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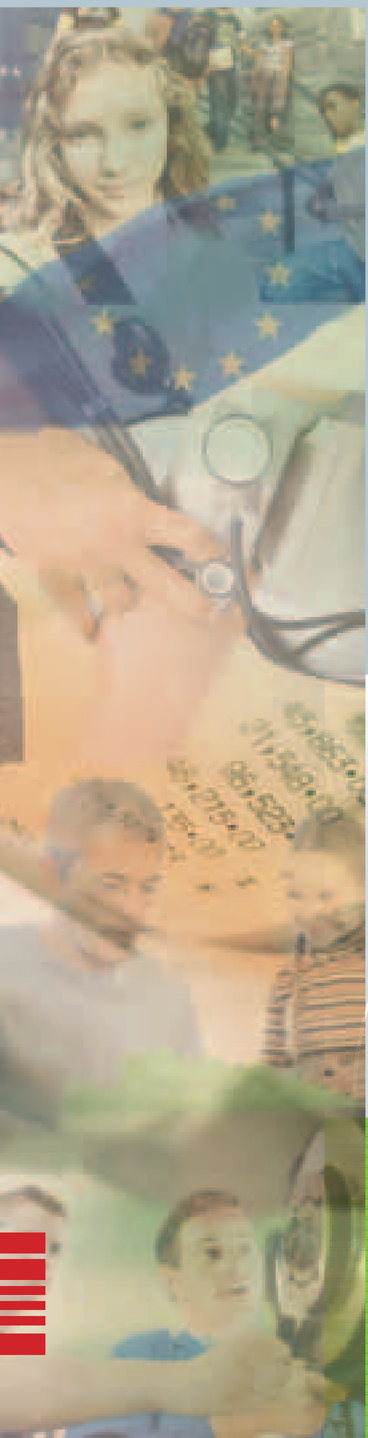

Scenarios for Phasing Out Nuclear Energy in Germany

FRIEDRICH EBERT STIFTUNG

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Scenarios for Phasing Out Nuclear Energy in Germany

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Summary

The exit from nuclear energy planned by the German government presents a number of opportunities but also harbours risks. This study shows that electricity prices for private households will be only slightly affected by withdrawal. The competitiveness of the German economy is also unlikely to be affected severely since electricity prices for industry and large companies will increase only temporarily. However, the CO_2 emissions of the German electricity sector could rise, depending on the timing of the exit from nuclear energy. In addition, if security of supply is to be guaranteed, besides the expansion of renewable energy new fossil fuel-fired power stations must be built or older plants permitted to remain operational for longer than originally planned.

Against the background of the objectives of efficiency, environmental sustainability and security of supply laid down in the Energy Management Act (Energiewirtschaftsgesetz) the phasing out of nuclear energy must be done in such a way that electricity prices remain affordable for industry and consumers, security of supply is not jeopardised and the goals of climate protection can be achieved over the long term. These energy policy aims will be achieved only if the exit from nuclear energy also marks an entry into a new energy policy. The resolution of possible conflicts of aims was discussed in connection with the decision on phasing out nuclear energy in 2002 and has already been addressed in the form of specific government decisions (for example, the decisions of the former coalition of Christian Democrats and Social Democrats in 2007, the so-called “Meseberg decisions”). This includes, in particular, measures to expand renewable energy and cogeneration, as well as reductions in energy consumption. The planned exit will once again make these measures the focus of energy policy. An important aspect of the analysis presented here is a discussion of the additional challenges which would arise if the exit takes place not, in accordance with the previously valid Nuclear Energy Act (Atomgesetz; AtG), in 2022, but is completed earlier (for example in 2020 or 2015).

In order to assess the implications for efficiency, environmental sustainability and security of supply in the case of different exit times in this study model-based analyses of the development of electricity prices and CO_2 emissions will be conducted for a series of exit scenarios: *Exit 2015, Exit 2020, Exit 2022* (that is in accordance with the Nuclear Energy Act AtG 2002 in force until autumn last year and also valid for the recent decision taken in July 2011), and *Exit 2038* (that is in accordance with the Nuclear Energy Act AtG 2010 that was valid from October 2010 to July 2011). Besides the expansion of renewable energy, the various effects of gas- as opposed to coal-fired power stations as replacements for nuclear energy are examined and further alternative scenarios explored.

The following **key findings** could be identified:

- *The development of spot market prices*[1] *shows, for the various exit scenarios, regardless of the exit date, an increase up to 2020 and a fall back to the base level of 2010 by 2030.* In the case of an early exit in 2015 or 2020 prices on the energy exchange at the beginning will be higher than in the case of an exit in 2022 since replacement capacities with higher generation costs than nuclear power stations must be put in place earlier on. Over the long term the price level will fall due to the growing proportion of renewable energy.
- *In the case of an exit in either 2020 or 2022 the spot market price in 2015 will be 5.9 ct/kWh. Exit 2015, by contrast, would lead to an increase of 13 per cent.* The spot market price in 2015 would be 5.9 ct/kWh in the case of *Exit 2020* or *2022* in comparison to a price of 5 ct/kWh at the beginning of 2011. Assuming a scenario involving the prolongation of the operational life of nuclear energy (*Exit 2038*) the result would be a spot market price of 5.2 ct/kWh. In the case of accelerated exit (*Exit 2015*) the additional price increase will amount to 0.8 ct/kWh (13 per cent) in comparison to Exit 2020 or 2022. With the further expansion of renewable energy by 2030 spot market prices will fall to 5-6 ct/kWh.
- *For households liable to the feed-in tariff system (FIT) levy*[2] *the timing of the exit from nuclear energy will have little effect on electricity prices.* In the case of *Exit 2020* or *2022* the electricity price in 2015 will be 21.7 ct/kWh, and in the case of *Exit 2015* it will be 22.4 ct/kWh. Calculating on the basis of average electricity consumption per household of 3500 kWh per year, this means a difference of around 2 per month. The maximum difference between an exit in 2015 and in 2038 is 1.2 ct/kWh (3.5 per month). The FIT levy will in this instance have a price-dampening effect for households.
- *Industrial customers that are exempt from the FIT levy will be harder hit by the medium-term increase in the spot market price.* If existing billing procedures are retained, however, there is the possibility of benefiting from the price-dampening effect of renewable energy over the long term. In the case of *Exit 2015* in comparison to *Exit 2020* or *2022* the burden for a typical industrial customer (with 24 GWh electricity consumption per year) would be 216,000 per year.
- *The exit from nuclear energy requires more rapid expansion of fossil fuel capacities than previously planned.* By the respective exit times of 2015, 2020 or 2022, on top of the projects under construction, new fossil fuel-fired power stations with a net output of 8 gigawatts (GW) must be planned in order to meet the annual peak load. This not only means that all the power stations under construction must be built but also requires the commissioning of fossil fuel-fired power stations which are at present only at the planning stage or leaving older plants in the grid longer than originally planned.
- *In the case of an earlier exit from nuclear energy than in 2022 there is likely to be a temporary increase in CO_2 emissions but their total quantity would be limited via European emissions trading. Exit 2022* would broadly mean a return to the old »status quo« – the legal framework of the Nuclear Energy Act AtG2002 that was in force until autumn last year. Europe-wide, additional nuclear power stations, if any, would be used only to a limited extent because, as a rule, being a low cost option they are operating at their capacity limits most of the time. *Exit 2020* would lead to a moderate short-term increase in CO_2 emissions. In the case of an exit by 2015, by contrast, CO_2 emissions would increase by 64 $MtCO_2$ (23 per cent) as against an exit in 2020 or 2022. From 2025 emissions for the exit points of 2022, 2020 and 2015 would be on a par.

