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## Security of Energy Supply: A Quantitative Scenario Study on Future Energy Systems for the EU25 for 2030

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### Purpose

The quantitative scenario study on the EU energy system focuses on the security of energy supply and different alternatives for the EU energy system. Five different scenarios for the EU25 energy system by 2030 were developed. The scenarios were then grouped into two main families called “advanced conventional” and “domestic action” and their respective pros and cons analysed with regard to all relevant EU-policy fields for providing policy recommendations.

### The Dual Challenge of Climate Protection and Security of Energy Supply

The EU currently faces two different challenges with regard to the future development of the EU energy system and the question of the ‘security of energy supply’. Firstly, the era of cheap and abundant conventional energy resources appears to be coming to an end. This means that maintaining reliable supply levels implies significant and timely investment in new and more expensive oil and gas production, which will put upward pressure on world market prices for oil, gas and, to a lesser extent, coal – with potential impacts for economic development and growth. Furthermore, the geographical concentration of oil and gas export potential, combined with newly emerging large energy importing economies (i.e. China, India) can be

expected to intensify international competition for market access to the declining resources and, ultimately, may also generate international conflicts.

Distinct from these issues, a second challenge has emerged. Climate change requires substantial reductions in global greenhouse gas emissions, which essentially means using less energy and switching to carbon neutral energy carriers.

Both challenges require determined and timely action from the EU and its member states, as well as from the international community at large. A conventional, albeit advanced, “business as usual” (BAU) strategy is likely to face increasing problems when trying to adequately cope with these simultaneous challenges.

In order to analyse important strategies and/or technology decisions (higher/lower nuclear share in electricity generation, in-



creased energy efficiency and use of combined heating and power [CHP], increased use of renewable energies) and highlight a range of possible future energy solutions for the EU25, five different scenarios have been developed according to the strategies and targets requested by the European Parliament's Committee on Industry, Research and Energy (ITRE).

## Five Options to Go Ahead

In order to draw different possible futures of the EU energy system, five scenarios based on two main sources were designed. The basic data, economic assumptions and the main results for the BAU scenario were derived from the latest available EU energy and transport projections (Decker 2006, Mantzos 2006, Mantzos & Capros 2006). Demand-side projections and analyses of higher penetrations of energy efficiency and renewable energies were derived from a recent scenario analysis by the Wuppertal Institute (Lechtenböhmer et al. 2005a/b). The quantification and combination of potentials, costs, strategies, policies and measures, and the calculation of scenarios were carried out using the Wuppertal Scenario Technique.

In the business as usual (BAU) scenario, the continuation of energy policy trends would already lead to a strong primary energy efficiency increase within the EU25. However, this increase would not be sufficient to compensate for growing GDP. As a consequence, primary energy demand would increase by almost 15% and import dependency by more than a third. Due to an increased share of renewable energy sources (RES) and a switch to natural gas, CO<sub>2</sub> emissions would increase by only 3% to 6.6%, depending on the nuclear energy policy. With regard to climate policy, it is assumed in the BAU scenario that the EU25 will accept international emission reduction targets for the commitment periods after 2012 of 15% by 2020 and 30% by 2030.

The N+ scenario – as defined in accordance with the request by the ITRE committee – is a variant of the BAU scenario based on the expansion of nuclear energy (thus N+). While in the BAU scenario nuclear capacity declines by 28% from 141 GW (2000) to 101 GW in 2030, in the N+ scenario the construction of about ten more new nuclear power plants of 1300 MW each is assumed, which would result in a nuclear capacity of about 126 GW in 2030 – or 25% more than in the BAU scenario. CO<sub>2</sub> emissions in power and steam generation decrease by about 6.6% vs. BAU by 2030, whereas total emissions from the EU25 decrease by 1.9%. Furthermore, this scenario also includes the use of carbon capture and storage (CCS), which can further reduce CO<sub>2</sub> emissions, albeit fairly modestly in the case of the EU (another 6%–7% of the power sector emissions compared to BAU).

The N– scenario marks the other end of a range of possible nuclear energy BAU scenarios. Power plants are assumed to perform less well in this scenario and this, together with waste issues and a stronger perception of the risks of nuclear energy, combines to increase the pressure on plant operators. Consequently, no new nuclear power plants are commissioned and a number of nuclear power plants will not reach a lifetime of 40 years. This results in a decline of nuclear capacities to 76 GW

in 2030. In total, CO<sub>2</sub> emissions in this scenario would be at a level of 72 million tonnes, or 1.9%, more than in the BAU scenario by 2030.

