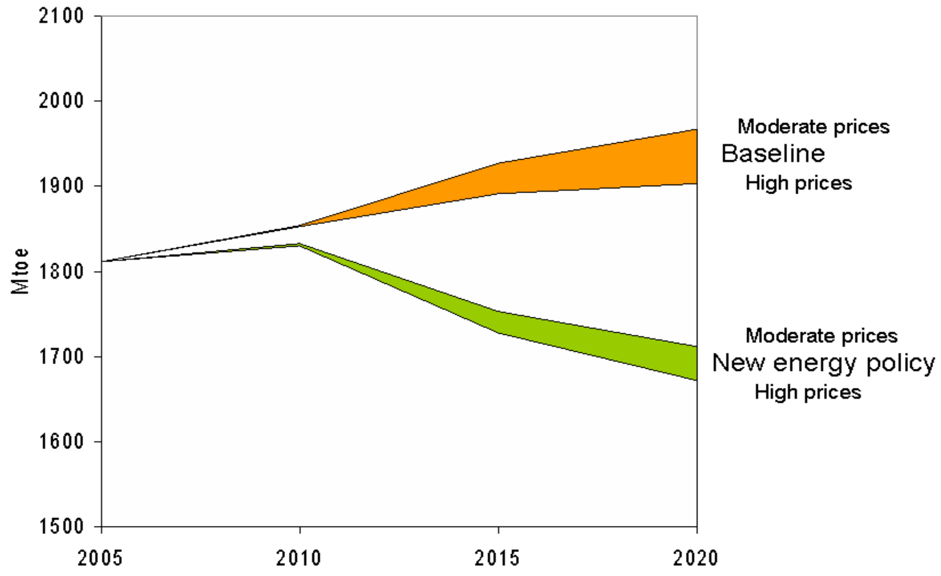
7 This price equates to an oil price of 66 $/barrel in 2008 money and a nominal price of 84 $/barrel in 2020 provided that the ECB reaches its target to keep inflation from now on below 2% pa.

8 This price equates to 109 $/barrel in 2008 money and to nominally 137 $/barrel with future inflation of just under 2% pa.

9 Both energy efficiency and energy intensity are used here largely as synonyms, although energy efficiency relates to individual processes and energy intensity to the energy system as a whole; the reason for doing so is that energy efficiency is often understood as an overarching policy action related to all sectors of the economy (see objectives on energy efficiency as endorsed by the European Council in March 2007).

Figure 8

Gross inland consumption (Mtoe)



Source: Primes

In spite of the growth in energy demand, the energy intensity improves under the Baseline. With moderate oil prices, energy intensity improves by 24% by 2020. These improvements could be as high as 27%, if high oil prices materialise. The energy intensity gains result from a structural shift towards more services and less material/energy intensive production in industry within a healthy GDP growth environment. They also result from efficiency improvements in all energy activities. The high energy price effect triggers additional energy efficiency. Higher energy costs are changing investment patterns and behaviour.

With the New Energy Policy, primary energy consumption decreases at a rate of between 0.4% and 0.5% pa depending on the oil price level. Primary energy demand would represent 6%-8% less compared to the current situation and would fall in 2020 to a level of between 1 670 and 1 710 Mtoe. After decades of rising energy demand, the EU's energy consumption would decline for the first time as a result of policies and measures on energy efficiency, renewables and climate change.

Action on energy efficiency (i.e. the vigorous implementation of existing Directives on matters such as building performance, Combined Heat and Power, end-use energy efficiency and energy services, eco-design of energy using products, as well as further policies along the lines of the Action Plan for Energy Efficiency[10]) could deliver efficiency improvements of 34%-36% by 2020 depending on the oil price. These gains correspond to 13%-15% additional

[10] See Communication from the Commission – Action Plan for Energy Efficiency: realising the potential, COM (2006) 545 final. This Action Plan sets a framework for policies and measures for energy savings. It suggests the implementation of regulatory measures, improvements of the energy transformation, measures for transport, improved financing tools and economic incentives, increased awareness and international partnerships.

energy efficiency improvements in 2020 compared to developments under a moderate price Baseline. However, energy demand from transport would still grow between 4% and 8% compared to the current situation.

2.2.2. Fuel mix

The current fuel mix of the European Union is dominated by oil, gas and solids which represent about 80% of the primary energy demand. Given current trends and policies with moderate oil prices this figure would remain relatively stable up to 2020. High oil prices could reduce the share of fossil fuels in primary energy demand to 75% by 2020, while the New Energy Policy would further diminish their share to 70%-71%.

With current trends and policies continuing, the oil and gas share in primary energy consumption is expected to remain stable in 2020 at a level comparable to the current one. High oil prices would reduce the oil and gas share by four percentage points in 2020. With the New Energy Policy the figure would be between 55% and 59%, with high oil prices leading to a stronger decline in the oil and gas share.

Carbon-free and indigenous energy sources (renewables and nuclear) in the EU's fuel mix would amount to 28%-30% under the New Energy Policy compared with only 21-25% under current trends and policies. The share of renewables would increase under all scenarios and price circumstances. However, this increase would be partly nullified by a falling nuclear share as a result of nuclear phase-out decisions and closure of nuclear plants considered unsafe in some Member States as well as sluggish replacement of existing nuclear plants at the end of their lifetime with plants of the same type.

The development of individual energy sources can be summarised as follows:

- Under each scenario, **oil** remains the most important fuel of the EU's fuel mix in spite of a decreasing share.

Following a steady increase due to growing consumption for transportation purposes, oil currently provides the largest contribution to primary energy, approximately 37%. Oil will still be the most important fuel in 2020, especially in transport, due to limited substitution possibilities. With moderate prices, the share of oil decreases in a broadly comparable manner under the Baseline scenario and the New Energy Policy, i.e. by 1% approximately. With high oil prices, however, the decrease is sharper, falling by three percentage points in the Baseline and slightly more in the New Energy Policy scenario.

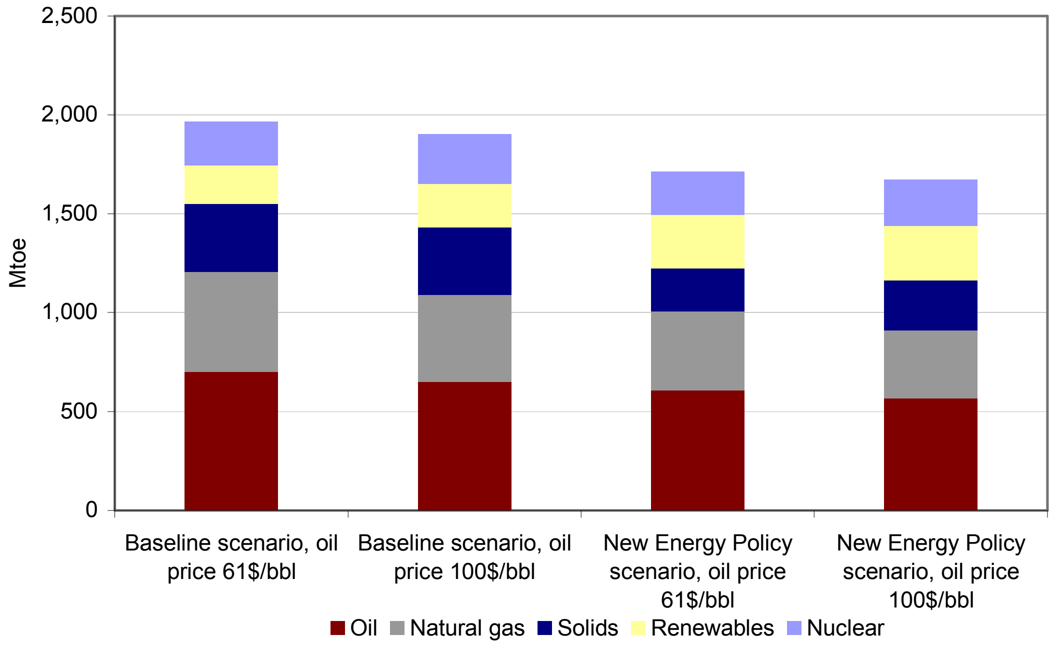
- The second largest element in the fuel mix of the European Union in 2006 is **natural gas,** which accounts for almost one quarter of the mix. This is six percentage points more than the share of solid fuels. Natural gas has penetrated all sectors, with the exception of transport. Since the mid-1990s, a lot of the new investments in power generation have gone into combined cycle gas turbines technology (CCGT). Low natural gas prices, relatively low capital cost and favourable technology characteristics, especially in terms of environmental emissions, are the drivers of this development.

The share of natural gas in primary energy consumption is expected to remain high, above 20%, under both scenarios. However, given the current trends and policies with moderate fossil fuel prices, the rapid penetration of natural gas hitherto experienced is projected to slow down. With high oil prices there would be a slight decrease in the gas share to 23% in 2020.

Under the New Energy Policy with moderate oil prices, natural gas is challenged by the massive penetration of renewable energy sources. The share of natural gas in the EU's fuel mix decreases to about 23%. Under high oil prices, the share of natural gas drops significantly to 21% compared with similar developments under moderate prices and also the present level. In power generation, high gas prices strongly affect the cost-effectiveness of gas-fired power plants: high gas prices would reduce gross electricity generation from gas by 21% in the absence of the new policy approach and would lead to a decrease of electricity generation from gas by 25% in 2020 under the New Energy Policy. Thus, as a result of the combined effect of the New Energy Policy and high oil prices, the natural gas share in the electricity mix of the EU is no higher than 17%.

Figure 9

The fuel mix (Mtoe) in different scenarios



Source: Primes

- Primary energy consumption of **solid fuels** (mainly hard coal and lignite) stagnated between 2000 and 2006 at around 18% of the EU's fuel mix. Solids are mainly used in the power generation sector and in some specific industrial applications.

Given current trends and policies with different oil price assumptions, solid fuels are projected to exceed their current level by 6%-7% in 2020 following oil and gas price increases and the nuclear phase-out in certain Member States. The share of solids in 2020 is expected to remain similar to current levels.

Under the New Energy Policy, coal and lignite consumption will be reduced. The share of solids in the EU's fuel mix falls sharply to 13% in 2020 under moderate oil and gas prices, but would reach 15% in the case of high prices in 2020. The share of solids in power generation would substantially diminish as a result of implementing the New Energy Policy (19% in 2020) compared to a baseline with moderate energy prices (30% in 2020). The decrease in the share of solids in the EU's fuel mix becomes much more moderate in the event of soaring oil and gas prices, which strengthen the relative competitiveness of coal.

- The highest growth after the 1990s has been witnessed in **renewables** and they are still projected to rank first in terms of growth till 2020. In 2006, their share in the EU's fuel mix is modest and corresponds to roughly 7% of the primary energy demand.

However, renewable energy sources (RES) increase their share in all scenarios. Given current trends and policies with moderate oil prices, the additional energy consumption in 2020 will be primarily met by renewables and natural gas. Renewables will increase their market share in primary energy[11] to 10% in 2020 (13% share in final energy). Use of RES increases most in power generation, followed by transport. There will also be considerable growth in heating and cooling of buildings as well as in industrial use of biomass/waste. High oil prices, favouring RES deployment, would add 1.6 percentage points to the market share of RES in 2020. With high oil prices, renewables will become the fourth pillar of the EU's fuel mix.

Following implementation of the New Energy Policy, the share of renewables in primary energy demand will increase substantially, reaching 16% in 2020 (and slightly more than 16% in the event of high prices). Under the New Energy Policy, renewables become the third largest source in the EU's fuel mix.

- As a result of political decisions on **nuclear** phase-out and the programmed closure of plants due to safety considerations in some Member States, nuclear shows a decline in all scenarios compared to current levels. In 2020, given current trends and policies with moderate oil prices, it will lose three percentage points, accounting for 11% of the primary energy demand. Under high oil prices, falling power generation from gas is compensated by higher electricity generation from nuclear energy (+13% in 2020), from renewables (+8% in 2020) and from solid fuels (+4%). Nuclear would then represent 13% of the primary energy demand in 2020.

Under the New Energy Policy nuclear energy would account for 13-14% of the primary energy demand in 2020, displaying a higher share with high oil prices.

2.2.3. Indigenous production, import dependency

Under each scenario, the EU's indigenous energy production declines sharply. The EU's oil and gas industry is facing declining resources, despite intensive efforts to increase the recovery rate in mature fields as well as in newer smaller fields. Gas production will decline at a slower pace (between 3% and 4% pa) than oil (about 6% pa) till 2020 under various oil price assumptions and policy measures. Solid fuels exploitation (in particular hard coal mining) drops because of high extraction costs, local environment issues in the proximity of opencast mines and diminishing state aids. These figures do not include the long-term potential offered by unconventional oil and gas (see chapter 3).

In view of these production trends, net imports of fossil fuels (oil, gas and solids taken as a whole) are expected to increase except in the case of the New Energy Policy with a high oil price. Given current trends and policies, net imports would increase between 21% and 33%,

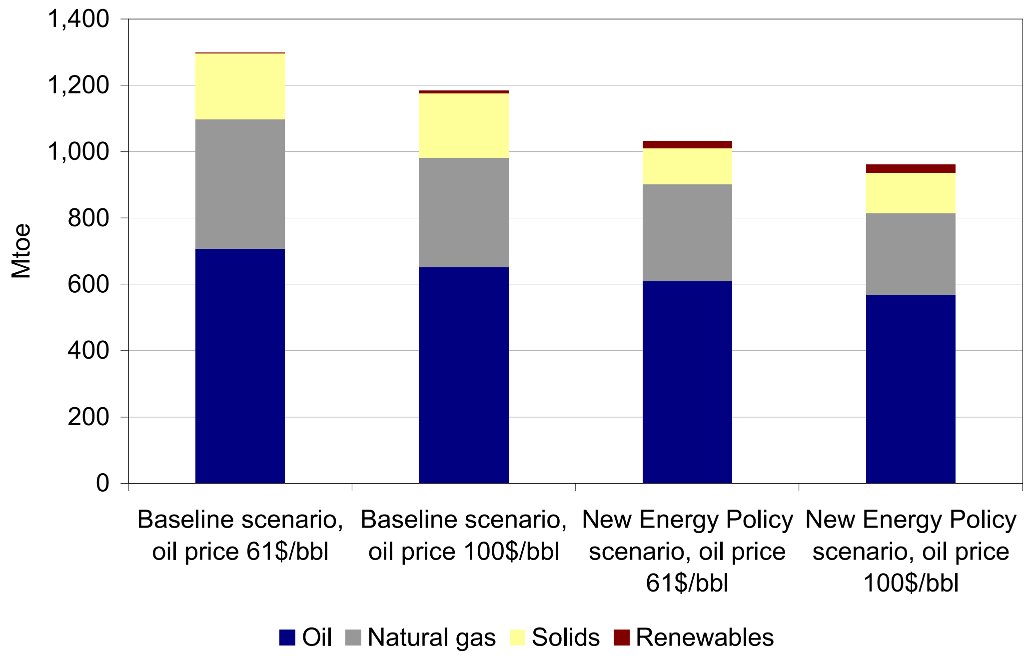
[11] The RES share is given here in terms of primary energy consumption as it is the case for all other energy sources. The political target for 2020 is about the RES share in final energy consumption, which leads to higher numbers given that final energy demand is only about two thirds of primary energy consumption. For more details see point 2.3.3.

with the higher increase occurring in the event of moderate oil prices. Only under the New Energy Policy with oil prices over 100$/barrel do net imports of fossil fuels decrease slightly in 2020 compared to the current levels as a result of the substantially reduced primary energy demand and the doubling of indigenous renewable energy production. This decrease is due to the combined effect of policy measures and high prices.

If current trends and policies continue, import dependency for oil could reach as much as 93% in 2020. High oil prices would only be able to lessen it by about half a percentage point in 2020. Even with the implementation of the New Energy Policy, oil import dependency is expected to remain high (92%) owing to the lack of alternative fuels, especially in the transport sector.

Figure 10

Net imports (Mtoe) in different scenarios



Source: Primes

Gas import dependency rises substantially to 77% in 2020 under current trends and policies with moderate oil prices, due to the strong rise in the primary gas demand (14%). Soaring oil and gas prices, which harm gas competitiveness, lead to a 2 percentage point decline in the import dependency of natural gas in 2020. This is due to the lower reliance on this energy source in power generation. The New Energy Policy promotes renewables and reduces the gas share in addition to reducing coal consumption in power generation. Thus the New Energy Policy would further contribute to decreasing gas import dependency. It would stand at between 71% and 73% in 2020.

Similarly to natural gas, solid fuel supplies will be increasingly based on imports, reaching between 57% and 59% in 2020 under a business-as-usual development (up from just under 40% today). The implementation of the New Energy Policy, and in particular the carbon constraints under the new ETS, will reduce the reliance on coal and lignite in the power generation sector. This leads to lower import dependency by 2020 (49-50%). With high energy prices, however, the decrease in imports of solid fuel is more modest, as coal's relative competitiveness will diminish less quickly.

2.3. Effects on EU energy security and on 2020 objectives

2.3.1. Energy security

Energy security is a major objective of the European Union to ensure its economic development and the well-being of its citizens. In both of the cases examined, the EU becomes more dependent on the external world to meet its energy demand compared to the present situation. Even in the event of a reduction in overall energy demand and with imports remaining at today's level (New Energy Policy and high oil prices) import dependency is set to increase.

Currently estimated at more than 54% of needs, external dependency would stabilise around 56% in 2020 assuming the implementation of the New Energy Policy and oil prices over 100 US$/barrel in real terms. However, import dependency would be higher with moderate oil prices (59% with 61 US $/barrel) and considerably higher under a business-as-usual development (between 60% and 64% depending on the oil price assumption).