1 Spot market prices are the prices for energy deliveries in short-term trading on the European Energy Exchange (EEX).

2 The feed-in-tariff system in Germany was established in 1991. In contrast to a common output subsidy for renewable energy, the feed-in subsidy is cross-financed by a levy that is paid by final consumers. Thus, the feed-in-tariff is income-neutral for the government.

- *The replacement of nuclear power stations by gas-fired instead of coal-fired power stations would have a roughly equivalent effect on electricity prices, but CO2 emissions would rise less sharply.* If the construction of gas-fired power stations is stepped up instead of coal-fired power stations the spot market prices in 2020 would be only around 0.1 ct/kWh higher than what they would be if the “coal option” was taken (in the case of *Exit 2020*). Furthermore, CO_2 emissions can be reduced. Especially in the case of an early exit in 2015 the additional discharge could be reduced by 20 per cent. Over the long term, however, as a result of the increasing market share of renewable energy, there would be only small differences between the gas and coal options with regard to CO_2 emissions.
- *Stronger expansion of gas-fired power stations than of coal-fired power stations would be advantageous because replacement would be more rapid and a long-term commitment to the fossil fuel route would thereby be prevented.* In addition, above all competition on the electricity market would be heightened because even smaller suppliers, such as municipal utilities with lower capital resources would be in a position to build these power stations and to achieve additional efficiency gains in conjunction with cogeneration. The use of the waste heat of power stations would allow for a further reduction of CO_2 emissions.
- *The development of fuel and CO_2 prices has a greater effect on the electricity price than the year of exit.* In the scenario *Exit 2020 – gas,* in the case of more sharply rising fuel and CO_2 prices spot market prices in 2020 would rise by 20 per cent.
- *If measures to increase energy efficiency fail and no reduction in electricity demand can be achieved electricity prices will likewise rise.* On the assumption of constant rather than declining electricity demand, spot market prices in 2020 could increase by 10 per cent. Load shifting measures (demand-side management), by contrast, could reduce prices only minimally and even the additionally investigated assumption concerning the addition of decentralised cogeneration would have only a modest influence on the price.
- *In the case of a more rapid expansion of renewable energies, wholesale prices could be reduced in conjunction with flexible gas-fired power stations.* In addition, the need for conventional back-up power stations could be reduced from 8 GW to 6 GW.
- *Implementation of an exit by 2015 depends decisively on whether replacement capacities of fossil fuel-fired power stations will be available in the short term.* Although early exit would not lead to dramatic price increases, CO_2 emissions would be significantly higher. Implementation of this scenario is conditional on the availability of replacement capacities through the building of new (fossil fuel) power stations exactly when they are needed. Consideration could also be given to prolonging the use of older coal-fired power stations.
- *Accelerated expansion of the grid is a key condition of both exit and longer term transformation of energy use.* Due to regional imbalances with regard to generation and consumption and the volatile supply of renewable energy (wind, photovoltaic) grid bottlenecks are increasing. This development will be further accelerated by the exit from nuclear energy. It is therefore necessary to implement the planned expansion of infrastructure as soon as possible in order to counteract a possible destabilisation of power supply operations.
- *A coordinated European climate and energy policy would facilitate and support the energy transformation in Germany. Here the Europe-wide promotion of renewable energy and the extension of European emissions trading scheme suggest themselves as appropriate measures.* Further Europe-wide expansion of renewable energy is an important step towards reducing the costs of the energy transformation over the long term. To that end, Europe-wide harmonisation of the promotion of renewable energy should be exam-

ined based on the integration of existing national promotion systems. The costs of European climate protection can be reduced if all relevant sectors can be included in the European emissions trading scheme. In particular, the heating and transport sectors have major potential for cost reductions.

– *The establishment of a permanent council for sustainable energy and climate policy should prepare the requisite foundations for sound decision-making for German energy policy. It would examine objectives and the instruments being applied and inform the Parliament and the general public about the opportunities, costs and risks of the change in energy policy.* Embarking on a change in energy policy offers German society a range of opportunities, but it also harbours risks. A German Council of Experts on Climate and Energy should therefore be established to inform the parliament and the general public in annual reports on whether targets are being met or not. The Council should investigate various energy policy alternatives with regard to their opportunities, costs and risk. This also includes the collection of necessary data, such as the cost development of renewable energy. Furthermore, it should also play an active role in the identification of research gaps and shortcomings in the implementation of policy measures. The collection of the kind of information needed to take appropriate action is necessary if society is to develop a more sophisticated understanding of the issues, thereby bestowing broad legitimacy and continuity on energy policy decision-making.

1. Introduction

The reactor accident at the Japanese nuclear power station in Fukushima as a result of the earthquake on 11 March 2011 triggered a debate in Germany on the future of nuclear energy, far exceeding previous debates in terms of both importance and scope. The Ethics Commission[3] in its final report of May 2011 considers an exit from nuclear energy within the next 10 years to be feasible. In July 2011 the decision was taken for a final shutdown of the last nuclear power station in 2022.

Besides the precise date of exit from nuclear energy an important and long-term social policy task concerns the orientation of future energy supply in Germany. For this reason, the debate cannot be conducted in isolation, focusing solely on the exit from nuclear energy. All systemically relevant aspects of energy supply must be taken into account. There are a number of feasible approaches to securing a reliable future energy supply for Germany. The debate on the forthcoming change of direction as regards energy has much to gain if a number of alternatives are juxtaposed and evaluated within the framework of an investigation in an open and unbiased way.

Against the background of the current public debate and the exploration of different paths that might be taken with the change of direction in energy use and policy (the so-called "energy transition") the following questions are examined in the present study:

- How will electricity prices develop as a result of the exit from nuclear energy? What effects will electricity prices have on various consumer groups and what does that mean for the social acceptability of the changes?
- What options are available for replacing nuclear energy and how are they to be evaluated economically and environmentally?
- What conflicts of climate and energy policy aims could turn up in the various scenarios?
- How rapidly could an accelerated exit from nuclear energy be accomplished in Germany? What are the implicit conditions for that? How can security of supply be ensured?
- What challenges will have to be dealt with as a result of the energy transition, regardless of when nuclear exit takes place? How can it be ensured that climate protection targets are met over the long term? What prospects arise from the European context?