**Table 1: Comparison of the scenarios – results for 2030**

Scenario	CO <sub>2</sub> emissions (% Δ 1990)	Primary energy demand (% Δ 1990)	Import dependency	Nuclear share in electricity generation	RES share in PE demand	Energy efficiency growth rate (2000 - 2030)
BAU	+4.7%	+14.6%	64.8%	18.7%	12.2%	1.5%/year
N+ (+CCS)	+3.0% (+1.3%)	+16.4%	62.7%	23.6%	12.0%	
N–	+6.6%	+12.2%	66.5%	13.8%	12.4%	
EE	–18.8%	– 8.2%	59.8%	15.7%	15.0%	2.2%/year
RE	– 45.1%	– 20.1%	49.1%	16.4%	31.4%	2.7%/year

Source: own calculations, Wuppertal Institute, 2006

The energy efficiency (EE) scenario assumes strong policy at EU level, as well as within the member states, targeted at accelerating the rate of increase of energy efficiency in order to reach a level of energy efficiency 50% higher than in the BAU scenario by 2030. This means that energy efficiency (GDP per ktoe primary energy use) would increase by 2.2% per year and reach 10.5 MEur/ktoe in 2030 (BAU: 8.5).

The renewable energy expansion (RE) scenario describes a restructuring towards a renewable energy system with a target of approaching a renewable energy supply as high as possible by 2030. To achieve such a high share of renewable energy, the scenario combines an even stronger drive towards energy efficiency (11.9 MEur/ktoe by 2030) with an accelerated expansion strategy of renewable energies, which reach a share of 31% of total primary energy supply in 2030. This strategy depends on the feasibility of the projected 34% share of fluctuating energies (wind, hydro, solar, tidal and wave) in the electricity system and on the feasibility of accelerating energy efficiency improvement to 2.7% per year.

## Policy Choices

The five scenarios developed for the study have been analysed with regard to the core energy policy fields. Brief discussions on recent trends, followed by implications for policy needs with regard to the different scenarios, have been discussed for each scenario.

The energy issues considered in this report interact directly and indirectly with many European policies, in particular the climate policy, the Lisbon strategy and the external (energy markets) policy, which do not focus exclusively on energy but function as framework policies. These policy areas with wider scope can significantly influence the feasibility of potential pathways for the

development of the energy system. In addition to these crosscutting policies, the following key energy policies are touched upon in the study: single European energy market, energy efficiency, renewable energies and energy technology policy.

### **Policies on EU External Energy Markets**

The comparison of scenarios with regard to policies on EU external energy markets shows that quite different challenges lie ahead in each scenario. In the BAU scenario – and in both nuclear scenarios – particular emphasis would be needed on external energy supply through the establishment of stable political relations with oil and gas producing countries and (for gas) transit countries and the mobilisation of huge investments – most of all for natural gas. In BAU/N+ the extended efforts to promote clean energy technology transfer in conjunction with a widening use of emission trading (notably the EU's emission trading system and clean development mechanism) are, to some extent, favourable to global stability but, on the other hand, also need global political stability.

The energy efficiency scenario and a fortiori the renewable energy expansion scenario would significantly relieve the pressure on external supplies to the EU due to decreased imports, while offering additional options to mitigate the worldwide depletion of fossil resources.

### **Single European Energy Market**

In spite of the general current policy lines for the creation of the legal and technical provisions for a single European energy market, which are important in all scenarios and have still to be developed, quite different challenges would lie ahead in each scenario.

In the BAU scenario – and in both nuclear scenarios – current policy trends would have to be pursued and even accelerated. Large investment would be needed for improvements of gas and electricity networks – about € 45 bn to € 50 bn for electricity grid investment including cross-border transmission, about € 11 bn to € 14 bn for long distance gas transmission, gas storage and liquefied natural gas terminals (CESI et al. 2005) and about € 800 bn over the 25-year scenario period for huge replacements in the existing stock of condensing power plants.

The energy efficiency scenario and, to an even greater extent, the renewable energy expansion scenario would present significant new challenges regarding accelerating progress in energy efficiency and the restructuring of the energy system towards higher shares of renewable energy sources and of CHP in district heating and industry. Grid investments for electricity would be expected to be near the upper limit of the above-mentioned numbers, while those for natural gas would approach the lower end. Investments for new power generation would be 20% lower in the EE scenario than in the BAU scenario and 10% lower in the RE scenario. In the RE scenario the effect of much lower capacity is partly offset by higher cost per kilowatt installed. Furthermore, investment would be

completely different. While even in the BAU scenario investments in new CHP and renewable capacities are projected to overtake investments in fossil and nuclear generation, the latter will stand in the EE scenario for only 20% of total investment and in the RE scenario for less than 10%.