This situation is mainly due to the decline in the indigenous production of oil, gas and solids, which is not being sufficiently replaced with indigenous sources such as renewables, and, in the absence of the New Energy Policy, to the increase in energy demand.

A still slightly increasing import dependency compared with the current situation, such as in the New Energy Policy case, can mask considerable improvements in the energy security situation. The energy savings and diversification improvements with more renewables will make the EU less vulnerable to the effects of volatile import price developments. In any case, the dependency rate in 2020 with the New Energy Policy would be markedly lower than under current trends and policies.

Diversification of the EU's energy demand is enhanced under the effect of policy measures and/or prices with a high penetration of renewable energy sources, although the primary energy demand remains in any case strongly dominated by the conventional sources.

2.3.2. Energy efficiency

The European Council's objective of "saving 20% of the EU's energy consumption compared to projections for 2020, as estimated by the Commission in its Green Paper on Energy Efficiency"[12] plays a central role in the European Union's energy policy. Energy efficiency is one of the key ways in which CO2 emission savings can be realised and the EU's growing dependency on external energy suppliers can be reduced.

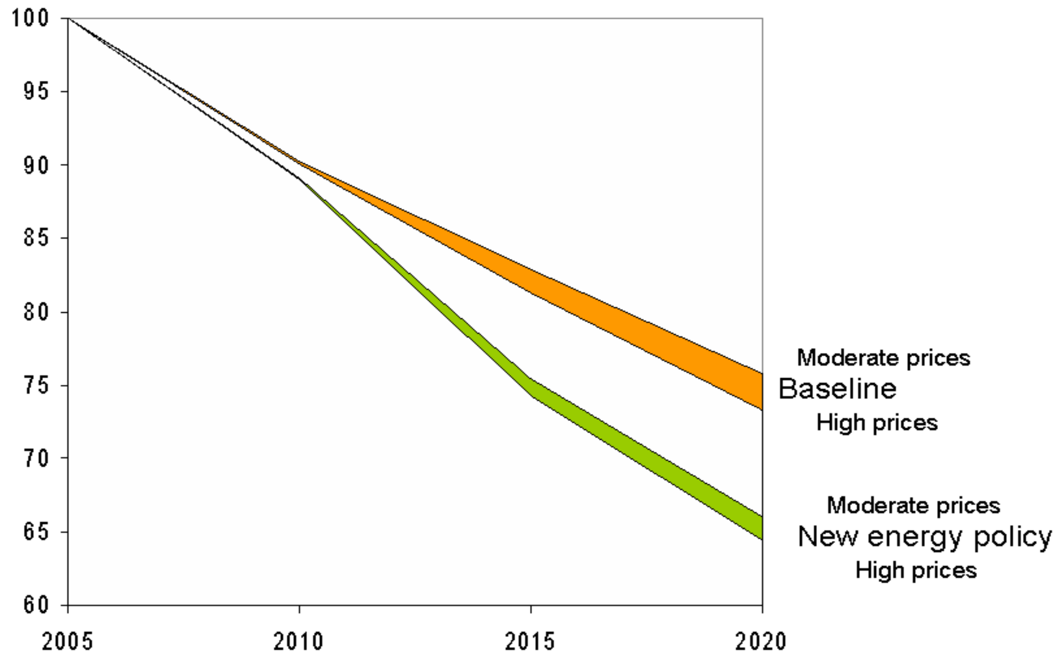
Given current trends and policies, energy intensity gains of 1.8-2% pa would result from a structural shift towards more services and less material/energy-intensive production in industry within a healthy GDP growth environment. It would derive from energy efficiency improvements in all energy activities. The implementation of the New Energy Policy would

12 European Council of 8/9 March 2007, European Council Action Plan (2007-2009) Energy Policy For Europe (EPE).

translate into energy intensity gains of 2.7-2.9% pa by 2020. Energy savings would increase between 13% and 15% in 2020 compared to developments under current trends and policies. Energy efficiency gains result to a certain extent from policy measures, but high energy prices also have an impact, albeit less marked, on the improvement of energy efficiency.

Figure 11

Energy Intensity (2005 =100)



Source: Primes

The objective of 20% savings in primary energy consumption remains a key pillar of the EU's energy and climate strategy.

2.3.3. Renewables

The European Union has set the ambitious objective of raising the share of renewable energy sources in its final energy consumption from around 8.5% in 2005 to 20% in 2020. This is a necessary contribution to the fight against climate change and the effort to diversify our energy mix.

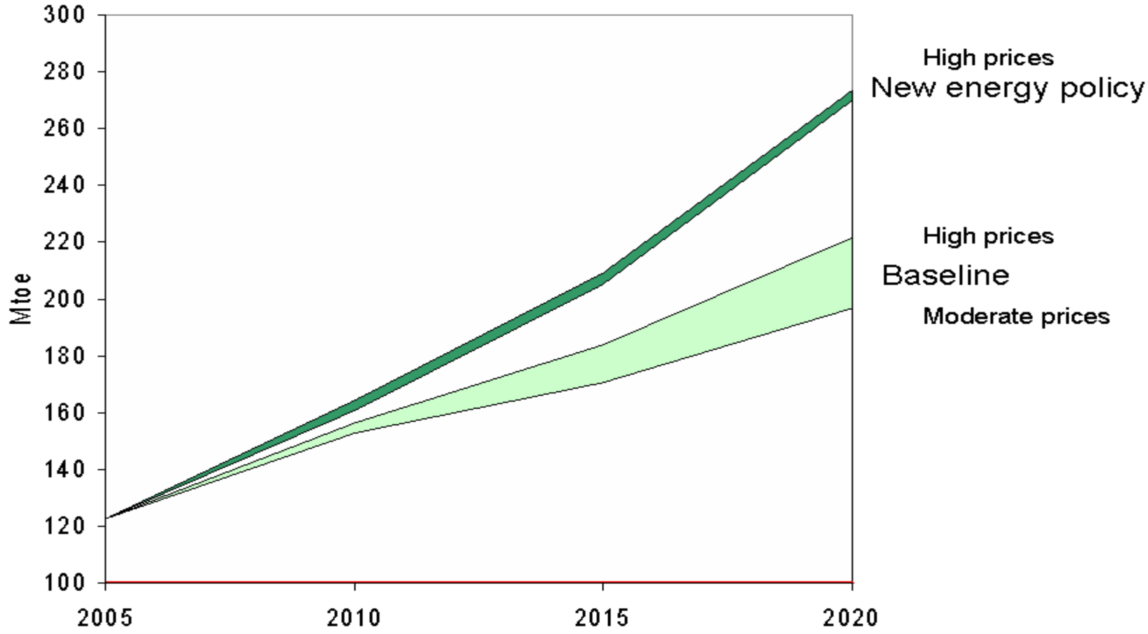
Penetration of renewable energy sources is driven by two major forces: the New Energy Policy and, potentially, high oil prices. Both favour RES deployment.

Given current trends and policies renewables would represent 13% of the final energy demand in 2020. Even with high oil prices, pushing higher RES deployment, renewable energy sources would not break through a limit of 15% in final energy demand.

Implementation of the New Energy Policy will result in 20% for renewable energy sources in final energy consumption. High energy prices could add an additional percentage point to the share of renewables in final energy consumption by 2020.

Figure 12

Renewables consumption (Mtoe)



Source: Primes

2.3.4. CO2 and GHG

In 2007, the Spring European Council set one binding target related to greenhouse gas emissions, including CO2, namely that by 2020 a reduction of at least 20% in GHG emissions compared to the 1990 level ought to be reached in order to enhance the sustainable development of the European Union.

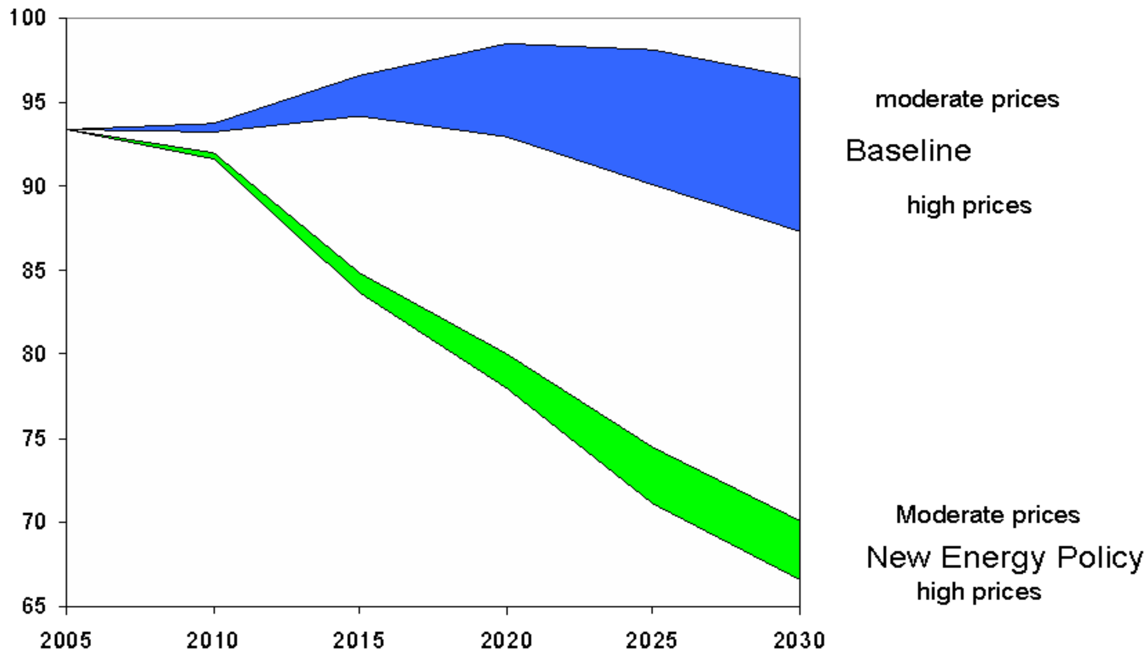
Given current policies and trends, irrespective of the level of energy prices, the 20% target will not be met in 2020. With moderate oil prices, energy-related CO2 emissions are set to rise by 5% between 1990 and 2020 – back on an ascending path, after earlier reductions due to restructuring in the EU12. Transport is responsible for more than 50% of the additional CO2 emissions till 2020. GHG emissions would decline by 1.5% between 1990 and 2020, due to the reduction in non-CO2 GHG emissions.

Transport accounts for a steadily increasing share of energy-related CO2 emissions under current policies and moderate fuel import prices, reaching 29% in 2020 compared to 27% in 2005 and 20% in 1990. After 2005, the share of the power sector and of industry in energy-related CO2 emissions remains relatively stable, while that of the residential sector declines by one percentage point over the period to 2020.

With high oil prices, energy-related CO2 emissions could stabilise at slightly below the 1990 level (-2%), due to greater RES deployment and the higher share of nuclear in the energy mix compared to the moderate Baseline developments. GHG emissions would be 7% less in 2020 than in 1990.

Figure 13

Greenhouse gas emissions (1990=100)



Source: Primes

Implementing the New Energy Policy and with moderate oil prices, energy-related emissions could be 20% below their 1990 level. This reflects the EU's unilateral commitment to the reduction of greenhouse gas emissions. Achieving a 20% cut in energy-related emissions solely on the basis of energy policy measures is also compatible with a minus 30% GHG reduction target. For such an objective, action in relation to non-energy-related CO2 and non-CO2 gases as well as greater recourse to JI/CDM credits is needed. The CO2 price required to achieve the 20% reduction in energy-related CO2 emissions would be €41 per ton of CO2 in 2020, which is lower than would be the case if no renewables policies were put in place. With high oil prices and a CO2 price equal to €41 per ton of CO2, energy-related CO2 emissions could be almost 23% below their 1990 level. This price is consistent with the one that would emerge from the "cost efficient scenario" analysed in the Impact Assessment for the January 2008 climate and energy package, which does not include JI/CDM credits. It is however important to bear in mind that the main scenario considered in the January 2008 Commission proposal, a policy case which achieves the CO2 and renewables objectives while allowing trade in JI/CDM credits, would result in a lower carbon price of about 30€ per ton CO2 while achieving less energy intensity improvements and CO2 reduction.

Implementing the energy and climate policy proposals would thus help the EU in delivering on its international commitments. It would also improve the environment and diversity of the fuel mix while fostering EU competitiveness through industrial leadership on efficient low carbon technologies.

3. EUROPE'S INDIGENOUS SOURCES OF OIL, GAS, COAL AND URANIUM

3.1. Diverging definitions, but common trends: Europe's resources are declining

Compared to a 'do nothing' approach, Europe's energy demand will decrease if the New Energy Policy is vigorously implemented. There will also be less reliance on fossil fuels in 2020 than today[13]. However, Europe's energy security will continue to strongly depend on the availability of primary energy sources. In the current EU energy mix, oil, gas, coal and uranium are the major primary energy sources and they will represent a significant part of the future energy mix of the EU.

Europe has always relied on external supply of energy sources to meet its demand and it will continue to do so. Currently estimated at more than 54% of its needs, this external dependency is expected to increase up to 56% in 2020, when oil prices over 100 US$/barrel (in 2005 money) are assumed in combination with the implementation of Europe's New Energy Policy. Import dependency would be a bit higher (e.g. 59% in 2020) with more moderate oil prices (e.g. 61 US $/barrel) as fossil fuel demand would be higher. This dependency is not a problem in itself. However, it requires an active energy security policy, building up internal strengths through a well-functioning internal energy with good interconnections, diversity in the types of energy used, clear regulation for security of supply and mechanisms for cooperation to deal with crises. It requires also an effective external action aimed at diversification of suppliers and supply routes as well as closer cooperation with producers and consumers. In view of the predicted growth of world energy demand, competition for resources will get tougher and the market power of the few large energy exporters will increase further.

It is difficult to specify how much gas, oil, coal and uranium still exists in the Earth's mantle and how much can be extracted in the future. A wide variety of methodologies is used for the assessment and classification of resources and data on fossil fuel resources represents sensitive information due to the geopolitical, economic and environmental factors influencing exploration and extraction activities. However, an overview of the resources' and reserves' situation for the European Union/European Economic Area (EU/EEA), compared with the information for the world as a whole, sets the scene for an energy supply security policy. Two trends are evident:

(1) Indigenous resources and the resulting reserves in the EU/ EEA are declining.

(2) The world's resources/reserves, still relatively abundant, are getting concentrated in the hands of a small number of countries.

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13 See New Energy Policy scenario, Annex 2 Part A.

Box 2

Resources and Reserves lack common definitions…

There is no common standard for defining and therefore assessing ***resources*** *and* ***reserves*** *at world level and even at EEA level because the majority of producing countries tend to use differing national classifications. There are also private entities that publish data on commercially exploitable reserves, which do not necessarily correspond to national or international classifications. Among the entities publishing information on resources and reserves are WEC (World Energy Council), OPEC (Organisation of Petroleum Exporting Countries), BGR (Federal Institute for Geosciences and Natural Resources, Germany), BP (British Petroleum p.l.c), and the Oil and Gas Journal.*

– *For the purposes of this document,* ***resources*** *refer to the amount of oil, gas or coal that may be present in deposits or accumulations discovered but not exploitable under the present technological and economic conditions, and those not discovered yet.*

– ***Reserves*** *refer to portions of oil, gas or coal in place claimed to be recoverable under current economic constraints and available technology.*

In the context of ***oil****, reserves are often sub-classified as proved, probable and possible:*

  – Proved Reserves are "Reasonably Certain reserves" to be produced using current technology at current prices, with current commercial terms and government consent. They are also known in the industry as 1P. Some industry specialists refer to this as P90, i.e. ideally having a 90% certainty of being produced.

  – Probable Reserves are "Reasonably Probable reserves" to be produced using current or likely technology at current prices, with current commercial terms and government consent. Some industry specialists refer to this as P50, i.e. ideally having a 50% certainty of being produced. This is also known in the industry as 2P or Proved plus probable.

  – Possible Reserves are reserves "having a chance of being developed under favourable circumstances". Some industry specialists refer to this as P10, i.e. ideally having a 10% certainty of being produced in the foreseeable future. This is also known in the industry as 3P or Proved plus probable plus possible.

The bulk of these definitions apply mutatis mutandis to ***gas*** *and* ***coal****.*

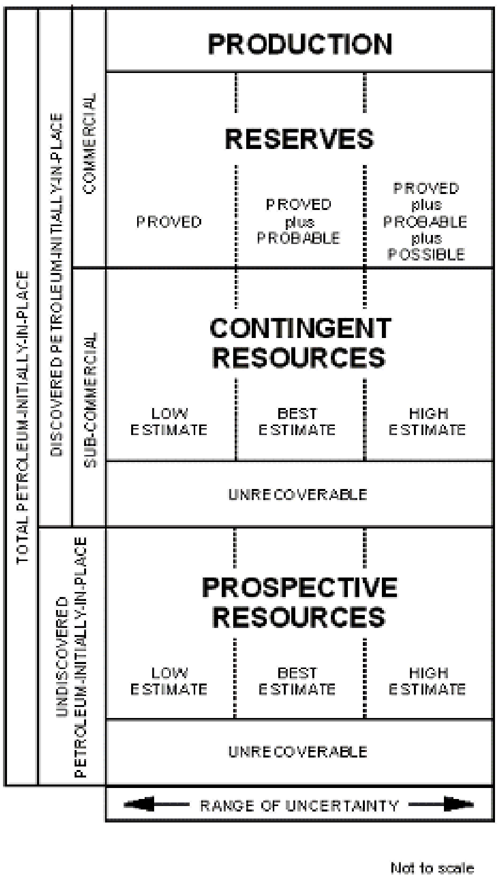
– *For uranium, specific categories have been established at international level*[14]*. Undiscovered resources refer to expected resources based on geological knowledge of discovered deposits and regional geological mapping. Identified resources are close to reserves since they are recoverable. They are, however, subdivided by cost*

[14] See OECD/International Atomic Energy Agency, "Uranium 2007: Resources, production and demand"

ranges and the most used category is "Identified Resources recoverable at a cost of less than USD 130/kgU".