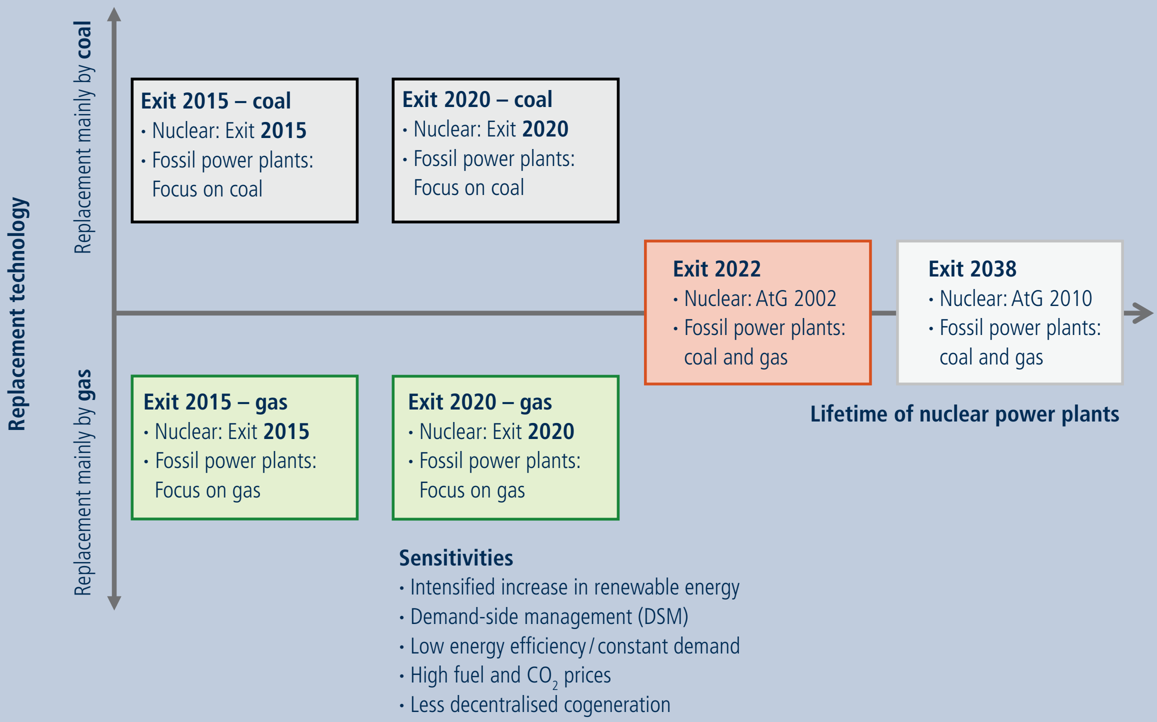
The first four questions are answered on the basis of a model for the German electricity market. Discussion of the effects of the European context and the options available with regard to maintaining policy over the long term is complementary to this. The study therefore represents a first step towards a systematic exploration of different paths that might be taken by the electricity sector. Using the electricity market model MICOES (Mixed Integer Cost Optimization Energy System) we analyse the development of electricity prices and CO_2 emissions for a series of nuclear exit scenarios (*Exit 2015, 2020, 2022* and *2038*) in the context of a range of replacement options (for example, giving priority to coal- or gas-fired power stations). These paths were tested for their robustness in sensitivity analyses in which individual assumptions were varied. In this way a range of alternative scenarios is explored. In order, for example, to evaluate the importance of energy efficiency measures the influence of (elec-

3 The German "Ethics Commission" was established in March 2011 by Chancellor Merkel in order to assess the risks and ethical questions of future nuclear power and to give input to establish a secure energy supply for Germany.

tricity) demand-side management and the failure of efficiency measures are analysed. In addition, different expansion paths with regard to decentralised cogeneration, as well as more steeply rising fuel and CO_2 prices are considered. Intensified expansion of renewable energies is also modelled. Figure 1 provides an overview of the scenarios. Furthermore, fundamental conditions which go hand in hand with the respective paths will be described explicitly, potential conflicts of aims presented and areas of action identified.

Figure 1:

Definition of scenarios



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2. Modelling Results

2.1 Additional Need for Fossil Fuel-fired Power Stations

Complete withdrawal from nuclear energy means that 21 GW in net power plant capacity have to be replaced. At present, due to the moratorium[4] and upcoming reviews around 10 GW in power plant capacity are out of operation. The electricity market has compensated for this short-term shutdown of a considerable number of nuclear power stations by making use of existing over-capacity, as well as by reducing net electricity exports. Furthermore, according to the German Association of Energy and Water (BDEW) (2011) a series of fossil fuel-fired power stations are under construction, whose capacity of around 11 GW (about 10 GW of which will come from coal-fired power stations[5]) will be available by 2015. We were able to take this into account in our model-based analysis. In this way, the capacity of the nuclear power stations can be completely replaced by 2015. However, it is also planned to shut down 14 GW in power plant capacity from old fossil fuel-fired power stations. And by 2020 a further 13 GW in fossil fuel-fired power plant capacity are to be shut down. This means that, in addition to the exit from nuclear energy, a total of 27 GW in fossil fuel-fired power stations will have to be replaced (see Figure 2). The options for filling this gap include – as we shall see – the expansion of renewable energy and of (centralised and decentralised) cogeneration, the reduction of electricity demand by increasing energy efficiency, the import (although only for a limited number of hours) of electricity from other European countries and the new construction of fossil fuel-fired power stations or the refurbishment of older fossil fuel plants.

According to the prognoses of the "Lead Study" (Leitstudie) conducted by the German Environment Ministry (BMU, 2010) an increase in wind power and photovoltaic capacity in the amount of 52 GW is assumed for the period 2010-2020. A further increase in conventional power plant capacity of 5 GW by 2020 is assumed in the form of decentralised combined heat and power generation plants (CHP). A further increase in energy efficiency and the resulting reduction in electricity demand is supposed to reduce peak load in 2020 by 4 GW. In the model the difference between the required 27 GW and the assumed replacement measures (increase in renewable energy, more CHP and higher efficiency) is replaced by conventional fossil fuel-fired power stations.

Based on economic considerations a further 8 GW are built in the model to cover peak demand. The scheduling of the expansion of capacity can be deferred further into the future depending on the date of exit (Figure 3). This means that in the case of a nuclear exit in 2020 not only will all the power station capacities currently under construction be ready, but that further fossil fuel-fired power stations currently planned or to be planned will have to be put into service. Alternatively, prolonged use of older coal-fired power stations can be considered. An even earlier exit in 2015 would represent an even greater challenge. This involves many other open questions and assumptions requiring further investigation.

4 A 3-month moratorium of the recently decided extension of nuclear power was established by mid-March, where eight out of 17 nuclear power plants were switched off.

5 The hard coal-fired power station Datteln 4 was not included in our calculations because it remains extremely uncertain when it will be put into operation.