### **Policy for Energy Efficiency**

The comparison of the current EU policy towards energy efficiency with the three scenarios – BAU, EE and RE – shows some crucial results.

The current EU demand side energy efficiency policy would (by definition) be sufficient in many fields to realise the BAU scenario as well as the two nuclear scenarios N+/N-. However, particularly in the transport sector, in electrical appliances and in industry, further action would be needed. Further action would be necessary as well to protract these policies until 2030. On the other hand, the current political targets with respect to energy efficiency, as set out by the Green Paper "Doing more with less" and the Energy End-Use Efficiency Directive, would not be achieved in the BAU scenario.

A much stronger policy for energy efficiency in the EU would be needed in order to meet the energy efficiency and the renewable energy expansion scenarios. This policy would have to instigate strong and rapid action in order to implement ambitious efficiency targets close to the technical optimum, introduce further stepwise improvements in the energy efficiency of cars, appliances, buildings and businesses, strengthen technology development and provide substantial financial support and appropriate institutions. The evolution in energy market design would also affect the progress in energy efficiency and renewable energy use by affecting end use prices, investment in new and efficient (CHP) generation capacity and the prospects for the introduction of demand side management policies.

### **Policy for Renewable Energies**

It is assumed that the EU will pursue a very active policy to promote renewable energies in all scenarios. As the analysis of the existing policy shows, broad additional activities are indispensable even in the BAU scenario. However, in this scenario – as in all the others apart from the RE scenario – set targets will be missed and the EU would have to solve the problem of further fostering a supportive framework for renewable energies against a background of possible disappointment.

In the renewable energy expansion scenario on the other hand, both current targets and ambitious targets for the future (20% in 2020, 35% in 2030) are achievable. However, the scenario also illustrates that these targets require a substantial restructuring of the whole energy system and economy by using the opening window of opportunity presented by the ageing energy system and its subsequent high reinvestment need. It appears that current policy for renewable energy – in spite of its impressive success – is not yet in a position to implement the changes needed for the realisation of this scenario.

## Conclusion and Policy Implications

### Two Ways to Go

The scenarios discussed in this report can be grouped into two main strategies.

The first type of strategy could be called “advanced conventional”. This route is described by the BAU scenario combined with the N+ scenario and specific greenhouse gas mitigation options of carbon capture and storage and, particularly, the use of clean technology transfer and other flexible mechanisms to achieve emission reductions outside the EU.

The other type of strategy, “domestic action”, relies much more on the domestic potential of renewable energy sources and energy efficiency and seems to have the capability to adequately cope with both major challenges so that the risks emanating from these are significantly lower.

Both strategies have crucial preconditions that may pose severe challenges to their feasibility. The advanced conventional strategy crucially relies on the successful implementation of an active foreign energy and technology transfer policy. Strong international competition for energy resources may become an increasing threat for this crucial foreign policy link. However, this scenario would carry less risk with respect to the management of change inside the domestic European society, since changes tend to be less radical than in alternative scenarios. The domestic action strategy, on the other hand, would swap, to some extent, the external threats from climate change and geopolitical turmoil for bigger challenges with respect to the management of the more radical changes inside the domestic European society (i.e. within the EU and its member states). More specifically, this strategy would stand or fall on the successful restructuring of the EU energy system and the bulk of all investment decisions.

## Robust Strategies

In spite of the diverging, and at least partly mutually exclusive, directions in which energy policy could steer (energy) policy choices, there are a number of policy actions that would be required in any strategy and which differ only in terms of intensity. Consequently, these policy areas should be given high priority for securing energy supply regardless of the strategy prioritised.

- The first strategy is enhancing demand side energy efficiency including cogeneration.
- The next robust option concerns renewable energies. All the scenarios assume high increases in this area as well, particularly in wind power generation and biomass use. What is more, some policies are already partly in place and the current targets on the EU level already correspond to a very ambitious RE scenario, but need to be supported by stronger policies and expanded by 2020 and 2030.
- In the energy market overall, and taking into account the efforts being made to enhance energy efficiency, it is also important that retail pricing of electricity appropriately reflect its scarcity and emission impacts on the wholesale market.
- Robust steps towards a future EU external energy and climate policy include the fostering of clean development and clean technology transfer, as this will strengthen international relations, partly relieve demand pressure on energy markets, create additional or strategically needed emission credits and expand markets for renewable and efficiency technologies, which would, in turn, support the domestic development of these technologies.

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