– The relations between resources and reserves in the context of oil may be illustrated in the following way:

FIGURE 1 - RESOURCES CLASSIFICATION SYSTEM



Source: WPC/SPE

– ***Unconventional oil and gas** can be exploited with improved technologies and moderately higher prices. It is generally accepted that unconventional oil includes heavy oil, extra heavy oil and bitumen (or tar sands) whereas unconventional gas covers coal bed methane, low quality and/or stranded gas, ultra-tight gas formations, Devonian shale gas, very deep gas and methane hydrates.*

– *The **Reserve-to-production** ratio (R/P) indicates the length of time (years) that the remaining reserves would last if production were to continue at the rate of production of a given year. Such a ratio is obtained by dividing the reserves remaining at the end of any year by the production in that year.*

– *This ratio must not be confused with the time span until depletion of the resources or end of production, as recovery can be enhanced through additional efforts or as new discoveries are made over time.*

– *In some instances, a reserve-to-consumption ratio is used. It indicates the length of time the remaining reserves would meet the current consumption requirements.*

3.2. Reserves and resources found in the European Union /European Economic Area

3.2.1. Oil

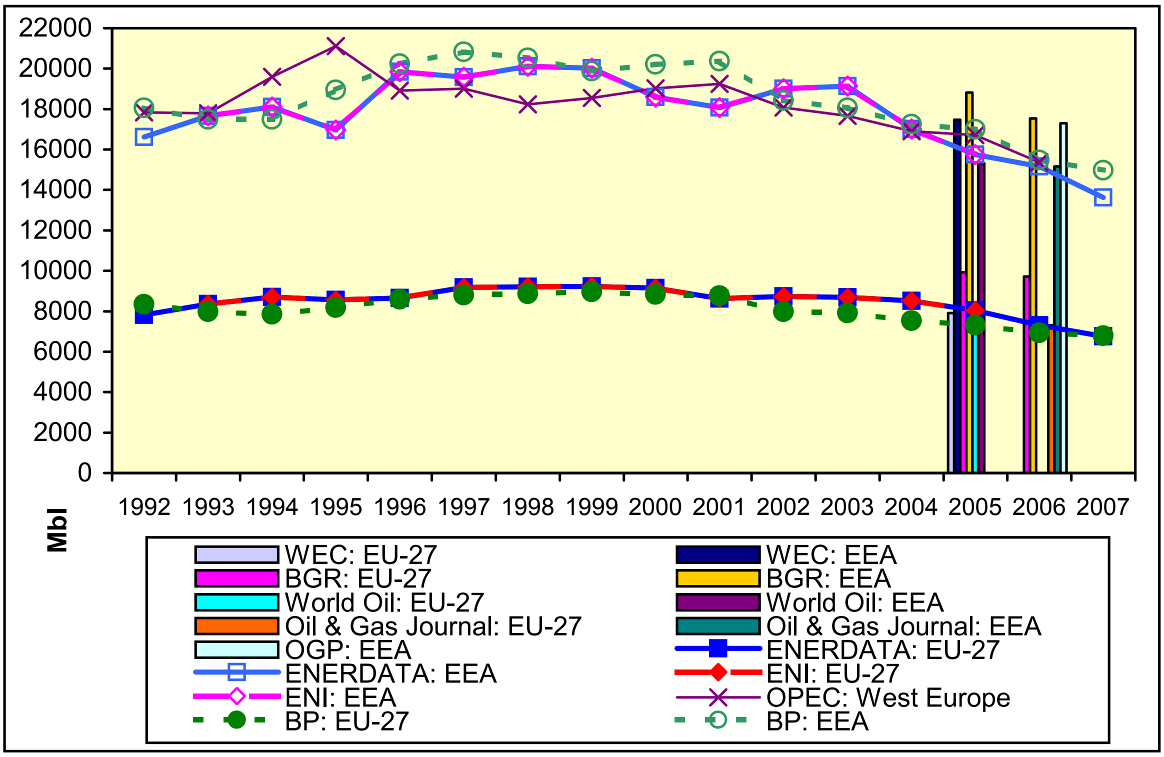
The EEA is currently an important oil producer ranking fourth in terms of global production, even though oil production has been declining since 2000 from 6.8 Mbl per day in 2000 to approximately 5 Mbl per day in 2007. However, the oil resources and reserves in the EEA are limited and represent a small proportion of world reserves.

As reported by different sources such as BGR and BP[15], the proved reserves of oil in 2006 for the EU range between 6.9 and 9.7 Bbl and for the EEA between 15.1 and 17.3 Bbl (*Figure 14*). At the end of 2007, according to BP, the proved reserves for the EU amount to 6.7 Bbl, whereas the corresponding figure for the EEA is 14.9 Bbl.

These reserves are mainly located in the North Sea area (Norway, United Kingdom and Denmark) and in South-East Europe (Romania).

Figure 14

EU-27 and EEA proved reserves of crude oil as reported by different sources, million barrels



Source: Various, calculations of the Joint Research Center (JRC)

The proved reserves for the EU represent between 0.5% (BP 2007) and 0.8% (BGR 2006) of world reserves. The different graphs below show a convergence of estimates and a relatively

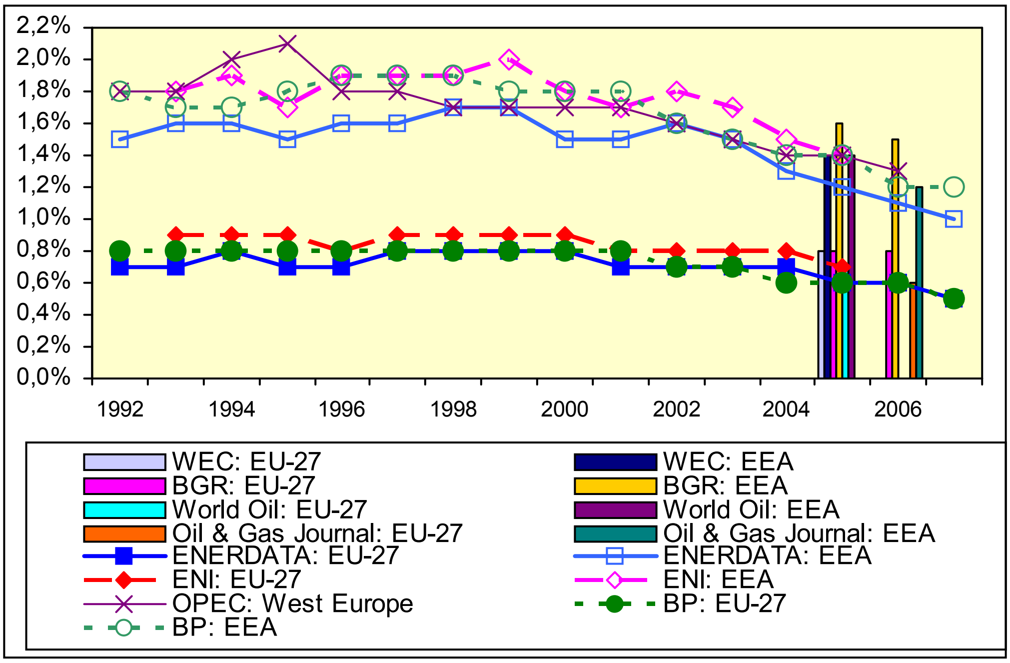
15 BP Statistical Review of World Energy June 2008, hereafter « BP ».

moderate declining trend in respect of current reserves *(Figure 15)*. At the current production rate, these proved reserves secure between 7.7 (Enerdata 2008) and 7.8 (BP 2008) years of domestic production.

Figures for the EEA also show a declining trend, with reserves falling even faster / steeper. These EEA proved reserves represent between 1.2% (BP) and 1.5 % (BGR) of world reserves. At current rates, the EEA proved reserves secure between 8 (derived from Enerdata data 2008) and 8.3 (derived from BP figures) years of domestic production.

Figure 15

Share of EU and EEA proved reserves of crude oil in world proved reserves according to different estimates, pct.



Source: Various, calculations of the JRC

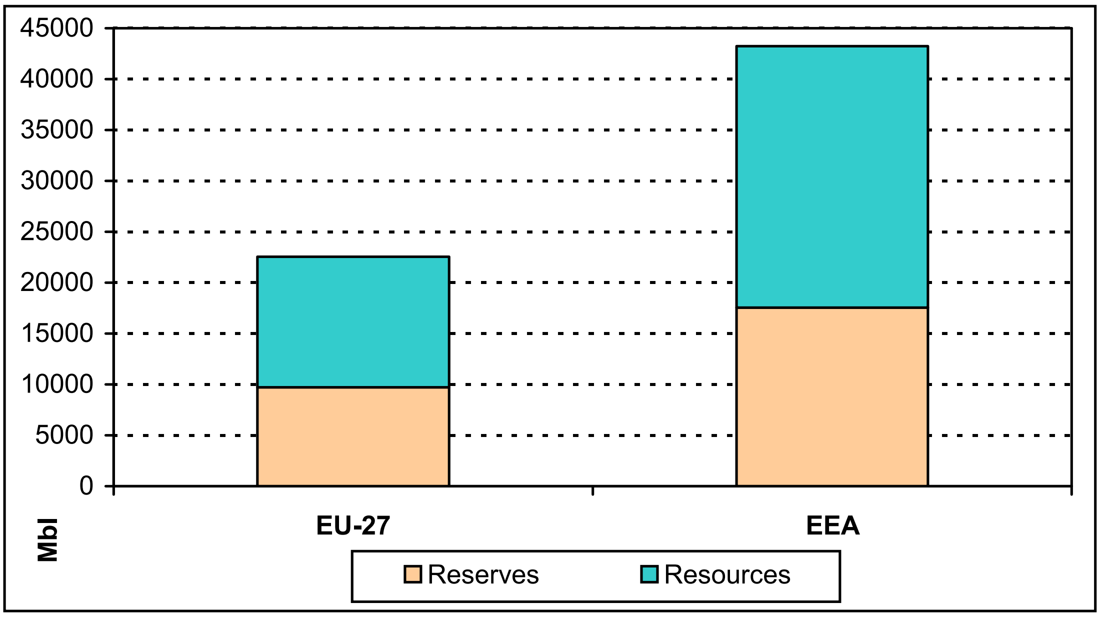
According to OGP, the EEA resources for oil at the end of 2006 could amount to some 26-27 billion of boe. In the light of BGR's estimates for the resources and reserves of crude oil in the EU/ EEA, the production potential still seems considerable.

Resources are more limited for the EU than for the EEA *(Figure 16)*. However, the remaining resources are concentrated in smaller accumulations and fields. Production in these fields will depend on favourable economic circumstances and improvement in oil recovery technologies.

Unconventional oil also offers additional potential *(Figure 21)*. For the EU-25, according to BGR, it could represent more than 25% of the conventional reserves and more than 60% of the conventional resources. For the EEA, it could represent up to 40% of the conventional reserves and more than 55 % of the crude oil conventional resources.

Figure 16

Cumulative conventional reserves and resources of crude oil in EU and EEA in 2006, Million barrels



Source: BGR, calculations of the JRC

3.2.2. Gas

The gas reserves and resources in the EU/EEA represent a very modest share of world reserves, even if the picture looks better for gas than for oil. As reported by different sources such as the Oil and Gas Journal, BGR or Enerdata, the proved reserves range between 2 700 Bcm (O&GJ) and 3 500 Bcm (BGR) for the EU. They ranged between 5 000 Bcm (O&GJ) and 6 200 Bcm (Enerdata) for the EEA at the end of 2006 (*Figure 17*).

The proved reserves for the EU correspond to 1.4% (WEC 2005), or 2.0% according to BGR, of the world's proved reserves. EEA gas proved reserves amounted to approximately 2.7% (WEC 2005), or 3.7% according to ENI 2007, of the world's proved reserves at the end of 2005 (*Figure 18*).

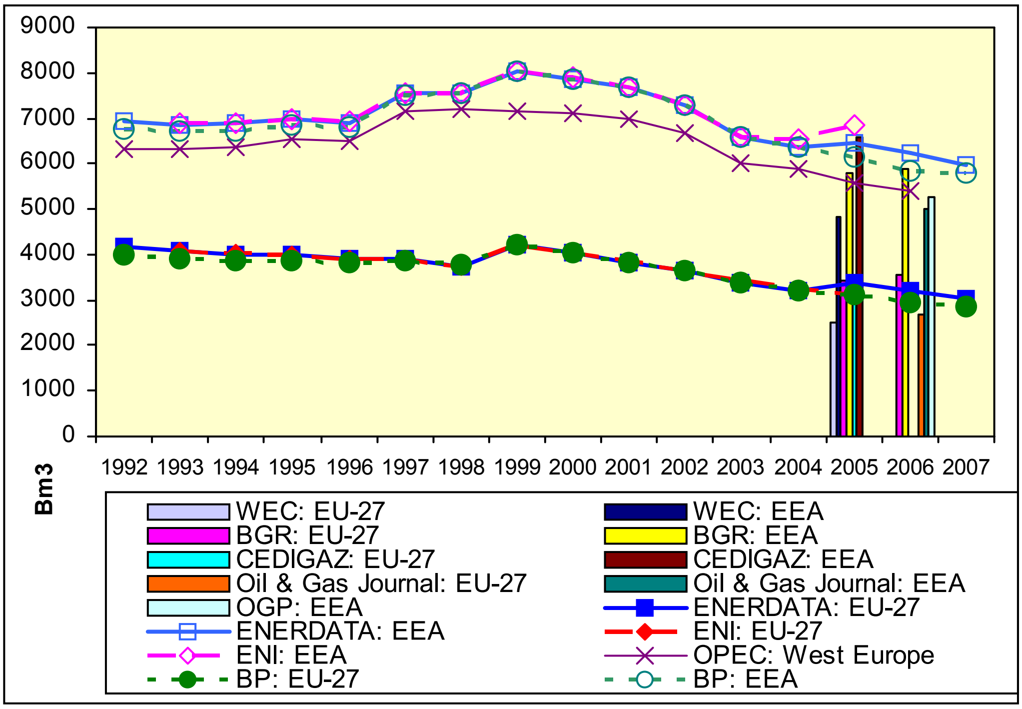
As demonstrated by the illustrations, there is a convergence of estimates showing a declining trend for proved reserves of natural gas for the EU/EEA. The decline appears to be somewhat faster for the EEA than for the EU.

Gas reserves are mainly located in Norway, the Netherlands, the United Kingdom and Romania.

At current production rates, the EU proved reserves secure between 14.4 (Enerdata) and 14.8 (BP) years of domestic production (BP). For the EEA, the proved reserves secure between 19.4 (derived from Enerdata figures) and 19.9 (derived from BP figures) years of domestic production.

Figure 17

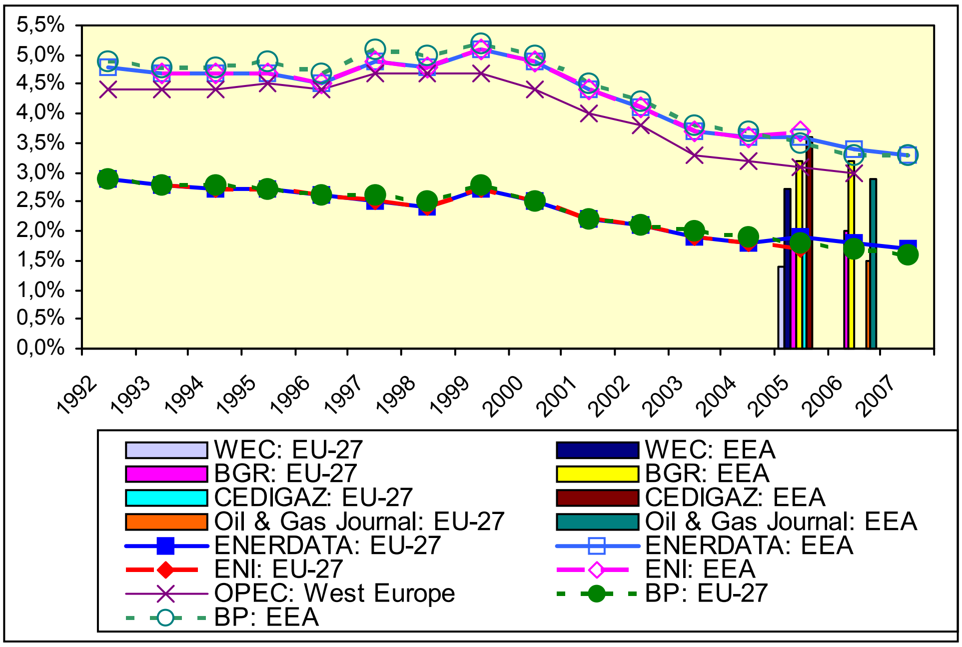
EU-27 and EEA proved reserves of natural gas, billion cubic meters



Source: Various, calculations of the JRC

Figure 18

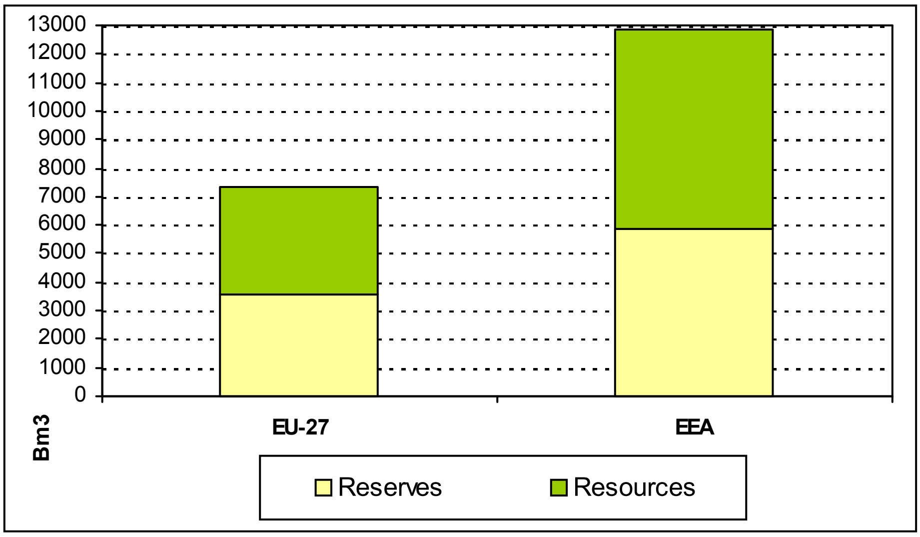
Share of EU and EEA proved reserves of natural gas in world proved reserves according to different estimates, pct



Source: Various, calculations of the JRC

Figure 19

Cumulative conventional reserves and resources of natural gas in EU and EEA in 2006, Billion cubic metres



Source: BGR, calculations of the JRC

Some estimates show that natural gas resources may remain significant at an EU/EEA level. According to BGR, the estimated resources for the EU are around 50% less than for the EEA. On the whole, resources of natural gas for the EEA could amount to approximately 7 000 Bcm, which more than doubles the current proved reserves (*Figure 19*).