Figure 2:

Replacement requirement due to the closure of conventional capacities by 2020

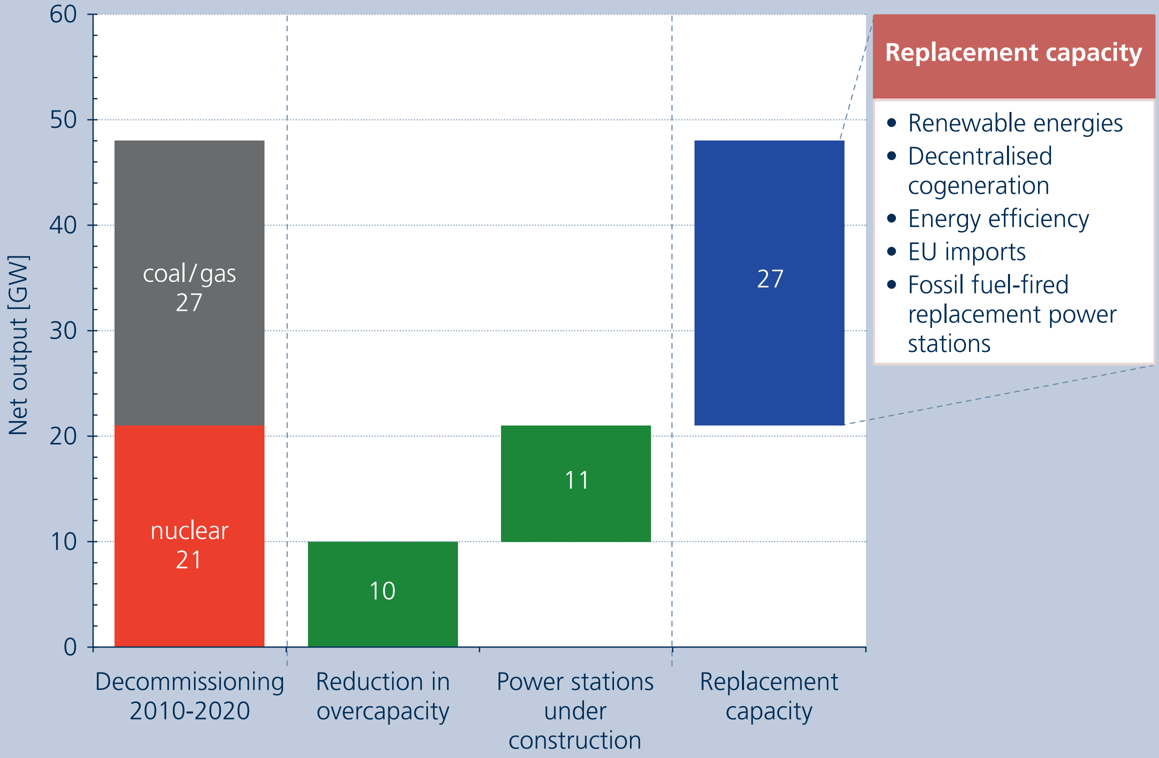

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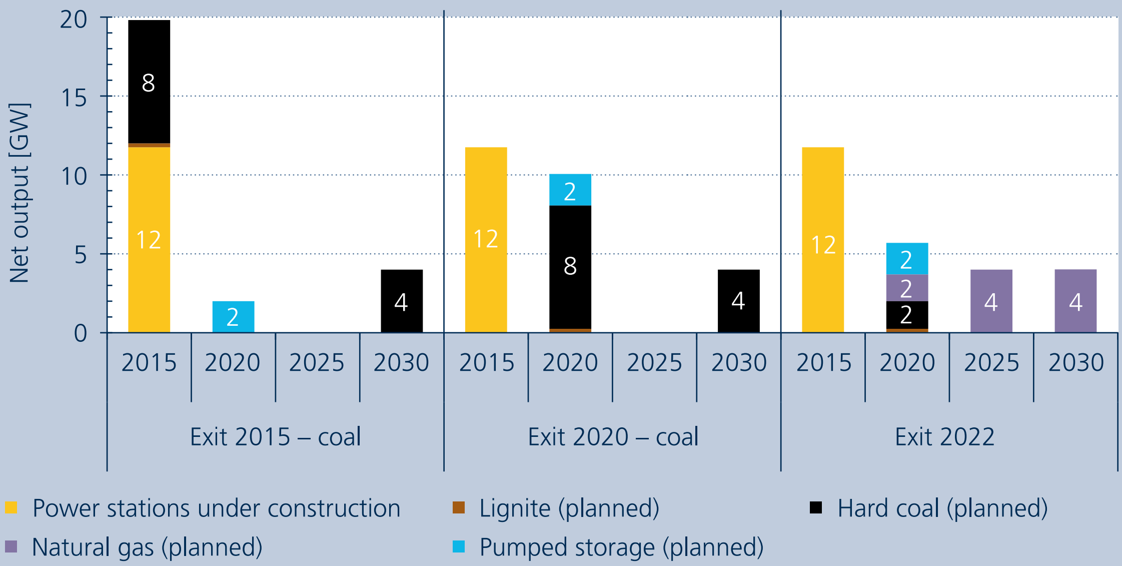
Figure 3:

Replacement capacity required in conventional power stations (by 2030; comparison of scenarios *Exit 2015 – coal, Exit 2020 – coal* and *Exit 2022*)



Source: own representation.

With regard to security of supply and also refraining from importing electricity via the European grid the construction of further gas turbines is worth considering as a cost-effective alternative. According to calculations based on the model, however, these plants could not be refinanced via the spot market due to low capacity utilisation. In addition, due to the input of photovoltaic energy the price of peak load at lunchtime will be reduced so that the contribution of gas turbines to covering demand will be further reduced. The economic viability of seldom needed gas turbines which (as a rule) is not forthcoming under these circumstances could be safeguarded by the introduction of capacity markets to complement the spot market in its current form.