These conventional natural gas resources could be augmented by unconventional resources. The unconventional resource potential is not negligible (*See box 3*). This potential will however be more difficult to exploit, in view of enhanced recovery techniques needed and the increasing share of sour gas to be encountered, posing safety issues.

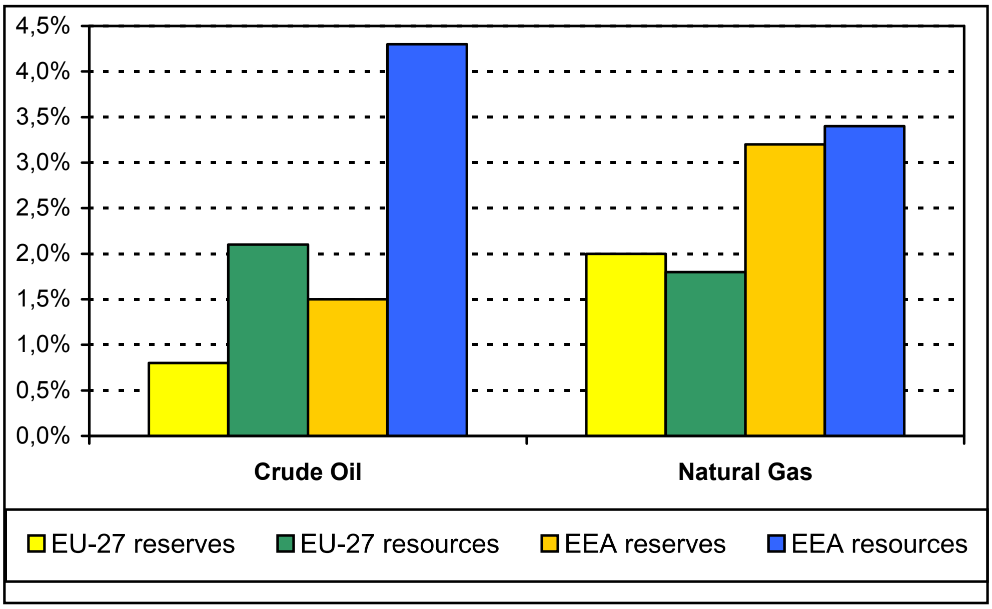
Box 3

Europe's remaining potential for gas and oil

Reserves and resources of crude oil and natural gas in the EU/EEA represent a modest share of world reserves and resources. The EEA almost doubles the oil reserves and resources of the EU (Figure 20).

Figure 20

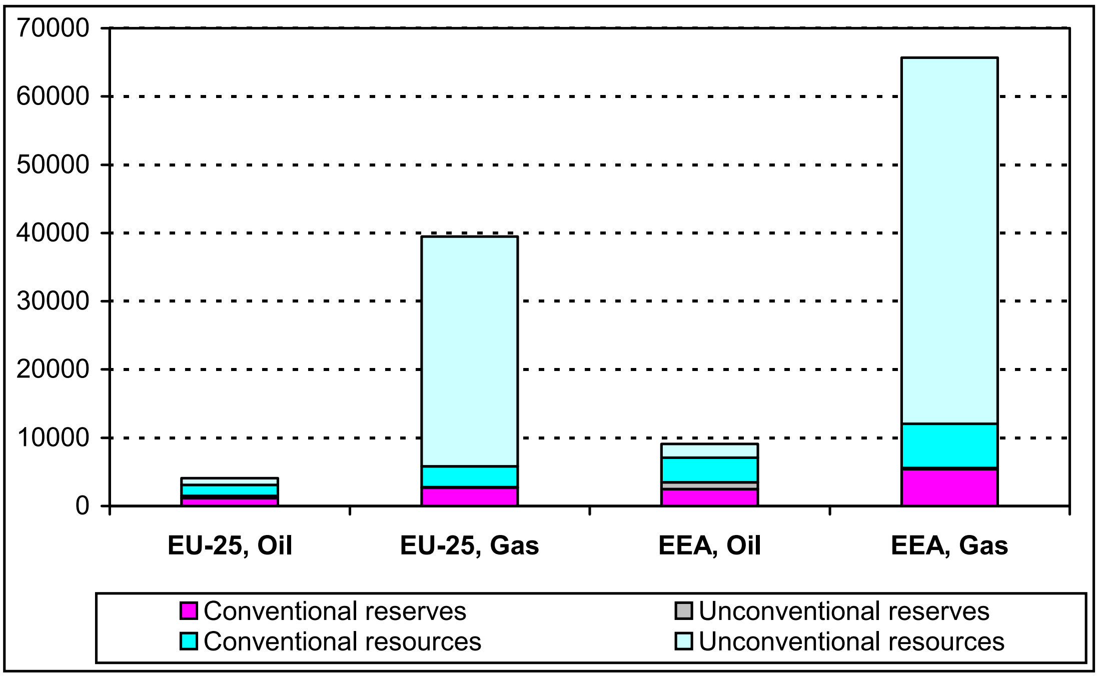
Reserves and resources – world share of EU and EEA by the end of 2006



Source: BGR, calculations of the JRC

Figure 21

Conventional and unconventional reserves and resources of crude oil and natural gas
2006, Million toe



Source: BGR, calculations of the JRC

3.2.3. Coal

About 80% of Europe's fossil fuel reserves are solid fuel (including coal and lignite). Proved reserves of coal and lignite may be considered as substantial, although they represent only a limited share of world reserves.

As reported by the World Energy Council, the coal proved reserves in the EU at the end of 2005 are estimated at about 8.5 Bt of hard coal and about 21 Bt of lignite (including sub-bituminous coal). On the whole, these proved reserves amount to about 29.5 Bt. According to BGR, which uses different classifications, reserves amount to 19 Bt of hard coal and 75 Bt of brown coal and lignite at the end of 2006 *(Figure 22).*

In BP's view, the EU's proved reserves represent 3.5% of world reserves and 50 years of today's production.

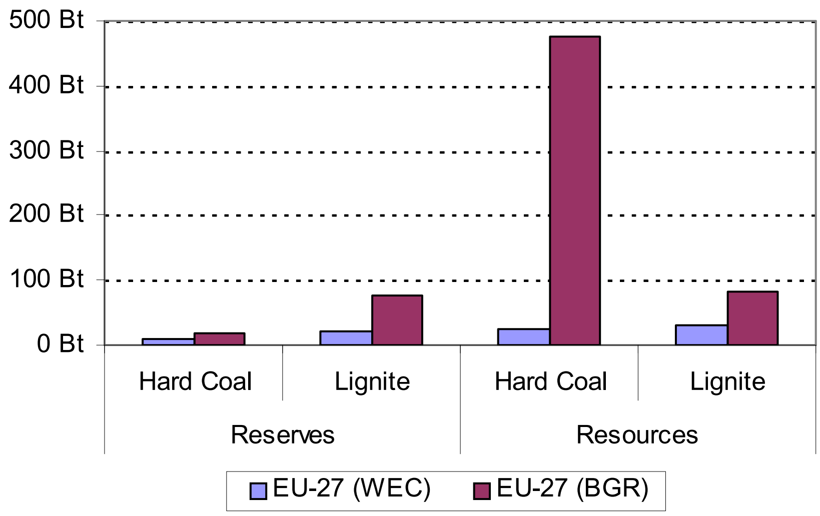
Proved reserves for hard coal are mainly concentrated in Poland, with significant reserves in Czech Republic and to a more limited extent in Spain, Hungary, UK and Germany.

For lignite, reserves are present in a group of countries extending from Germany to Greece.

Coal resources are reported to correspond to 476 Bt for hard coal and 83 Bt for brown coal and lignite at the end of 2006 (BGR). The WEC, using different classifications, estimates these resources at around 24.5 Bt for hard coal and 31 Bt for lignite (including sub-bituminous coal) at the end of 2005 *(Figure 22).*

Figure 22

Reserves and resources of coal in the EU in 2005 (WEC) and 2006 (BGR)



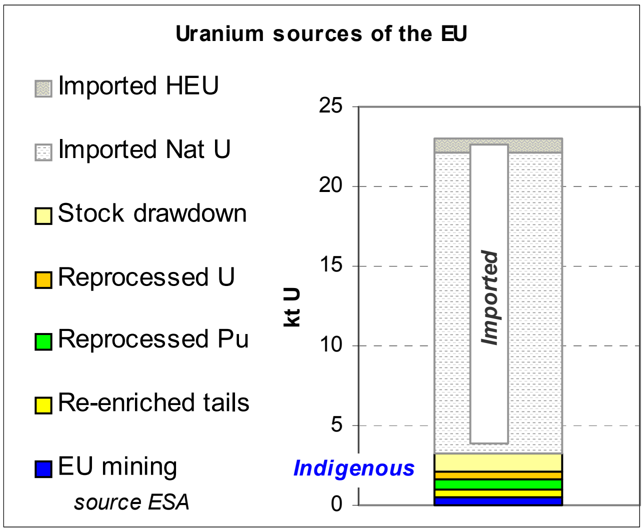
Source: WEC, BGR

3.2.4. Uranium

Identified resources of uranium (<USD 130/kgU) in the EU are very modest and unevenly distributed. As reported by OECD and IAEA[16], they amount to approximately 105 500 tonnes U and represent 1.9% of world identified resources as of 1 January 2007. Denmark holds the biggest identified resources with 32 300 tonnes U while France, Spain and Sweden have identified resources above 10 000 tonnes U.

It has to be noted that EU indigenous sources are substantially complemented by reprocessed and re-enriched sources. The situation for 2007 is presented in *Figure 23*.

Figure 23



Only a few countries have reported their estimates on undiscovered resources. On the basis of the available information, undiscovered resources in the EU could represent 1.1% of the world's undiscovered uranium resources. Undiscovered resources are thought to be present in Denmark and Hungary.

3.3. World reserves and resources

3.3.1. Oil

The world's proved reserves of oil have increased at an average annual rate of 2.4% since the beginning of the 1980s. According to BP, they increased from around 910 bbls in 1987 to around 1 238 bbls at the end of 2007. The situation at the end of 2007, however, shows a decline in proved reserves for BP. At the end of 2006, the proved reserves amount to 1 239.5 bbls. Enerdata considers that the world's proved reserves amount to 1 339 bbls in 2007 and are higher than the reserves at the end of 2006, which were 1 332.5 bbls. In this case, no decline in world reserves is observed.

Over two thirds of oil reserves are concentrated in the Middle East (61%) and Russia (6.4%). South and Central America and Africa account for 18.5% of the proved reserves. Reserves

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[16] See OECD/International Atomic Energy Agency, "Uranium 2007: Resources, production and demand", 2008.

tend to be concentrated in a small number of countries. Thirteen countries have individual proved reserves above 2% of the world's proved reserves. Only seven of these countries have individual proved reserves above 5% according to BP. Apart from Venezuela and Russia, these countries belong exclusively to the Middle East (Iran, Iraq, Kuwait, UAE and, with 21.3%, Saudi Arabia).

BP considers that the world's proved oil reserves amount to 41.6 years of current production. The reserves-to-production ratio for the Middle East is much higher: 82.2 years. It is 21.8 years for Russia. Enerdata estimates the world's proved reserves at 47.4 years of current production.

Conventional oil resources have been estimated at 82 Bt at the end of 2006 by the BGR, which in this case covers the resources that are proved but not economically recoverable at present or are recoverable amounts of geologically indicated resources. The US Geological Survey estimates that about 140 Bt of recoverable conventional oil could be discovered.

Unconventional oil is also believed to offer considerable potential under favourable economic[17], technological[18] and environmental[19] conditions. Around 600 bbls (IFP) could be recovered, which is comparable to the Middle East's proved reserves (755.5 bbls according to BP). This unconventional potential is mainly located in the Americas (the extra heavy oil from Venezuela and the oil sands from Canada). With 175 bbls in oil sands reserves, Canada ranks second in global oil reserves.

3.3.2. Gas

The world's proved reserves of natural gas have constantly increased since 1980 at an average annual rate of 3.4% and the volume of proved natural gas reserves has more than doubled over that period (WEC). The world's proved reserves have increased from approximately 70 Tcm since 1987 to 177 Tcm in 2007 (BP). They amount to about 181 Tcm at the end of 2006 (BGR) and to about 182 Tcm in 2007 (Enerdata). This increase in world reserves results both from new discoveries and to a greater extent from new assessments of existing fields in the Middle East, Asia/Oceania and Africa.

The world's proved reserves represent between 59.8 (Enerdata) and 60.3 (BP) years of production.

Almost half of the reserves are concentrated in a limited number of super giant fields (WEC 2007). Almost two thirds of the new discoveries have been made offshore. Offshore reserves represent about 70 Tcm.

According to BP, around 41% of the world's proved reserves are located in the Middle East. The former Soviet Union accounts for more than 30% of the total at the end of 2007. Oceania and Africa represent around 16% (8% each). Gas reserves tend to be concentrated in a small number of countries. Only seven countries have individual proved reserves above 2% of the world's proved reserves and, according to EIA, Russia, Iran and Qatar together hold about 58% of the world's oil reserves (International Energy outlook 2007).

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17 A moderated high oil price is necessary for unconventional oil to be exploited under good economic conditions.

18 New technologies are required.

19 Environmental impacts related to their exploitation are significant. Site regeneration takes time for example.

Natural gas resources appear to be very substantial. BGR's estimate is that global resources of conventional natural gas stand at about 207 Tcm. Some estimates consider that the prospects for yet-to-find natural gas could expand the lifetime of natural gas up to 130 years at the current rate of consumption (WEC).

Unconventional resources are considered to represent a potential ranging from about 13 500 to 25 000 Tcm.

3.3.3. Coal

World coal reserves are much more abundant than gas and oil reserves. Proved coal reserves have been estimated at between 847 Bt (WEC 2005) and 1 019 Bt (BGR 2006). At current production levels, proved reserves are estimated to last between 133 (BP using WEC figures) and about 150 (WEC 2007) years.

Contrary to oil and gas, coal reserves are widely available, in almost every country, with recoverable reserves in around 70 countries. Overall, Northern America, CIS and Asia/Oceania have an equal share of reserves, ranging from 27% to 30 % of total reserves.

More than 80% of the world's coal reserves are nevertheless concentrated in six countries:

– USA (28.6%),

– Russia (18.5%),

– China (13.5%),

– Australia (9%),

– India (6.7%),

– South Africa (5.7%).

Source: BP Statistical Review of World Energy, June 2008

World coal resources could amount to 8 818 Bt of hard coal and 3 075 Bt of lignite (BGR).

3.3.4. Uranium

Identified world resources of uranium (<USD 130/kgU) are around 5.5 million tonnes U. At the current rate of consumption, these resources correspond to about 100 years of supply (OECD/IAEA).

These identified resources are widely distributed throughout the world. Uranium resources have been identified in the following countries:

– Australia (23%),

– Kazakhstan (15%),

– Russia (10%),

– South Africa (8%),

- Canada (8%),
- United States (6%),
- Niger (5%),
- Namibia (5%), and
- Brazil (5%).