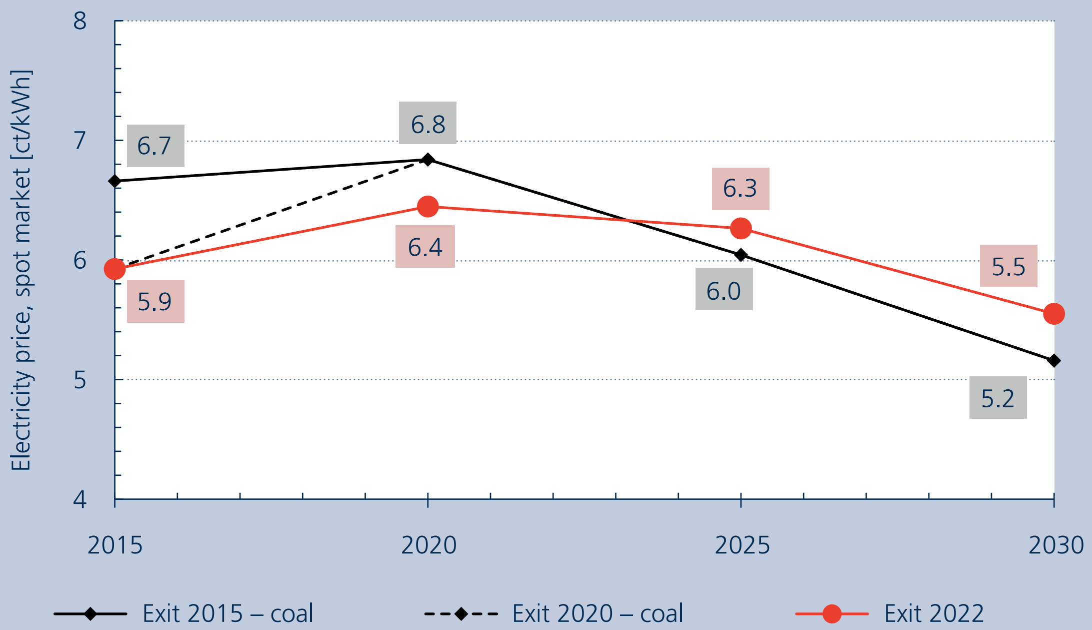
2.2 Electricity Prices

Within liberalised electricity markets, spot market prices can be assessed by using the merit order of the considered power plant fleet. The marginal power plant, i.e. the plant with the highest (short-term) generation costs still needed to meet a given demand, establishes the spot market price. As the demand changes from hour to hour, so do the spot market prices. If nuclear power stations are now to be decommissioned the spot market price will rise, at least temporarily, since now more cost-intensive power stations will be put into operation to cover demand. The increasing proportion of renewable energy in the electricity mix (40 per cent in 2020, 65 per cent in 2030) will work in the opposite direction, bringing about a long-term fall in the spot market price level. The reason is that, in accordance with the feed-in-tariff system renewable energy must be supplied at »negative« cost in order to be able to ensure sale corresponding to the obligation of grid operators to purchase renewable energy (*Einspeisevorrang*). As a result, the spot market price will rise until 2020, but then fall again to below the initial level by 2030 due to the ever increasing proportion of renewable energy (Figure 4).

In the case of an early exit in 2015 the spot market price in that year would be 6.7 ct/kWh and thus 0.8 ct/kWh over the price in the cor-

Figure 4:

Development of the electricity price at the spot market (base) in the period 2015 - 2030 under selected scenarios



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responding year in the case of an exit in 2020 or 2022. The reason for this is the need to draw on cost-intensive replacement capacities ahead of time. However, prices under the *Exit 2015* scenario will converge again in 2020 to those of the *Exit 2020* scenario since these replacement power stations remain necessary independent of the exit time that is merely put back five years in the *Exit 2020* scenario. In the case of an exit in 2022 drawing on replacement capacities can be put back even further so that the prices in 2020 will be 0.4 ct/kWh lower. Long term, however, spot market prices remain lower in the case of early exit with coal as the replacement option than under the Exit 2022 scenario. This can be put down to the intensified expansion of gas-fired power stations in the case of *Exit 2022* (Figure 3) which have a higher cost level.

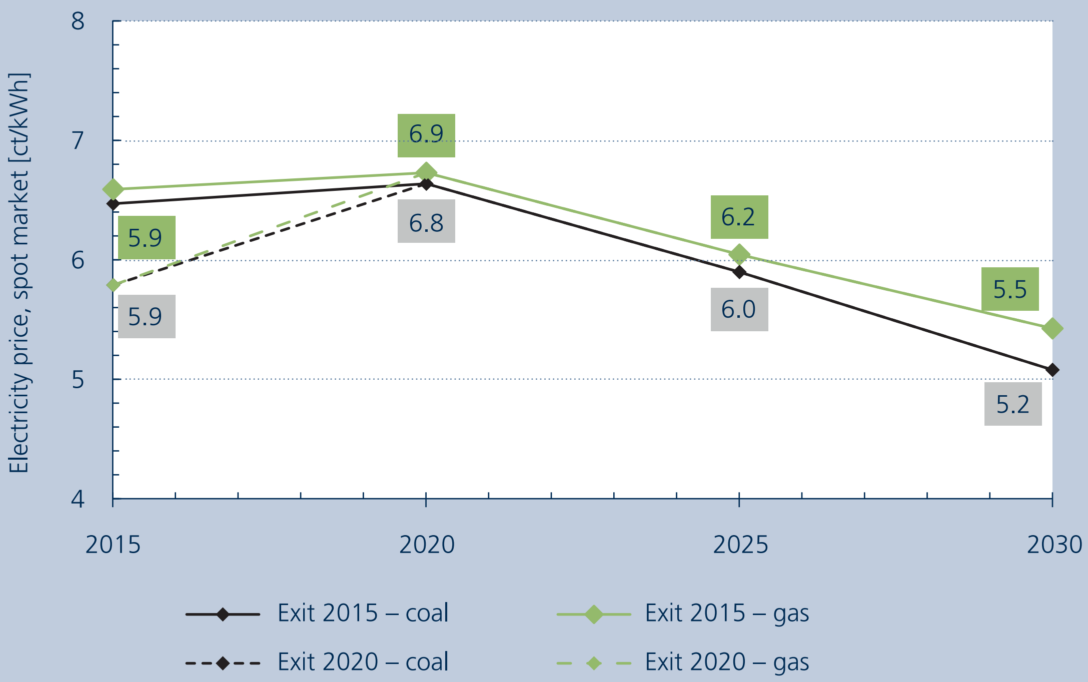
2.2.1 Comparison of Expansion of Gas-fired Power Stations instead of Coal-fired Power Stations

As far as electricity prices are concerned it doesn't matter whether nuclear power stations are replaced by gas- or coal-fired power stations. The reason for this is that, on the basis of the assumed fuel and CO2 prices, electricity production costs for both technologies are approximately equal. Accordingly, if – apart from the projects under construction – exclusively gas-fired power stations are built instead of coal-fired power stations the spot market prices in 2020 will be only around 0.1 ct/kWh higher than those under the scenario involving intensified expansion of coal-fired power stations (*Exit 2020*).

Given the 2010 decision to prolong operational lifetimes of nuclear power plants investment in the construction of new gas-fired power stations was no longer economical. Since the cancellation of operational prolongation and the decision of a nuclear phase out in 2020, however, the original market situation that was valid until autumn 2010 has reasserted itself and, as a consequence, the economic viability of gas-fired power stations considerably improved. The results of the model confirm this. Based on developments in the international gas market (for example, WEO 2010) the putting into operation of gas-fired power stations will remain attractive in the medium term, too.

Figure 5:

Development of wholesale prices comparing the replacement options of coal and gas



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2.2.2 Electricity Prices for Households Customers

The impact of the different exit times on household customers is barely discernible (Figures 6 and 7). In the price calculations constant grid charges are assumed and the FIT levy adapted in accordance with the spot market price. The FIT levy which is paid by household customers is based on the difference between compensation under the FIT system and the average electricity procurement costs on the electricity exchange and thus counteracts price increases on the spot market.

The maximum difference is to be found in 2015, at 1.2 ct/kWh (between *Exit 2015* and *Exit 2038*). In the case of average household use of 3500 kWh per year that means an additional cost of 3.5 euros per month. The price difference between *Exit 2020* and *Exit 2015* of 0.7 ct/kWh amounts to around 2 euros per month. The gradual alignment of spot market prices between the scenarios *Exit 2015* and *Exit 2020* eliminates the additional costs between the two exit scenarios by 2020. In that year, the price difference at the household level of these scenarios in comparison to *Exit 2022* comes to 0.3 ct/kWh or 0.88 euros per month for the average household.

2.2.3 Electricity Prices for High Electricity Using Industrial Customers

Power intensive industry exhibits greater variety than private households since due to special agreement status many individual regulations have been agreed with particular suppliers. This impedes precise analysis of the effects of an accelerated exit from nuclear energy on individual components of the electricity price.

However, based on the same assumptions, the price component corresponding to electricity generation in the electricity price can be isolated, which stands at 5.9 ct/kWh (*Exit 2020* and *2022*). A price increase of 0.9 ct/kWh is to be expected in the case of accelerated exit by 2015 in comparison to a scenario involving exit by 2020 or 2022, which means a price increase of 8 to 10 per cent in relation to the end price. The additional burden for a typical industrial customer (with 24 GWh annual consumption) is 216,000. In case of *Exit 2038* the cost saving compared to *Exit 2020* or *Exit 2022* is 168,000.

2.3 CO_2 Emissions

In the case of an exit from nuclear energy and substitution with coal-fired power stations or gas-fired power stations the CO_2 emissions of the electricity generation sector would increase with exit in 2020 or 2015 in comparison to exit in 2022. Over the long term, however, under this scenario emissions would be similar. Exit in 2022 would only mean a return to the old "status quo" before the prolongation of the operational life of nuclear power stations in autumn 2010. An exit in 2020 instead of in 2022 would mean only a short-term rise in CO_2 emissions (Figure 8). Complete exit in 2015, however, would push up CO_2 emissions: in 2015 they would be 64 million tonnes higher than in the case of exit in 2020 or 2022. The additional emissions could be reduced by 20 per cent if the expansion of gas-fired power stations was stepped up instead of coal-fired power stations.

An increase of 64 million tonnes would raise German CO_2 emissions of the electricity sector by almost a quarter in 2015. Climate protection would not be endangered by this, however, since the total quantity of emissions in the European electricity sector is limited by the EU emissions trading system. As a result, however, the CO_2 price would rise. This would mean that across Europe power stations would be utilised which emit less CO_2. Since nuclear power stations have lower marginal costs their capacities are, as a rule, already fully utilised, within the framework of the existing possibilities. Rising CO_2 prices would therefore lead mainly to the utilisation across Europe of more efficient fossil fuel-fired power stations.

Figure 6:

Electricity prices for household customers 2015 (in real terms 2007)

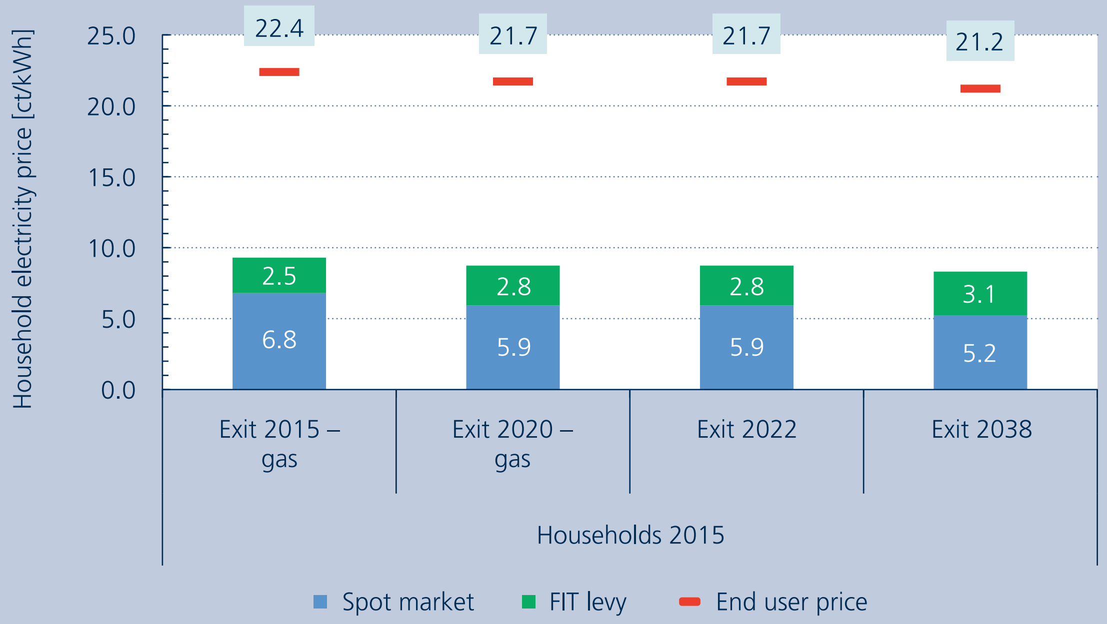

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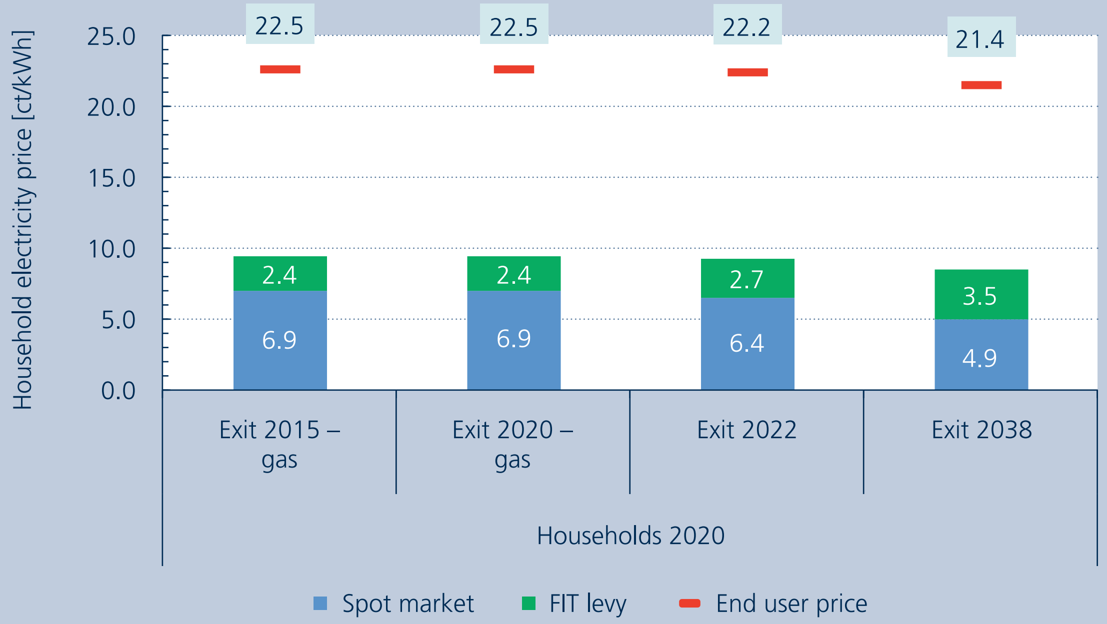
Figure 7:

Electricity prices for household customers 2020 (in real terms 2007)



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2.4 Sensitivities and Robustness of the Results

The results of the model are determined to differing extents by the initial assumptions. Within the framework of a sensitivity analysis the following were considered: fuel and CO_2 prices that are rising stronger compared to the default assumptions; failure to achieve efficiency targets (and a constant electricity consumption at today's level as a result of that); increased flexibility on the demand side by means of demand-side management measures; more modest expansion of decentralised cogeneration; and a more rapid expansion of renewable energy (Figure 9).