Source: OECD/IAEA, 2008

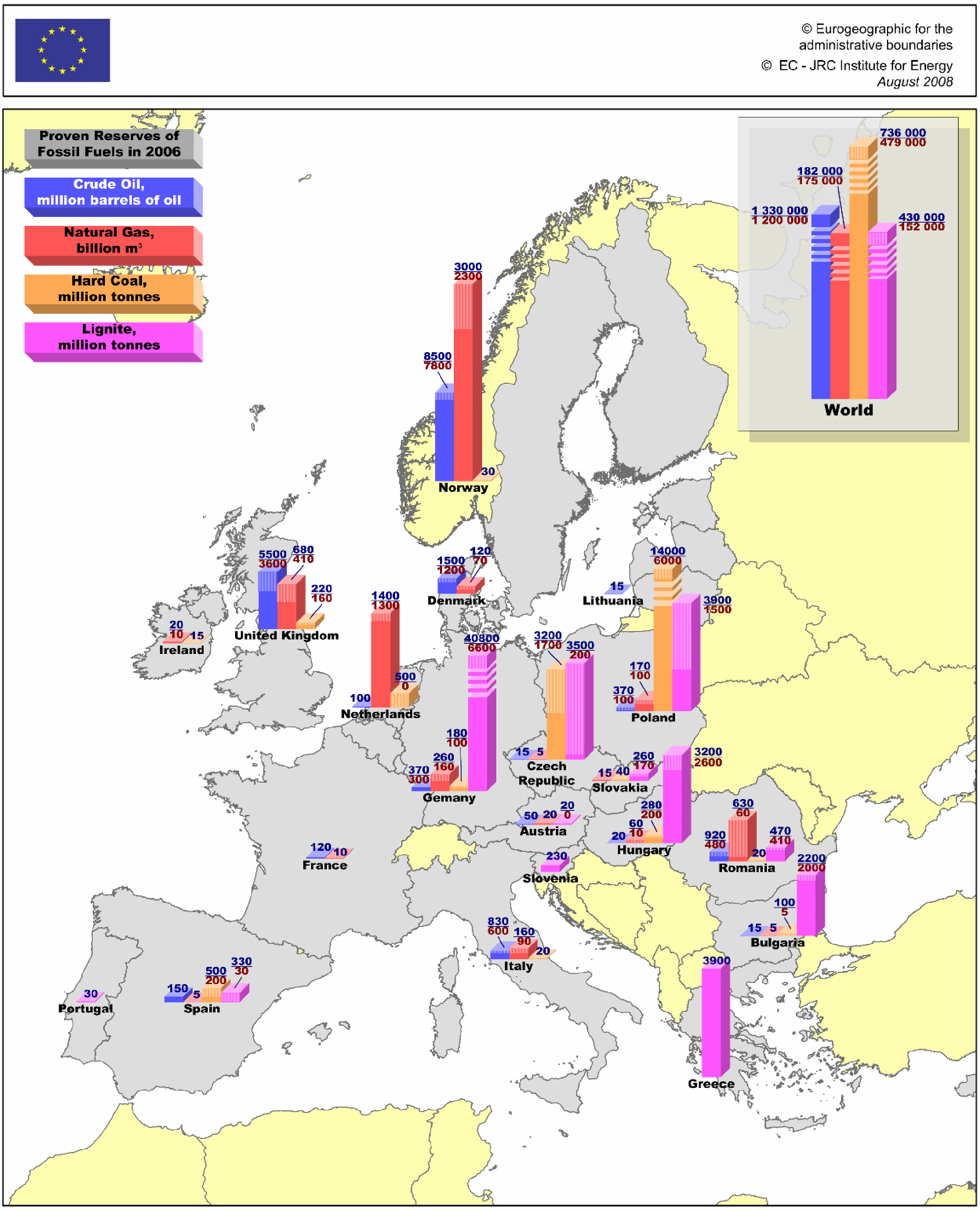
The undiscovered resources thought to be present in the world are estimated at 10.5 million tonnes U.

3.4. Europe's fossil fuel map

An overview of Europe's indigenous fossil fuel reserves is presented in *Figure 24*.

Figure 24

Upper (blue) and lower (red) estimations of proved reserves of fossil fuels



4. EUROPE'S CURRENT AND FUTURE ELECTRICITY GENERATION CAPACITY: CHALLENGES AND OPPORTUNITIES

Electricity plays a crucial role in the economic and social development of the European Union and in the quality of life of its citizens and consumers. It is a key sector for the EU economy and constitutes an essential component of EU energy security. A sufficient power generation capacity and infrastructure – and more generally power generation adequacy - are therefore a constant concern, along with transmission and distribution networks. This issue is all the more sensitive in that electricity is consumed at the time it is produced and demand has to be met all the time.

Deregulation and liberalisation have profoundly changed the landscape of power generation, enhancing the role of private actors. Changing supply conditions and the regulatory framework directly impact on power generation. Oil, gas and coal supply prices as well as the price for CO2 allowances have a major impact on the future development of Europe's power generation infrastructure. As a result of the regulatory framework having evolved at EU level, electricity has become predominantly commercial and the market players have made the needed investments. On the other hand, energy security is a public good and public authorities bear a responsibility for a market design that is conducive to ensuring that sufficient power will be on offer in order to meet future demand. In other words, private actors will make the necessary investments but public authorities are ultimately responsible for a market design that fosters energy security and encourages investment.

Against this background, power generation in the EU faces challenges and brings opportunities at the same time. Europe's electricity generation capacity is at a crossroads (4.1) and the way forward has to be sketched out (4.2).

4.1. Europe's electricity generation capacity at a crossroads

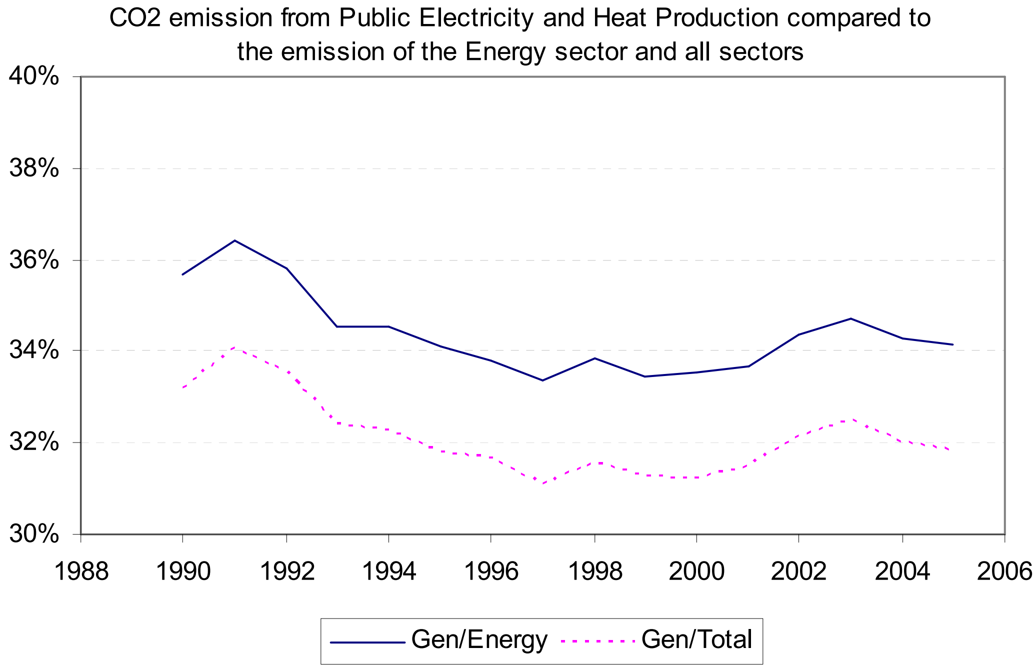
The EU must deal with two major challenges to ensure that its generation capacity is adequate in the future: (i) promoting clean generation and making capacities available on time to produce enough electricity at affordable prices; and (ii) ensuring reliability with a view to greater diversity of input fuels. Equally, these challenges have to be considered as opportunities to revamp the EU's generation capacity in a way that improves its economic and environmental performance and provides greater reliability.

4.1.1. Need for clean generation and new capacities

Europe's New Energy Policy context imposes a major shift in the power generation infrastructure. CO2 and GHG emissions have to be reduced and these objectives have a direct impact on generation capacity, given the share of power generation in CO2 emissions (*Figure 25*).

Figure 25

Share of the power generation sector in CO2 emissions



Source: European Environment Agency (EEA)

The current situation is mainly due to coal-fired generation, which represents the largest share of emissions from the power sector as well as the second biggest share of installed capacities in the EU (*See Figures 34, 35*). As a result of the new environmental requirements (including ETS and IPPC), the decommissioning phase of installed capacities could be accelerated, necessitating replacement of capacities to keep generation at a sufficient level to meet demand.

The price of carbon emissions (ETS allowances) and the relative costs of Carbon Capture and Storage (CCS) and other low-carbon technologies will thus be among the major parameters to be factored into investment decisions for new capacities together with the security of supply of the primary energy needed. Most of the coal-fired replacement capacity till 2020 would be in capture-ready facilities, that is to say plants which could be retrofitted when CCS becomes commercially viable, probably after 2020.

Given current trends and policies, final electricity demand is expected to increase over the period to 2030, requiring additional generation capacities (*See Figure 26*). So far, at EU level, generation capacity has kept pace with steadily growing demand. For the existing generation park this means that power capacity has risen from 681 GW in 2000 to 740 GW in 2005, i.e an increase of approximately 60 GW or 12 GW on an annual basis, which represents an average rate of growth of 1.7% (*See also Figure 30*). Over the same period, electricity consumption has grown at an average annual rate of 1.8%.

Figure 26

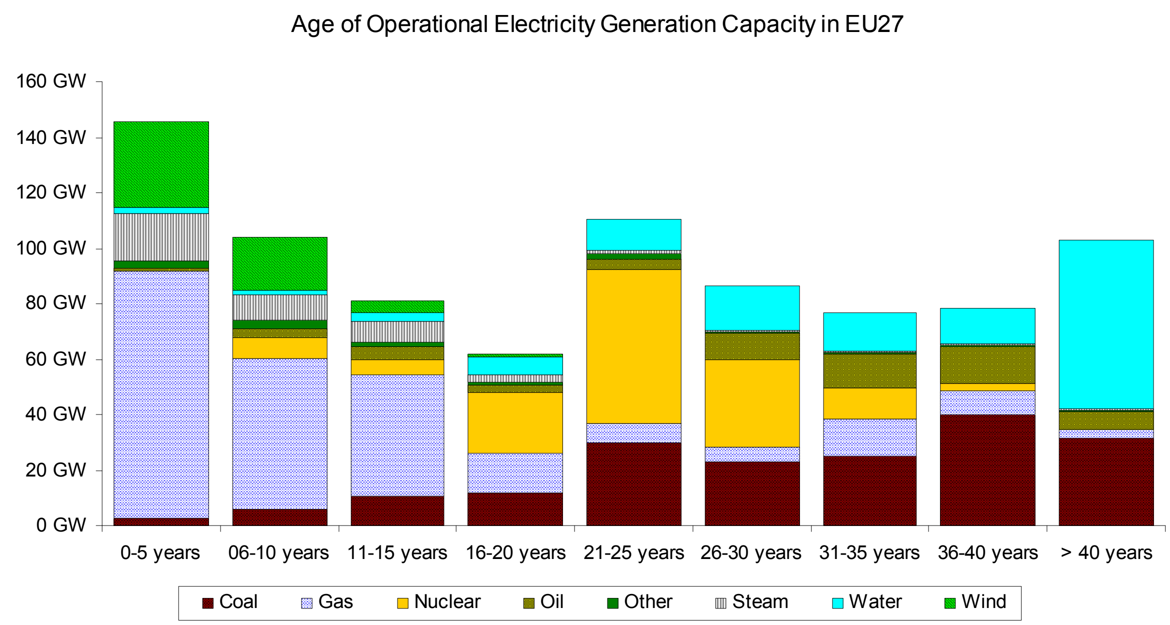
Final Electricity demand for EU-27

	2005	Baseline scenario 2020		New Energy Policy 2020	
		61$/bbl	100$/bbl	61$/bbl	100$/bbl
Final electricity demand (TWh)	2762	3525	3509	2990	3028

Source: Primes

Under the baseline scenario, the EU would need a net power capacity in the year 2020 which is, depending on the oil prices, about 160 or 200 GW higher than today. Under the New Energy Policy scenario, the net power capacity in the year 2020 would be higher than today by about 150 GW, with moderate oil prices, and 180 GW with higher prices. In addition to creating this amount of extra capacity, it will be necessary to replace existing installations: power plants are ageing all across the EU. A substantial part of the current nuclear and coal capacity came on stream between 1980 and 1985, and even before then. Decommissioning should take place by 2020 or 2025, under the assumption that coal infrastructure operates over an average period of 40 years[20] (*See Figures 27, 28*).

Figure 27



Source: Platts

20 Which explains the significant replacement of coal fired installations during the 2011-15 period (33GW) as shown in Figure 39

Figure 28

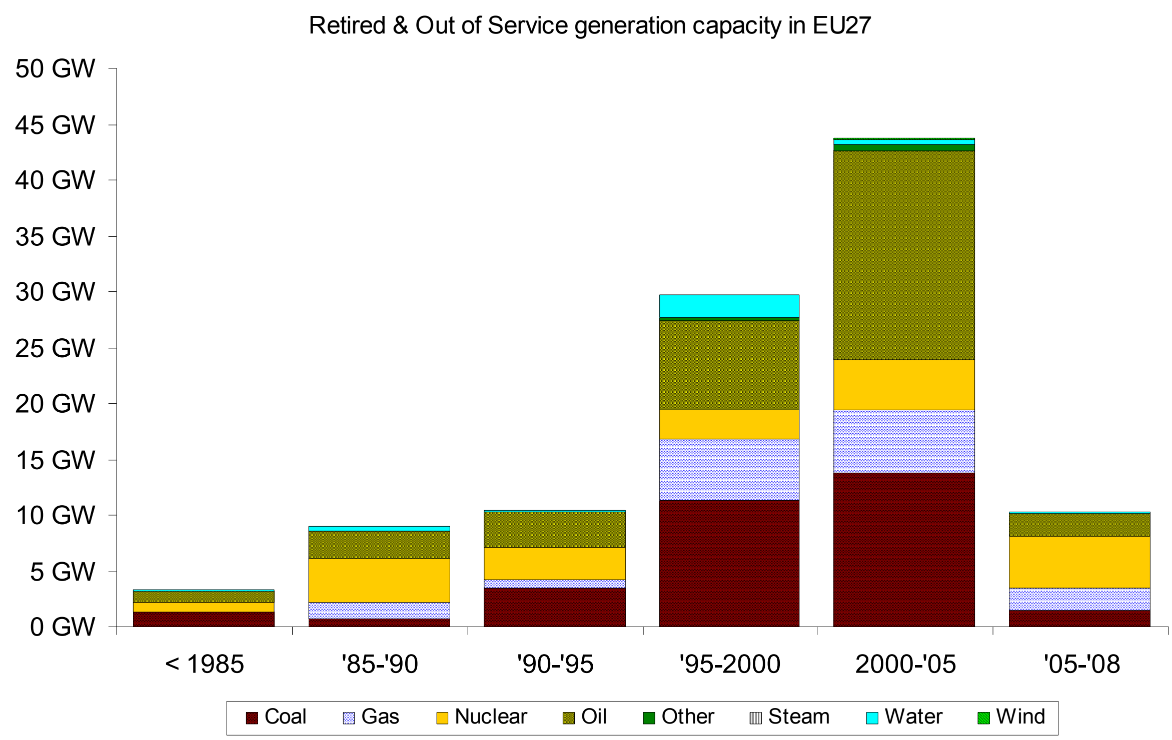
Time horizon of decommissioning

	Nuclear	Combined cycle gas turbine	Pulverised coal	Wind on-shore	Open cycle gas turbine
Lifetime (years)	40	25	40	20	20

Source: OECD/IEA, 2006

The recent deregulation phase of the electricity markets has been characterised by optimisation of the use of existing infrastructure and a tendency to delay decommissioning (*See Figure 29*). Demand has thus been partly met by better use of the existing capacities, which also means that further decommissioning could be expected.