The biggest influence on spot market prices is exercised by the assumption about the future development of fuel and CO_2 prices which, in comparison to scenario *Exit 2020 – gas* lead to a 20 per cent increase from 6.9 to 8.6 ct/kWh. This is linked to a reduction in the FIT levy due to the lower differential costs, so that the electricity price for private households rises by a total of 4 per cent to 23.5 ct/kWh, and in the case of consumption of 3500 kWh per year leads to an additional monthly cost of 3.14 euros.

The assumption of a rise in energy efficiency also exerts a big influence. If electricity consumption, contrary to policy targets, remains at its current level instead of falling wholesale prices will increase by 10 per cent, whereas the falling FIT levy will limit the price increase for end users to 2 per cent (additional monthly cost of 1.2 euros).

The influence of these assumptions on the electricity price is thus similar to or even greater than the timing of exit itself. In contrast, the impact of load shifting measures (demand-side management) can reduce prices only minimally, while less cogeneration has a relatively low impact on prices. The implementation of measures to increase efficiency is thus an important task in the re-orientation of the energy supply system.

Figure 8:

CO_2 emissions in conventional power stations 2015-2030

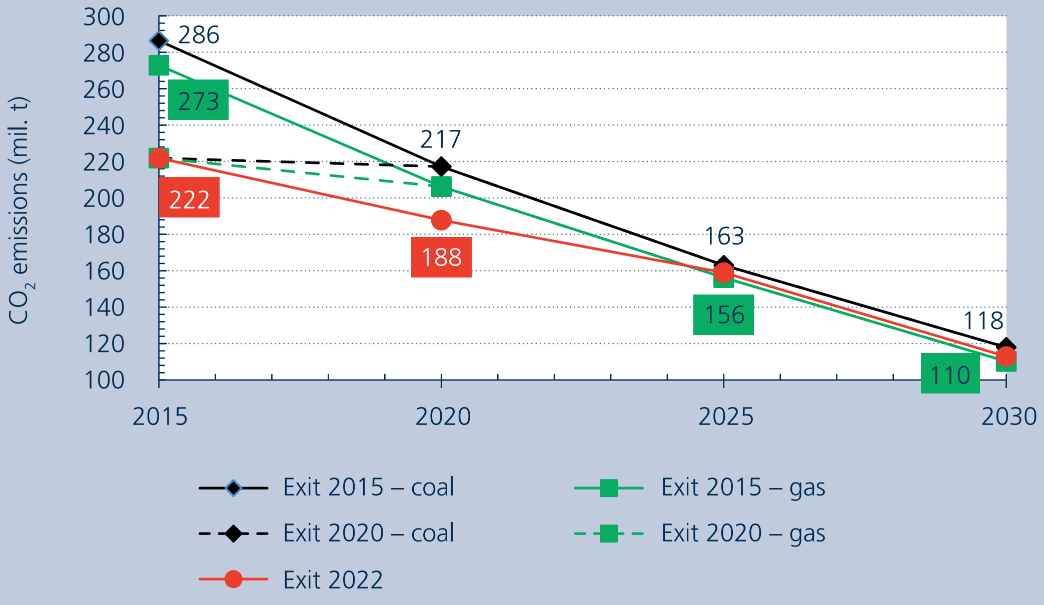

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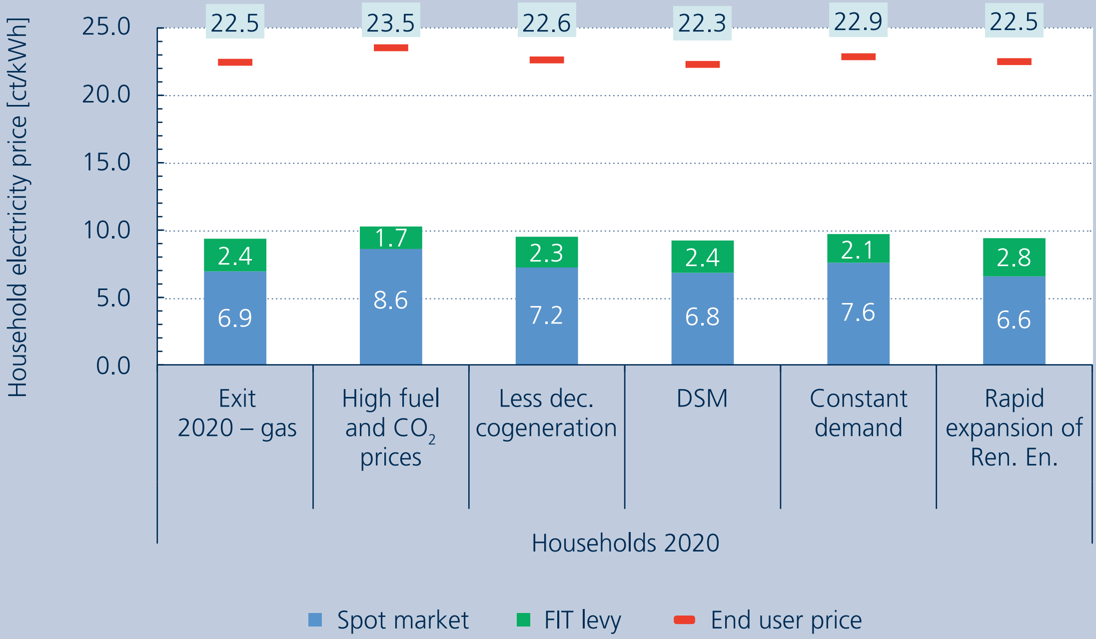
Figure 9:

Sensitivities in relation to spot market prices, FIT levy and household electricity prices in 2020 with regard to the scenario *Exit 2020 – gas*



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3. Required Government Action

3.1 Grid Expansion

A key condition for all expansion options with regard to electricity generation is adequate expansion of the electricity grid. The energy transition confronts the German electricity grid with two challenges. First, a large part of the supply of renewable energy – especially wind energy – fluctuates in the north-east of the country. Second, for historical reasons transmission capacity between old and new Federal State is comparatively low. The situation is exacerbated by the fact that conventional power stations in the new Federal States "overproduce" relative to regional demand and thus export electricity to the rest of the country. This territorial imbalance means that especially from the south-west to the north-east there are regular grid bottlenecks.