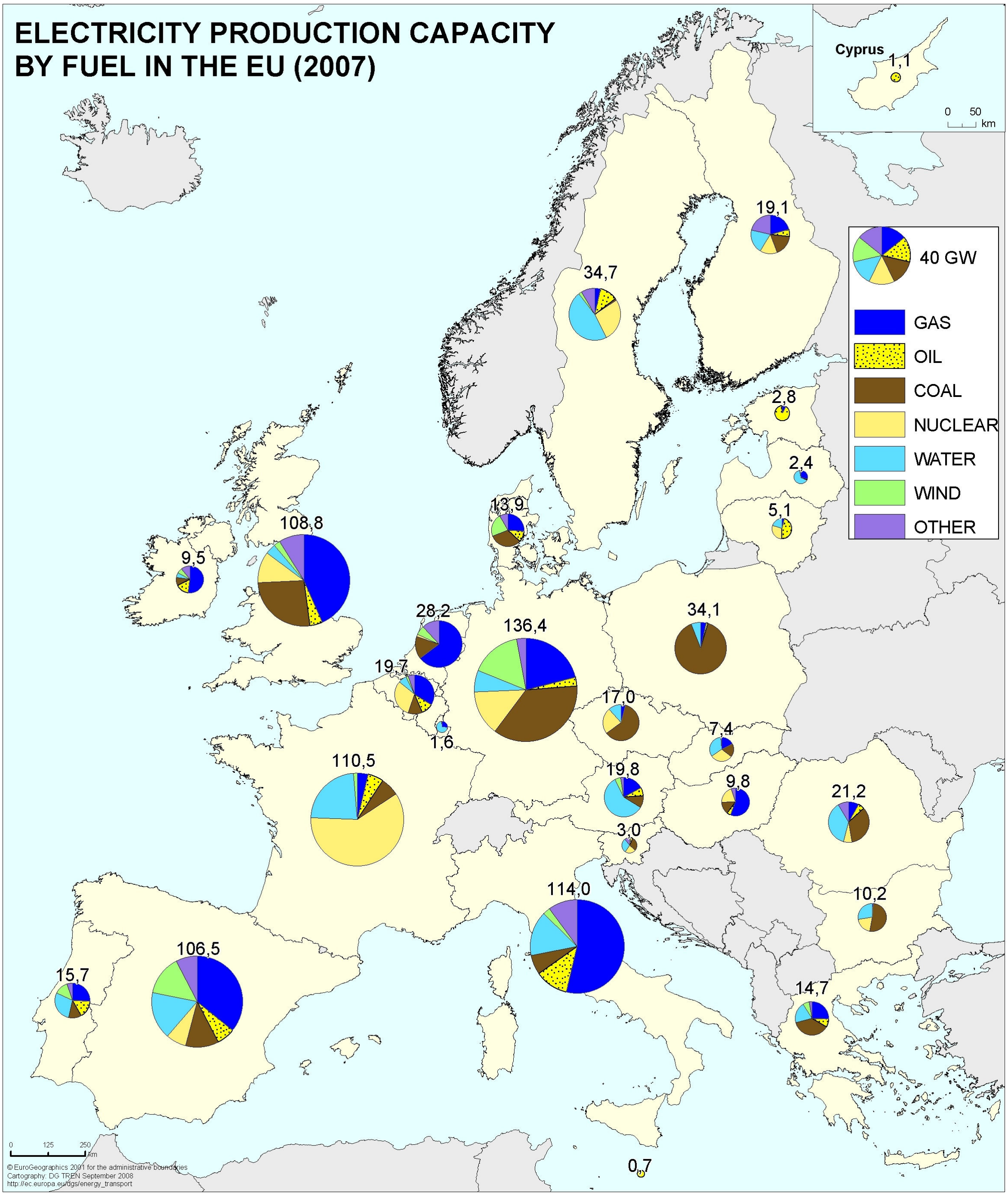
Figure 29



Source: Platts

New generation capacities are necessary both to replace existing ageing capacities whose lifetime will soon come to an end and to expand capacities to meet future demand. Overall, capacity expansion covering both replacement of existing capacities and building of new capacities amounts to 360 GW until 2020 (New Energy Policy case), which is somewhat less than under current trends and policies.

Figure 30
Overview



Source: Platts

On the supply side, remaining capacities seem sufficient in the short and, for certain parts of the EU, medium term to meet the demand[21]. However, without new capacities coming on stream, disruptions may occur at EU level from 2015 onwards and even earlier in some parts of the EU[22], in particular for central Europe (CZ, HU, PL, Slovakia) and Baltic countries[23], notably as a result of the planned decommissioning of nuclear power plants.

4.1.2. Need for reliable, flexible and diverse generation mix

Power generation infrastructure has to be flexible enough to withstand possible supply shocks. Generation adequacy is generally measured on the basis of margins of installed capacities (incl. a margin for capacity unavailable because of maintenance/repair or specific meteorological conditions) over peak load, i.e the highest expected level of demand currently and in the future. These margins are known as reserve or capacity margins and represent the extra supply capacity available to respond to unexpected events (extreme weather, unplanned shutdowns) while maintaining sufficient operating margins[24]. They have been considered acceptable when ranging between 18% and 25% of the total generating capacities, and 15% seems to be accepted as the bare minimum nowadays. With such margins, sufficient power can be generated and the whole generation system will prove more reliable.

In a liberalised market, the issue of remaining capacities over the peak load is of a different nature compared with the situation prevailing in a regulated market. The market has to provide the right pricing signal and incentives for operators in order to keep an adequate level of spare capacities and not endanger energy security.

So far, in the EU, generation capacity has also kept pace with peak demand (For UCTE countries, *see Figure 31*). Large-scale blackouts which occurred in the past did not result from a lack of generation capacities. This general situation is confirmed in particular by ETSO[25].

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[21] ETSO – Generation adequacy – An assessment of the interconnected European power systems 2008-2015 – Update to year 2007.

[22] Idem

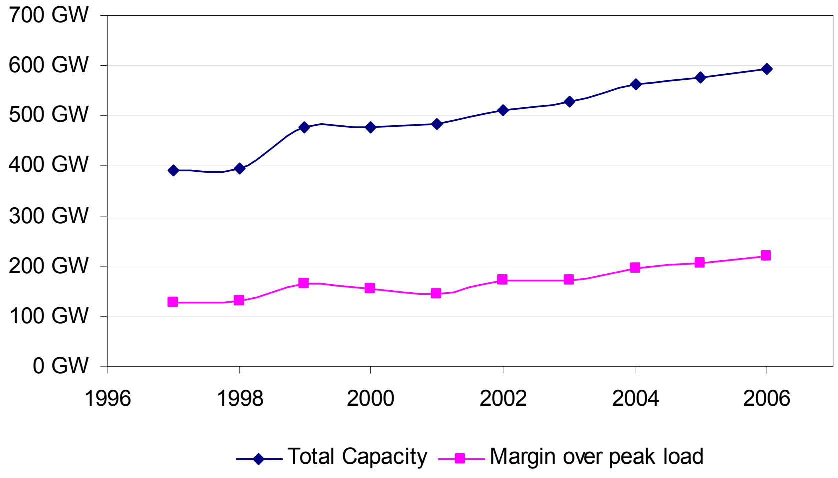
[23] Idem

[24] It should be noted that intermittent renewable energy capacity cannot and is not counted as fully available for evaluating the reserve margin. For example, only a fraction of wind capacity is considered to contribute to total capacity for determining the reserve capacity.

[25] ETSO – Generation adequacy – An assessment of the interconnected European power systems 2008-2015 – Update to year 2007.

Figure 31

Evolution of reserve margins for the UCTE countries



Source: UCTE

However, the possible peak demand in EU-27 over the period 2005-2020 is projected to increase steadily, resulting in a need for new capacities (*See Figure 32*).

Figure 32

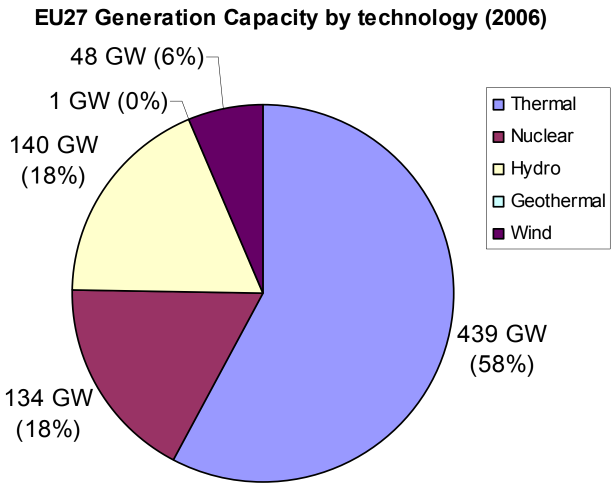
Possible evolution of peak demand and capacity to meet peak demand in EU-27 (Eurelectric)

	2005	**2010**	**2020**
Peak demand capacity (GW)	508	543	622
Total demand (TWh)	3100	3325	3800

Source: EURPROG 2007

The reliability of the EU's generation capacity will also be strengthened by a more diverse generation mix. Diversity may be a business and a policy aim at the same time since it avoids risk exposure, provides flexibility to accommodate variations in demand and helps to reduce too heavy dependency on one type of fuel and/or on one technology. Diversity may thus foster reliability and greater independence. It is crucial for energy security and should be considered when assessing the adequacy of power generation infrastructure in the EU.

Figure 33

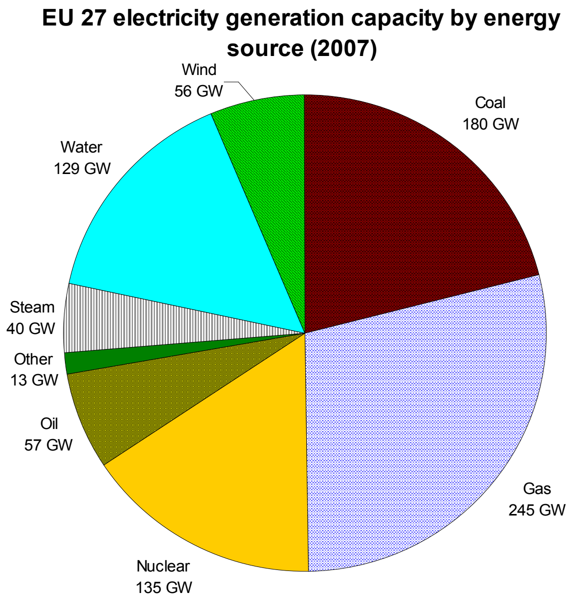


Note: Total Generation Capacity amounts to 762 GW in 2006

Source: Eurostat

Diversity is a multifaceted concept. It could be characterised as an energy mix between fuels and technologies which is subject to appropriate switching capacities, providing an additional buffer against shocks and helping to curb potential risks.

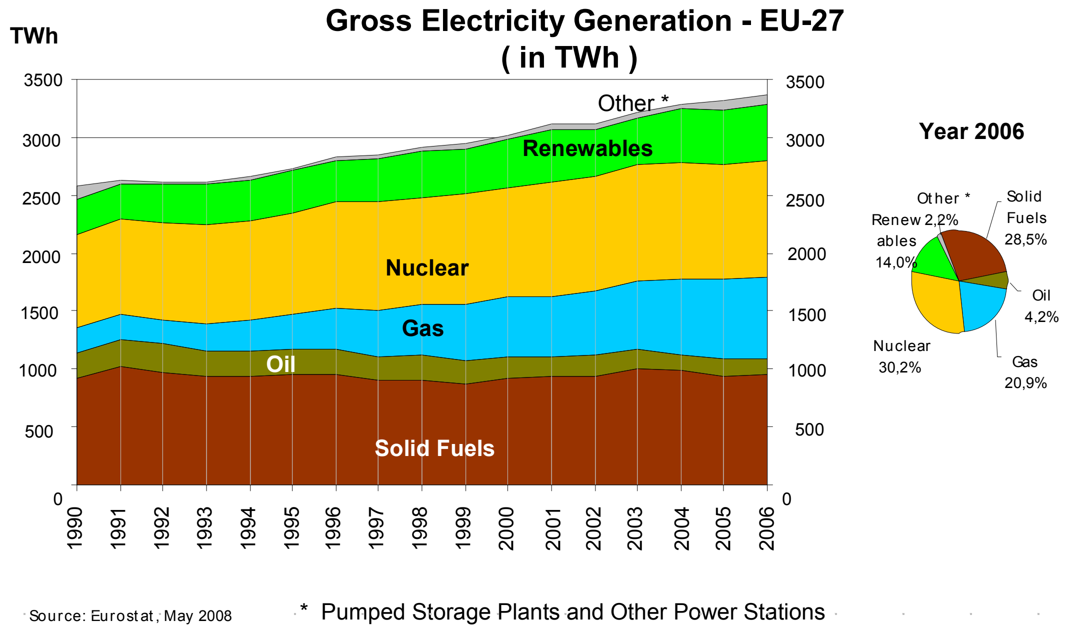
Figure 34



Note: Total Generation Capacity amounts to 855 GW in 2007; it includes Operating and Cold Standby Capacities

Source: Platts

Figure 35

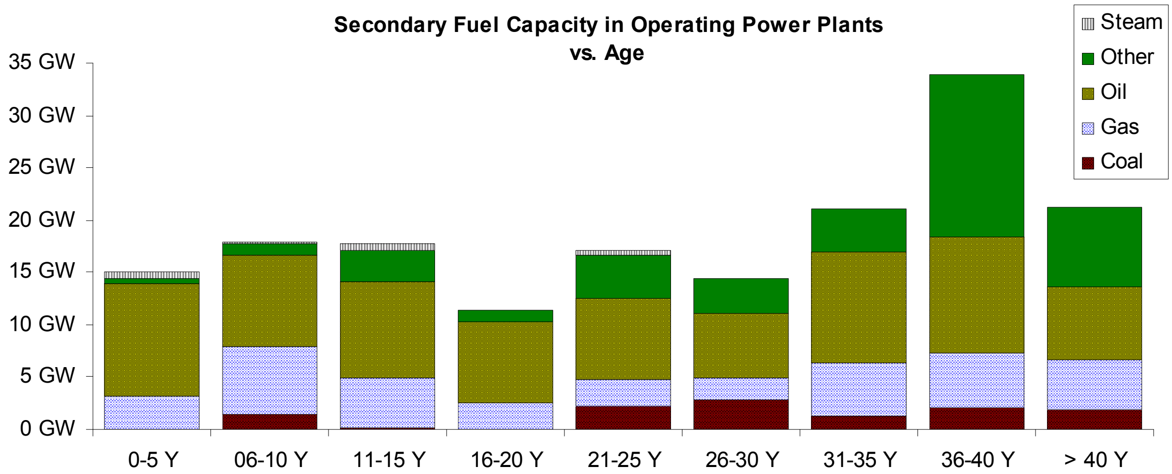


Currently, the EU's generation mix is diversified (*See Figures 33, 34, 35*). About 30% of power production is from nuclear and another 30% results from solid fuel power plants. Natural gas and renewables are the fuels used for the remainder of the EU's electricity production while the role of oil for electricity generation is now very limited. Compared to 1990, coal and oil have dropped respectively from 40% to about 30% and from 8% to 4%. Natural gas has been the major substitute for coal and oil. The current EU energy mix shows an increasing dependency on natural gas. Renewables have made their way into electricity production while undergoing at the same time a structural modification with an increase of wind and biomass and a relative decrease of hydro (*See Figure 27*).

With a view to energy security and to balancing supply and demand in particular in the case of peak of demand, the generation mix needs to offer generation flexibility between technologies. This also makes sense from an economic point of view since the generation costs vary according to technologies and load profiles.

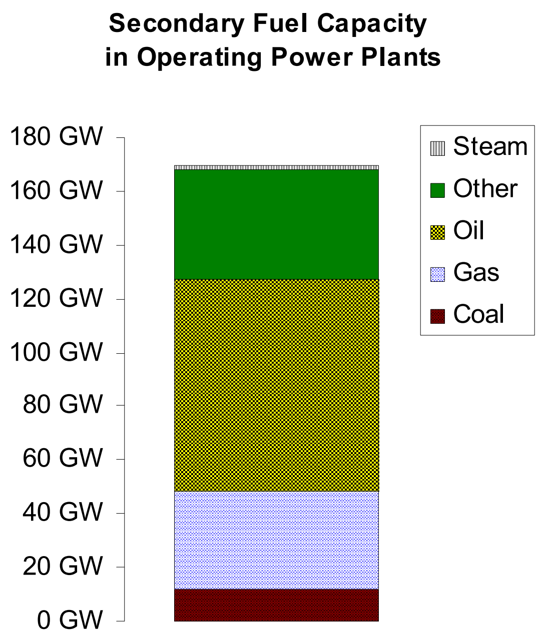
As for secondary fuel in operating power plants, it appears that oil is predominant and represents a relatively constant share of the existing switching capacities (*See Figures 36, 37*).

Figure 36



Source: Platts

Figure 37



Source: Platts

EN EN

4.2. The future of power generation capacity in Europe

Massive investments in new, low-carbon generation capacities are needed to supply the electricity Europe will need in the future. These investments will deliver the expected results only if they are not hampered and/or delayed.

4.2.1. The potential for new, low-carbon power generation investments

Under the new energy policy scenario, the capacity expansion necessary to meet the future power demand and to replace ageing facilities amounts to circa 360 – 390 GW over the period 2005-2020 depending on oil prices. This corresponds to around half of the currently installed capacity. With the Baseline, the capacity expansion needed amounts to circa 370 – 415 GW depending on oil prices.

Compared to the past, the current investment needs are quite specific. There is a need for integrated investment decisions to make sure that the challenges of energy security and climate change are properly met. According to the New Energy Policy case, power generation based on gas and renewables would account for about 300 - 315 GW of the required capacity expansion, depending on oil prices. With the Baseline, this would amount to 265 – 290 GW, depending also on oil prices (*see Figures 39, 41*).

Figure 38

Power capacity (in GW)

POWER CAPACITY	2005	New Energy Policy 2020		Baseline scenario 2020	
		61$/bbl	100$/bbl	61$/bbl	100$/bbl
Total	740	891 (+20%)	919 (+24%)	901(+22%)	946 (+28%)
Solids	189	149 (-21%)	158 (-16%)	186 (-1.5%)	203 (+7.5%)
Oil	67	34 (-49%)	36 (-47%)	38 (-43%)	38 (-43%)
Nuclear	134	113 (-16%)	115 (-14%)	113 (-15%)	116 (-13%)
Gas	181	228 (+26%)	233 (+28%)	282 (+55%)	273 (+51%)
RES	168	366 (+118%)	378 (+125%)	282 (+67%)	316 (+88%)

Source: Primes

Figure 39

Capacity expansion (in GW) - New energy policy scenario

CAPACITY EXPANSION	2006-10		2011-15		2016-20		**2005-2020**	
	61$/bbl	100$/bbl	61$/bbl	100$/bbl	61$/bbl	100$/bbl	**61$/bbl**	**100$/bbl**
Total	*131.4*	*134.9*	*112.6*	*120.5*	*113.6*	*133.2*	***357.6***	***388.6***
Solids	8.5	8.9	33.1	35.7	6.1	14.2	**47.7**	**58.8**
Oil	2.9	3.5	1.8	2.4	0.9	1.1	**5.5**	**7.0**
Nuclear	0.7	0.7	3.9	3.9	2.8	5.1	**7.4**	**9.7**
Gas	60.5	60.3	16	16	13.1	17.4	**89.5**	**93.8**
RES	58	61.5	57.9	62.4	90.7	95.5	**207.5**	**219.4**

Source: Primes

On the basis of these forecasted capacity needs (360 - 390 GW) investments are expected to cost around €400 - 435 billion. Over time, investment needs may accumulate in the following way (*Figure 40*):

Figure 40

Overall investment needs – EU 27 - New Energy Policy scenario

		2006-10	**2011-15**	**2016-20**
Investment needs (billion € 2005)	(61$/bbl)	131.0	131.4	134.9
	(100$/bbl)	137.0	139.6	161.5

Source: Primes

Figure 41

Capacity expansion (in GW) Baseline scenario

CAPACITY EXPANSION	2006-10		2011-15		2016-20		**2005-2020**	
	61$/bbl	100$/bbl	61$/bbl	100$/bbl	61$/bbl	100$/bbl	**61$/bbl**	**100$/bbl**
Total	*130.9*	*137.1*	*114.3*	*128.9*	*123.6*	*151.1*	***368.8***	***417.1***
Solids	12.3	14.5	39.1	46	33.6	45	**150.9**	**105.5**
Oil	5.5	4.5	3.0	3.6	1.1	1.2	**9.6**	**9.3**
Nuclear	0.7	0.7	3.8	3.9	2.9	6.1	**7.4**	**10.7**
Gas	69.5	70.8	37.1	35.6	36.7	28.2	**143.3**	**205.4**
RES	42.9	46.7	31.3	39.8	49.2	70.6	**123.4**	**157.1**

Source: Primes

On the basis of these forecasted capacity needs (370 - 415 GW) investments are expected to cost around € 375 - 445 billion. Over time, investment needs may accumulate in the following way (*Figure 42*)

Figure 42

Overall investment needs – EU 27 - Baseline scenario

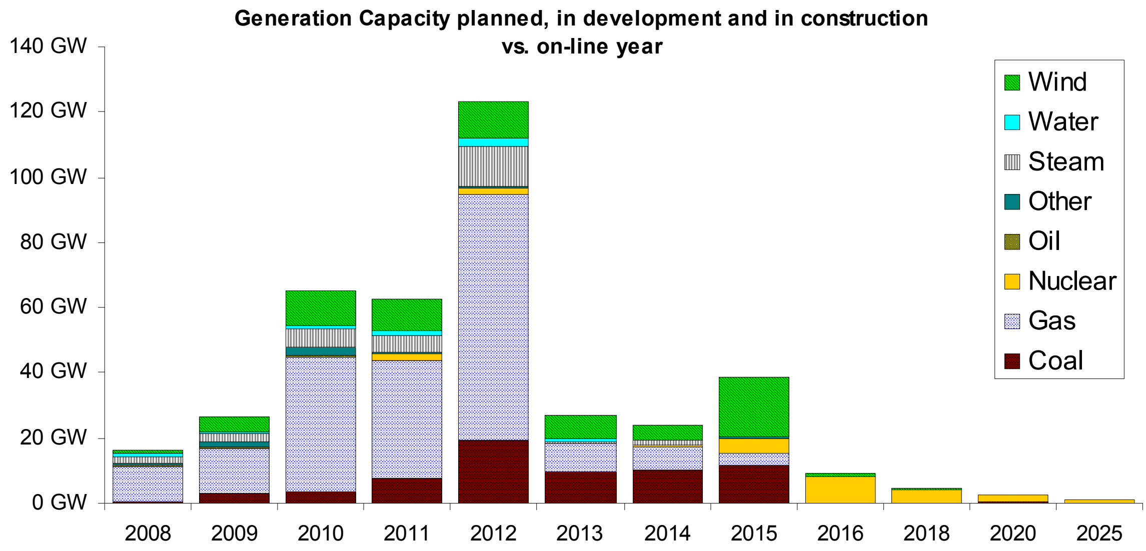
		2006-10	**2011-15**	**2016-20**
Investment needs	(61$/bbl)	127.8	116	130.9
(billion € 2005)	(100$/bbl)	135.2	136.5	176.1

Source: Primes

Power generation investments have to be decided well in advance to produce the desired effect. Investments are generally made for the long term and there is a risk of delay. In addition to the classical reasons for delay such as those related to authorisation procedures, investors may be confronted with bottlenecks for new technologies, increasing steel prices, and a lack of available engineering skills.

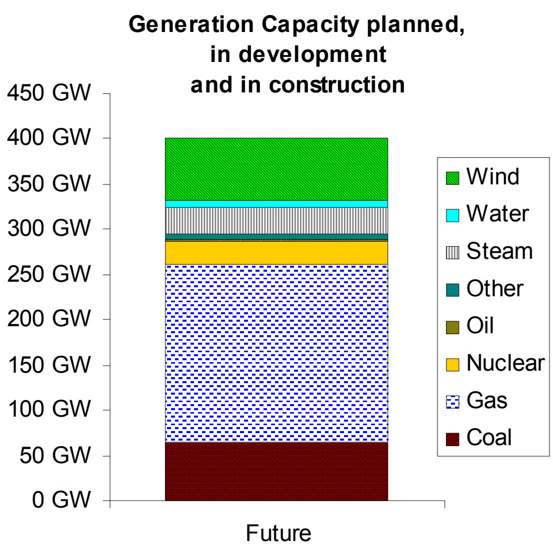
Provided the investments which are currently planned by the operators are confirmed and properly carried out, it can be estimated that future demand will be satisfied (*See Figure 43*). Nevertheless, experience shows that only a small proportion of investments planned or announced are carried out eventually. Investments in electricity supply are indeed very complex: they are highly capital-intensive with long lead-times both for building and for commissioning (i.e. bringing new capacities on stream). Their time horizon for profitability depends strongly on various external elements and conditions, which renders decision-making difficult for economic operators. Despite these difficulties, investments needed to meet the demand have been made so far. In the current context, volatile prices for some fuels may make investors reconsider or adjust investment projects.

Figure 43[26]



Source: Platts

Figure 44



Source: Platts

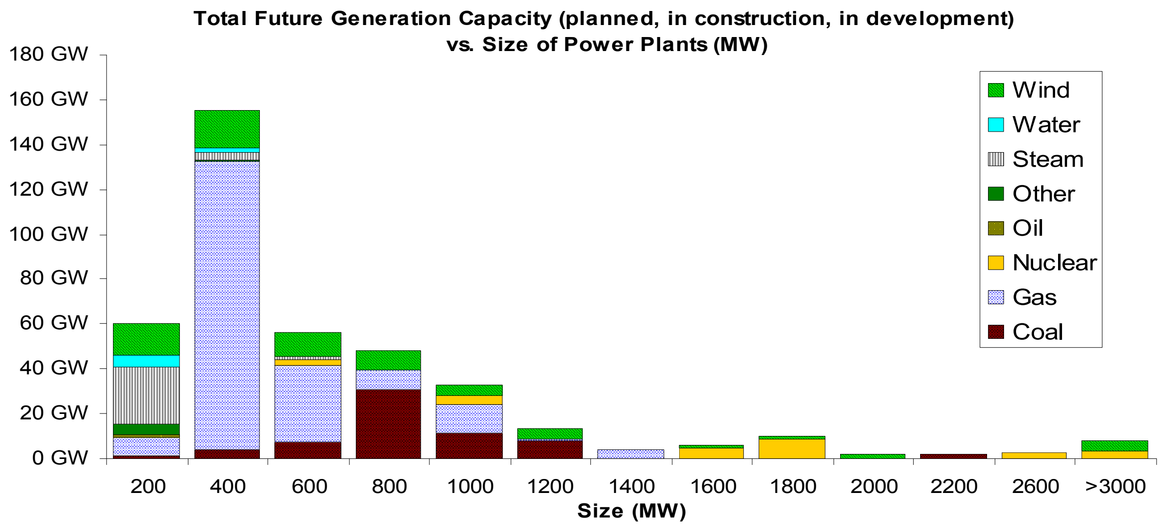
26 These figures are based on information collected from industry.

Recent investments have mainly focused on gas-fired generation and to a lesser extent on wind power and CHP. This evolution has enhanced the generation mix and reduced GHG emissions. It has nevertheless also increased the dependency on gas suppliers from third countries (*See Figure 34*). A greater share of renewable energy will therefore not only further reduce GHG emissions from the power sector but will also foster diversity of the energy mix and lessen the import dependency on gas. In the New Energy Policy scenario, there are few investments in gas fired generation after 2010.

In that context, all other options ensuring at the same time cost-effective, reliable and low-carbon power generation have to be explored. Nuclear power constitutes an option if a Member State so wishes, provided that safety requirements and waste treatment are properly addressed. Co-generation could also help to meet peak demand locally to a certain extent. Use of CHP technologies in public utilities and private households for example would release pressure on the conventional power generation infrastructure and would limit dependence on centralised generation units. Obviously, the flexibility required may also be provided by a varied set of measures on the demand side. Smart metering and demand-response programmes offering variation in electricity tariffs during peak hours could help with shaving peak demand and thus consolidate the reliability of the power generation infrastructure. Evidence suggests that peak demand can be shaved by demand-side measures by up to 5%.

The planned investments demonstrate a further move towards diversification by fuels used but also by size with a tendency to build smaller, decentralised units, which would strengthen the reliability of the EU's power generation capacity[27] (*See Figure 45*).

Figure 45



Source: Platts

4.2.2. A shared responsibility for Europe's future generation capacities

Private investors have made the necessary investments and no lack of generation capacities has been observed so far. However, planned investments will be of value in meeting the EU challenges only if implemented rapidly and vigorously. With this in mind, public authorities

27 Leaving aside the challenges for the grid and its management

should facilitate investments and the implementation of investors' strategies contributing to the EU's energy security. At the EU level, the decisions that have been made and the political stance that has been taken are such that the legal framework may be considered stable and predictable with the adoption of the third internal market package as well as the ETS and RES framework as of 2009.

In the current context, the public authorities' contribution to the implementation of the necessary investments must focus on the planning and authorisation phases of investment projects. Planning difficulties are often the cause of delays and may negatively affect projects. Difficulties in obtaining authorisation to build new plants may result in delays that extend the average construction times even further (*see Figure 46*) or, in the worst case, frustrate projects to such an extent that they are abandoned.

Figure 46

Construction time

	Nuclear	Combined cycle gas turbine	Pulverised Coal	Wind on shore	Open cycle gas turbine
Construction time (months)	60	36	48	18	24

Source: OECD/IEA, 2007

Part A
Annex 1 -Description of the PRIMES model
Main assumptions of the 2007 baseline scenario
and of the policy case (New Energy Policy)

5. THE PRIMES ENERGY SYSTEM MODEL: DESIGN AND FEATURES

PRIMES is a general-purpose energy model that provides projections for the medium and long term, starting from 2010 and running up to 2030 with results for every fifth year. PRIMES is not a tool for making short-term forecasts. The model can simulate the effects of changes in assumptions (e.g. on policies) or in a normative way (e.g. satisfying emission restrictions).

The PRIMES energy system model is a partial market equilibrium model that combines clearing of energy markets via price adjustments with a detailed technico-economic representation of the energy system found in the EU.

The model was developed by and is maintained at the National Technical University of Athens, E3M-Laboratory. Following on from the first version of the PRIMES model developed in 1995 with funding from the European Commission, the model has been continuously improved and extended. The current version (4) of the model covers each EU-27 Member State individually, EU candidate countries and neighbours such as Norway, Switzerland and Turkey. Its geographic scope is being extended to the countries of South-East Europe.

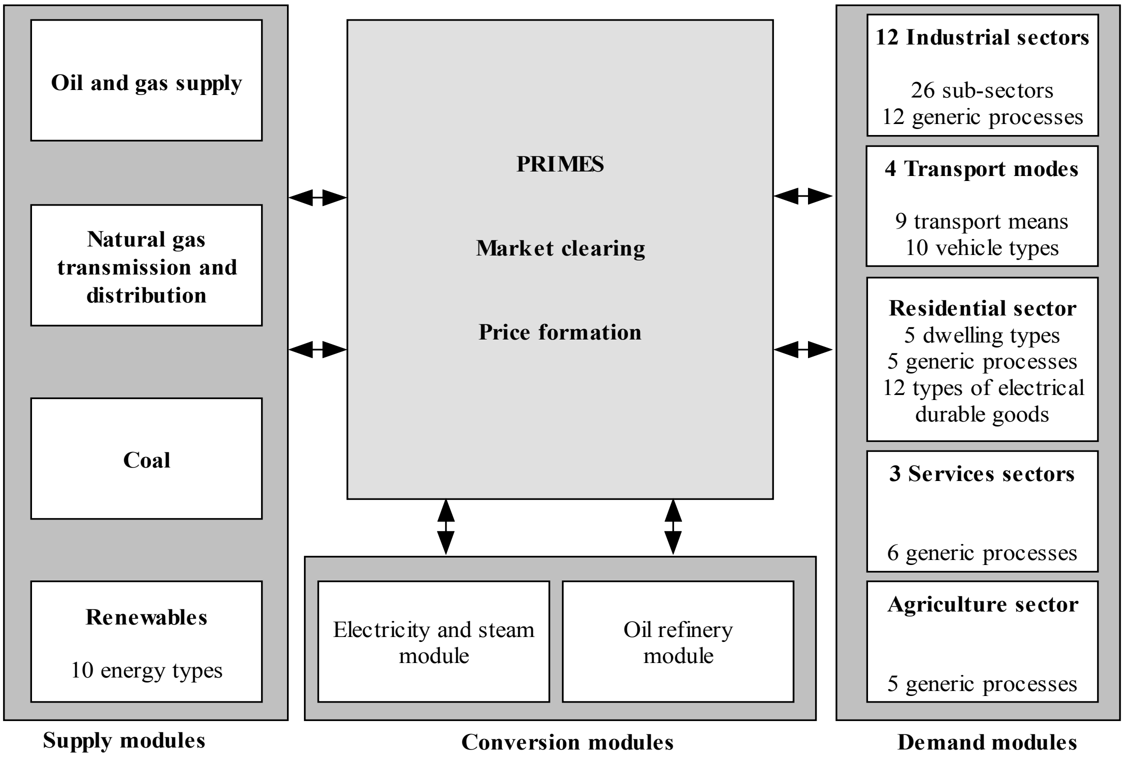
The energy baseline scenarios of 1999, 2003, 2005 and 2007 and various scenarios on issues such as energy efficiency, renewables, nuclear and climate change derive from PRIMES. The Commission departments concerned used PRIMES for the energy and climate package of January 2008.

Main features

PRIMES simulates a market equilibrium solution for energy supply and demand. The equilibrium is determined by prices for each energy form such that the quantity considered optimum by producers matches the quantity consumers wish to use. The equilibrium is static (within each time period) but repeated in a time-forward path, under dynamic relationships.

PRIMES is organised in a modular way representing fuel supply, energy conversion and end-use of demand sectors (see Figure A1). With this modularity, each sector is represented and any single sector or group of sectors can be run independently for stand-alone analysis. The different modules interact via the exchange of fuel quantities and prices.

Figure A1
PRIMES modular structure



The model is organised by energy supply sub-system: oil products, natural gas, coal, renewables, electricity and steam production, including conversion, and by end-use sectors for demand (twelve industrial sectors, transport, residential, services and agriculture). Some end-use sectors may also be suppliers, for example industrial co-generators of electricity and steam.

The model is behavioural. It also represents the available energy demand and supply technologies and pollution abatement technologies. The system reflects considerations about market economics, industry structure, energy/environmental policies and regulation. These considerations are conceived so as to influence market behaviour of energy system agents.

Box A1

PRIMES energy sector coverage

For each EU-27 Member State, EU candidate country and neighbouring country, the PRIMES energy system covers (see Figure A1):

12 industrial sectors:
subdivided into 26 sub-sectors;
using energy in 12 generic processes (air compression, furnaces, electric arc, etc.);
4 transport modes, 9 transport means and 10 vehicle technologies;
5 dwelling types (residential sector) using:
energy in 5 processes (e.g. space heating, cooking, water heating and air conditioning);
12 types of electrical durable goods (refrigerators, washing machines, television sets, etc.);
3 services sectors using energy in 6 generic processes (air conditioning, office

equipment, lighting, etc.);
agriculture sector using energy in 5 generic processes (greenhouses, pumping, etc.);
14 types of fossil fuels, 10 types of renewable energy (hydro, wind, solar, etc.) and energy carriers such as hydrogen and methanol.

The modular structure of PRIMES reflects a distribution of decision-making among agents. These agents decide individually about their supply, demand, combined supply and demand, and prices. The market-integrating part of PRIMES simulates market clearing.

Box A2

Set of policies represented in PRIMES

Taxes, subsidies, tradable permits or certificates;
Technology supporting policies;
Environmental policy instruments;
Market interventions and regulations.

PRIMES assumes that producers and consumers both respond to changes in prices. The factors determining the demand for and the supply of each fuel are represented, so they form the demand and/or supply behaviour of the agents. Through an iterative process, the model determines the economic equilibrium for each fuel market. Price-driven equilibrium is considered in all energy and environment markets, including Europe-wide clearing of oil and gas markets. The modelling framework takes into account networks such as the Europe-wide power grid and natural gas network, and interconnections with third countries on electricity and gas.

PRIMES also simulates the technology choice in energy demand and energy production. The model explicitly considers the existing stock of equipment, its normal decommissioning and the possibility of premature replacement.

The model covers all technologies relevant to the energy system, including the possible use of carbon capture and storage. Many details on a great number of technologies such as investment costs, efficiencies, load factors, operation and maintenance costs are included. Power plant investments are thus determined endogenously on the basis of long-run marginal costs. Cost parameters change over time reflecting technical progress.

Box A3

Power generation and steam/heat in PRIMES

PRIMES is particularly detailed on power generation and steam/heat. For simulating investment decisions the model chooses from among more than 150 power generation technologies with different technical and cost characteristics. The choice depends on cost, demand levels and load curve characteristics also in relation to the simultaneous provision of electricity and heat. The potentials for each fuel and energy use, as well as for the development of new sites for large-scale power plants and also for nuclear and wind, are represented through non-linear cost-supply curves for each country.

Power generation, heat/steam supply by CHP and by boilers or district heating are simulated simultaneously in order to analyse possible substitutions and synergies, as for example cogeneration (CHP). A distinction is made between large-scale utilities and smaller-scale industrial cogeneration. The model represents the seasonal and daily patterns of electricity load and heat/steam load, which are taken into account in simulations. The gas supply model also considers time variability of gas load but assumes daily balancing.

The power generation sub-model of PRIMES represents the transmission network across Europe and performs a DC-linear power flow simulation, taking into account cross-border restrictions (e.g. lack of interconnectors). The model can solve either an EU-wide power market equilibrium (in which power trade flows among countries are a result of the model) or a country-by-country power market equilibrium.

The model estimates all prices of energy commodities in an explicit way. Pricing is assumed to follow a Ramsey - Boiteux equilibrium with possible mark-ups on total costs reflecting market competition regimes. Price determination reflects recovery of total costs including stranded investment, if applicable. Several options are available for price-related policy instruments, such as emission trading schemes, renewables trading schemes, simulation of feed-in tariffs, taxes and subsidies.

The model computes CO_2 emissions from energy. It is further linked with IIASA's GAINS model to estimate other environmental emissions (including SOx, NOx, PM, VOC and all non CO_2 greenhouse gases).

PRIMES has around 180 000 equations and endogenous variables per Member State and time period for the core model. The input data base includes around 220 000 time series per Member State. PRIMES is comparable in scope and complexity with the "National energy modelling system" (NEMS) used by the US government.

6. THE BASELINE AND POLICY CASE SCENARIOS: MAIN ASSUMPTIONS

The Baseline scenario for the EU and each of its 27 Member States reflects energy policies implemented until the end of 2006 as a starting point for projections which are presented from 2010 onwards in 5-year steps until 2030.

The 2007 Baseline scenario takes into account the high energy import price environment of recent years, sustained economic growth and new policies and measures implemented in the Member States.

The Baseline scenario does not assume that (indicative) targets as set out in existing Directives, such as share of renewables, will necessarily be met. The numerical values for these policy indicators are outcomes of the modelling and reflect implemented policies rather than targets. This also applies for CO2 emissions that are not constrained by Kyoto targets in the Baseline scenario.

The Baseline scenario is a reference development for scenarios on alternative policy approaches or framework conditions (e.g. higher energy import prices), in addition to its role as a trend projection.

The Policy case examines the implementation of the energy policy targets on greenhouse gas (GHG) emissions and renewables (RES), in line with the proposals made by the Commission in January 2008. It also includes considerable action on energy efficiency by taking into account the vigorous implementation of existing Directives on e.g. building performance, CHP, end-use energy efficiency and energy services, eco-design in the Member States, as well as further efficiency policies along the lines of the Action Plan for Energy Efficiency.

The energy consequences of adopted or proposed new energy and climate policies are explored. From the security of supply perspective, it focuses on EU-27 energy demand, domestic production and imports to 2030. It determines overall policy effects by comparison with the baseline that depicts the energy / CO2 situation without these policies.

6.1. Common assumptions

The 2007 updates of the energy Baseline scenario and the Policy case (2008) are based on a set of common assumptions.

- Demographic assumptions

Projections for EU-27, taken from EUROSTAT forecasts, reflect a slightly increasing population up to 2020 with no further increase thereafter.

The average household size in the EU-27 is expected to decline from 2.4 persons in 2005 to 2.1 persons in 2030 (UN projections and information from the Member States).

- Macroeconomic assumptions

The projections on economic growth (2.2% on average up to 2020) are in line with DG ECFIN's short and long-term expectations.

The macroeconomic scenario reflects changes in the structure of the EU economy. Sectors with higher value added develop more rapidly than energy and material intensive sectors. However, the pace of change is expected to decelerate in the long run.

- Energy import price assumptions

The price assumptions for the EU-27 result from world energy modelling. Price trajectories for oil, gas and coal are derived from a conventional wisdom view of the development of the world energy system. Two prices environments have been used: a moderate and a high oil prices environment. Fossil fuel prices develop as follows:

Table A1
Prices of Fossil Fuels

$'2005/boe	2005	2010		2015		2020	
		61$/bbl	100$/bbl	61$/bbl	100$/bbl	61$/bbl	100$/bbl
Oil	54.5	54.5	69.7	57.9	83.3	61.1	100.1
Gas	34.6	41.5	46.3	43.4	61.4	46	77.5
Coal	14.8	13.7	15.8	14.3	20.3	14.7	24.2

Note: boe stands for barrel of oil equivalent (roughly 7.2 boe = 1 toe). The dollar exchange rate is assumed to equal 1.25 $/€.

The oil prices in real terms translate into a nominal price of 84 $/barrel in 2020 (moderate prices environment) and 138 $/barrel in 2020 (high oil prices) provided that the ECB can keep inflation below 2% per year (their target), which is currently not realised (latest projection for 2008: 3.6 %).

- Energy taxation assumptions

Tax rates are kept constant in real terms at their 2006 levels unless otherwise provided for in the Energy Taxation Directive. In some Member States, the EU minimum rates will apply at the end of transition periods. During these periods, the Member States concerned are authorised to apply lower rates.

- Degree days

The degree days, reflecting climate conditions, are kept constant at the 2000 level. This is higher than the long-term average (some warming has already happened) without assuming that this trend will continue (the extent of which would be very uncertain). The degree days in 2000 were fairly similar to the ones in 2005. This allows comparison of recent statistics with the projection numbers, without entailing the need for climate correction.

- Technical-economic parameters

PRIMES includes all relevant technologies for the energy system, including the possible use of carbon capture and storage, and many details on a great number of technologies such as investment costs, efficiencies, load factors, operation and maintenance costs. As a result power plant investments can be determined endogenously on the basis of long-run marginal costs. Cost parameters change over time reflecting technical progress.

The technical-economic characteristics of existing and new energy technologies used in the demand and the supply sectors of the energy system evolve over time and improve according to exogenously specified trends. According to the Baseline logic, consumers and suppliers are generally hesitant to adopt new technologies before they become sufficiently mature. They behave as if they perceive a high cost (or a high subjective discount rate) when deciding upon adoption of new technologies.

Public policies, through campaigns, industrial policy, R&D support and other means, aim at pushing more rapid adoption of new technologies by removing uncertainties associated with their use. In this way, the technologies themselves reach maturity more rapidly as a result of "learning-by-doing" effects and economies of scale. In the Baseline scenario, policies to promote clean and efficient technologies continue focussing on support schemes for renewables following past trends.

- Discount rates

Discount rates differ according to the type of economic actor.

In the case of power generation, discount rates may vary over time to reflect increasing competition. Decision-making on power plant investment is simulated by applying a cost of capital rate (similar to a discount rate), which also includes a risk premium; this rate ranges from 8.2% to 10.5% according to the time period and the size of the typical generating company.

In industry, services and agriculture the discount rate amounts to 12% for the whole projection period. Households have an even higher discount rate of 17.5%. For transport, private passenger transport investments (e.g. for cars) are based on a discount rate of 17.5%, while for trucks and inland navigation the rate is 12%. The assumed discount rate for public transport energy investment is 8%, reflecting the acceptance of longer pay-back periods than those required in industry or private households.

All these rates are in real terms, i.e. after deducting inflation.

6.2. Specific assumptions

6.2.1. Baseline (2007) – Main assumptions

The 2007 Baseline scenario includes policies and measures implemented in the Member States up to the end of 2006. This concerns in particular ongoing policies on:

- Completion of the internal energy market by 2010, taking into account derogations for electricity and gas market opening as regards e.g. isolated gas markets or recent introduction of natural gas;

- Energy efficiency (implementation of the building, CHP, labelling Directives, etc; national policies on education, information, public procurement, CHP, etc). The assumption that the CO2 agreement with the car industry (essentially fuel efficiency) for 2008/09 would be honoured had to be dropped but there is still considerable improvement assumed;

- Renewables (e.g. implementation of measures under the electricity and biofuels Directives, ongoing national policies supporting RES deployment);

- Nuclear (nuclear phase-out as agreed in certain Member States, closure of existing plants in recently acceded Member States according to agreed schedules; nuclear investment is possible in countries that have not ruled out nuclear or see such investment as unlikely for the medium term);

- Promotion of clean and efficient technology;

- Climate change (continuation of the EU ETS over the projection period without extension to new sectors).

The CO2 prices in the ETS sector increase from 20 € (2005)/t CO2 in 2010 to 22 €/t CO2 in 2020. They reflect current levels and preserve the baseline approach of a continuation of current policies – but taking into account that CDM/JI credits may become more expensive over time.

6.2.2. Policy case

The main assumptions of the Policy case refer to Greenhouse Gas emissions and RES targets, energy efficiency and energy import prices.

6.2.2.1. - GHG emissions target

The Policy case scenario is consistent with the EU's target on the reduction of greenhouse gas emissions by at least 20% in 2020 compared to the 1990 levels (unilateral commitment by the EU). This scenario achieves the GHG reduction with energy policy measures alone without use of JI/CDM credits and action on other gases than energy related CO2 emissions. While achieving this way a 20% cut in energy-related CO2 emissions, this scenario shows that the EU could do better than the unilateral 20% GHG reduction commitment._This scenario is, therefore, compatible with the possible case of successful international climate negotiations, in which the EU would accept a target up to minus 30% for GHG including action in respect of non-energy-related CO2 and non-CO2 gases as well as recourse to JI/CDM credits. The Policy case scenario showing a greater contribution from energy efficiency following the 20% savings objective endorsed by the European Council of March 2007 is, also, more strict than the one actually proposed by the Commission in the *Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020* (SEC(2008)85/3).

For ETS including aviation, full auctioning is assumed only for the power generation sector. The other sectors subject to ETS continue to receive allowances without auctioning. However, allowances have a much higher price than under baseline conditions as a result of greater scarcity following the proposed ETS Directive. Moreover, the Policy case excludes action outside the EU via JI/CDM (similar to the cost-efficient reference case of the joint RES / climate policy Impact Assessment for the January 2008 package).

The CO2 price required to achieve the ETS cap of the January 2008 proposal, generated by the PRIMES model, is €41 per ton of CO2 in 2020.

The policy instruments employed to achieve the GHG reduction target are directly linked with those for the RES target. EU ETS will facilitate growth in renewable energy; the renewable energy Directive will create conditions enabling renewable energy to play a key role in reaching the GHG reduction target. Therefore, the carbon price required under the energy policy case assumption is lower than in the case where no renewables policies are put in place.

6.2.2.2. - RES target

The Policy case includes the achievement of a 20% share of renewable energy sources in final energy consumption at EU level by 2020. The RES target is achieved cost-efficiently through equal RES incentive/support across Member States. This is compatible with country-specific targets and full trade in guarantees of origin for renewables, which ensures the cost-effective achievement of the EU target[28].

The RES incentive to achieve the 20% target amounts to 43 €/MWh in 2020. Similarly to the carbon price, the level of incentive for reaching a given RES target is lower with the simultaneous pursuit of GHG policies as a carbon price favours the deployment of RES.

In the Policy scenario, the 10% target for biofuels is achieved at EU-27 level by 2020, with free trade being allowed between the Member States. In addition, some imports of biomass/biofuels from third countries are envisaged.

This scenario assumes that GHG and RES policies continue over time without modelling major new initiatives that have not yet been defined in the policy process.

[28] This approach keeps the modelling robust vis-à-vis any change of national RES targets that may be made in the process of Council negotiations.

6.2.2.3. - Energy Efficiency

The Policy scenario assumes vigorous implementation of existing Directives on e.g. building performance, CHP, end-use energy efficiency and energy services, eco-design in the Member States as well as further efficiency policies along the lines of the Action Plan for Energy Efficiency.

The same scenario shows energy savings of 13% compared with the baseline, i.e. energy intensity declines by 13% in terms of primary energy consumption in 2020. This follows from the assumption that a 20% greenhouse gas reduction in 2020 compared to 1990 is reached with energy policy measures in the EU alone under the conditions of the proposals made by the Commission in January 2008 on ETS and RES.

However, the need to implement vigorously the Energy Efficiency Action Plan at national and Community level remains. This Action Plan offers a safety margin if the implementation of one or the other measure were to achieve less than envisaged. It would also help the EU to reach more ambitious greenhouse gas targets (e.g. minus 30% instead of 20%) as a possible result of international climate negotiations.

Reversing long-standing increasing trends, the primary energy consumption decreases by 5.6 % in 2020 compared to 2005.

Part A

Annex 2 – Overview of the results of the 2007 baseline scenario and of the policy case (New Energy Policy)

Table 1: Primary energy demand, EU primary production and net imports (Mtoe) in 2020 for EU-27

Primary energy demand, EU primary production and net imports (Mtoe) for EU-27	*2005*	*Baseline scenario, oil price 61$/bbl*	*Baseline scenario, oil price 100$/bbl*	*New Energy Policy scenario, oil price 61$/bbl*	*New Energy Policy scenario, oil price 100$/bbl*
Primary energy demand (Mtoe)	*1,811*	*1,968*	*1,903*	*1,712*	*1,672*
Oil	666	702	648	608	567
Natural gas	445	505	443	399	345
Solids	320	342	340	216	253
Renewables	123	197	221	270	274
Nuclear	257	221	249	218	233
EU primary production (Mtoe)	*896*	*725*	*774*	*733*	*763*
Oil	133	53	53	53	52
Natural gas	188	115	113	107	100
Solids	196	142	146	108	129
Renewables	122	193	213	247	250
Nuclear	257	221	249	218	233
Net imports (Mtoe)	*975*	*1,301*	*1,184*	*1,033*	*962*
Oil	590	707	651	610	569
Natural gas	257	390	330	291	245
Solids	127	200	194	108	124
Renewables	1	3	8	23	24
Import dependence (%)	*52.1*	*64.2*	*60.5*	*58.5*	*55.8*
Oil	81.6	93.0	92.5	92.0	91.6
Natural gas	57.7	77.2	74.6	73.1	71.1
Solids	39.2	58.5	57.0	50.0	49.0
Energy intensity (% change compared to Baseline scenario, oil price 61$/bbl)			*-3.3*	*-13.0*	*-15.0*

Table 2: Final energy demand (Mtoe), gross electricity generation (TWh) and emissions index in 2020 for EU-27

Final energy demand (Mtoe), gross electricity generation (TWh) and emissions index for EU-27	*2005*	*Baseline scenario, oil price 61$/bbl*	*Baseline scenario, oil price 100$/bbl*	*New Energy Policy scenario, oil price 61$/bbl*	*New Energy Policy scenario, oil price 100$/bbl*
Final energy demand by sector (Mtoe)	*1,167*	*1,348*	*1,293*	*1,185*	*1,140*
Industry	324	368	357	354	339
Residential	307	336	320	281	272
Tertiary	174	205	194	160	154
Transport	362	439	423	390	375
Final energy demand by fuel (Mtoe)	*1,167*	*1,348*	*1,293*	*1,185*	*1,140*
Oil	493	540	499	465	433
Gas	287	314	287	255	235
Solids	53	55	56	50	50
Electricity	238	303	302	257	260
Heat (from CHP and district heating)	41	46	44	41	41
Other	55	89	105	117	121
Gross electricity generation by fuel type (in TWh)	*3,275*	*4,078*	*4,065*	*3,443*	*3,493*
Nuclear energy	998	866	977	851	911
Renewables	488	824	887	1,086	1,094
Fossil fuels	1,790	2,389	2,201	1,506	1,489
Emissions index (1990=100)					
Total GHGs emissions	93.4	98.5	92.9	80.0	78.0
CO_2 emissions (energy related)	97.5	105.1	97.7	79.8	77.5

Table 3: Net installed power capacity in 2020 (GW) and investments in power generation during 2005-2020 for EU-27

Net installed power capacity in 2020 (GW) and investments in power generation during 2005-2020 for EU-27	*2005*	*Baseline scenario, oil price 61$/bbl*	*Baseline scenario, oil price 100$/bbl*	*New Energy Policy scenario, oil price 61$/bbl*	*New Energy Policy scenario, oil price 100$/bbl*
Net installed power capacity (GW)	*740*	*901*	*946*	*891*	*919*
Oil fired	67	38	38	34	36
Gas fired	181	282	273	228	233
Solids fired	189	186	203	149	158
Renewable energy	168	282	316	366	378
Nuclear energy	134	113	116	113	115
Net power capacity investment during 2005-2020 (GW)		*369*	*417*	*358*	*389*
Oil fired		10	9	5	7
Gas fired		143	135	90	94
Solids fired		85	105	48	59
Renewable energy		123	157	207	219
Nuclear energy		7	11	7	10
Investment expenditure in power generation including CHP during 2005-2020 (billion € 2005)		*375*	*448*	*397*	*438*