Expansion of current grid capacities over the medium to long term is therefore necessary above all because only in this way can the expansion of renewable energy – among other things, as already described, as a substitute for nuclear energy – be guaranteed over the longer term. In order to accomplish the energy transition, therefore, fundamental adjustments or extensions of grid infrastructure or grid operations will be necessary. Nevertheless, the relevant total investment plays only a subordinate role.

This gives rise to four key areas of action for grid infrastructure and operations with regard to the energy transition: (I) reduction of the country-wide imbalance with regard to generation and demand; (II) guaranteeing grid stability in the case of fluctuating supply; (III) data availability and transparency and (IV) new construction and expansion of existing grid capacities.

Practical options with regard to grid expansion:

- Alignment of new construction of power stations and generation plants to the needs of grid infrastructure, for example, through targeted promotion of investment in regions with high demand and low supply.
- Optimisation of grid operations with regard to stability, for example, through the certification of existing power stations and generation plants in accordance with a list of criteria for safeguarding the system.
- Collection and making available of data needed for evaluating and modelling the grid situation and expansion.
- Further acceleration of grid expansion in accordance with existing plans and legislative initiatives, such as "Plan N" and the law on accelerating grid expansion (NABEG).

3.2 A Coordinated European Climate and Energy Policy Is Needed

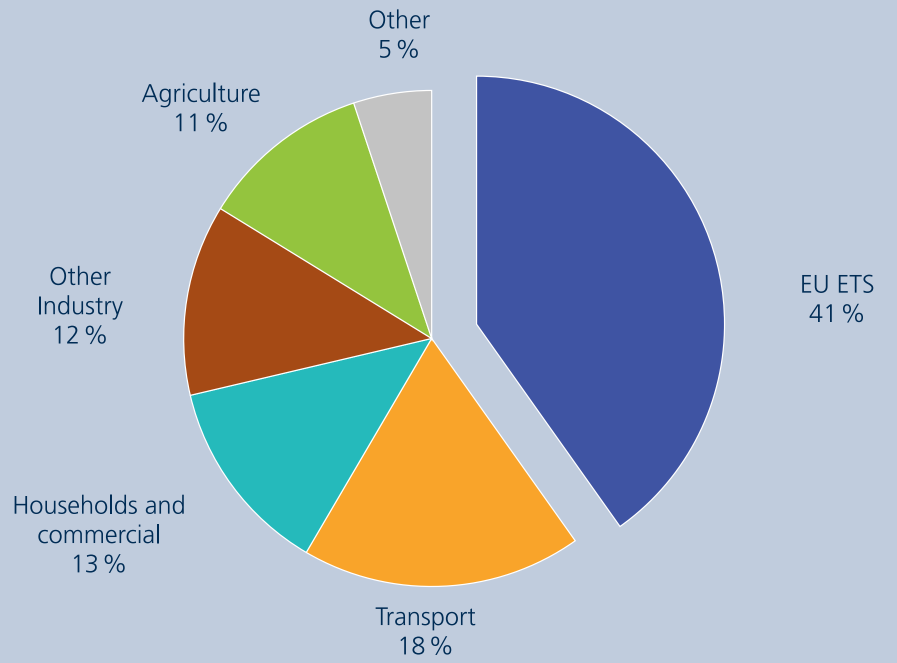
Credible climate protection targets are needed at the EU and the global level in order to guarantee long-term durability, also of national targets. Besides climate protection goals important policy decisions are being taken at the EU level with regard to energy policy. The results arising from the model also show that, on the one hand, achievement of the objectives of energy efficiency and, on the other hand, the expansion of renewable energy is crucial in efforts to avoid rises in electricity prices. The two measures will be successful and have a long-term future, however, only if national energy strategies are brought into line with European climate and energy policy. Further development of the EU emissions trading system and the harmonisation of the promotion of renewable energy are extremely important for future climate energy policy.

The EU Emissions Trading System (EU ETS) is the EU's central climate policy instrument. However, to date the EU ETS covers only around 40 per cent of the EU's greenhouse gas emissions, namely in the areas of electricity generation and industry (Figure 10). From an economic point of view it would make sense to regulate emissions to the furthest extent possible under the ETS. The next candidate for inclusion in the ETS is transport, but integration of the residential sector would also be sensible. The end result of this development should be that all sectors are included. Inclusion of these sectors would reduce the costs of climate protection because the search for the most efficient mitigation measures would then be extended to sectors in which particularly high cost savings can be assumed. Over the long term, the increase in CO_2 prices could also be restrained in this way.

The costs of renewable energy can be reduced significantly by making the right choice of location. Long-term harmonisation of support systems for renewable energy is, because of the comparative cost advantages, an important step towards decarbonising electricity supply at minimum cost. However, the question of whether EU-wide harmonisation would really bring the hoped-for benefits depends decisively on the specific design of the support system. Consider-

Figure 10:

Distribution of EU-wide greenhouse gas emissions by individual sectors in 2008



Source: Data of EEA 2008, own representation.

ing existing experiences with national support systems it would therefore appear to make sense to examine the integration of these systems in a uniform European framework by means of gradual harmonisation of national support systems.

Practical options for European integration:

- Extension of the European Emissions Trading System to cover more sectors.
- Examination of a Europe-wide harmonisation of the promotion of renewable energy, taking into consideration the integration of existing national support systems.

3.3 Transparency and Scientific Monitoring

The energy transition not only entails technical challenges; it is also the beginning of a long process, which requires broad public assent, especially in order to resolve potential conflicts about additional infrastructure projects and with a view to the social acceptability of a potential increase in energy prices. Associated concerns can be overcome, however, only if the entire transition process is conceived of as a social learning process. Transparency is a key condition of widespread social acceptance. The transition process therefore requires an ongoing parliamentary debate and a scientific monitoring in order to attain credibility through the development of a long-term strategy and thus legitimacy for the energy transition.

At the parliamentary level the Bundestag could set up a standing committee on sustainable energy and climate policy on the model of Great Britain's government-independent "Committee on Climate Change" in order to furnish more transparency. One task of the committee would be to propose short-, medium- and long-term climate and energy policy goals to parliament. In this way it would be determined at what point and how much emissions reductions are to be achieved; how large the proportion of renewable energy should be; and how grid expansion, research into storage technologies and increases in energy efficiency can be driven forward. The committee would play an active role in this, identifying research gaps and deficiencies of implementation. The Ethics Commission has recognised the need for more transparency and has proposed a parliamentary representative for the energy transition.

However, this should only undertake the »monitoring and controlling« of targets. What is crucial, however, is that the committee not only propose ways of achieving these goals, but also have the task of presenting to the Bundestag a number of practicable alternatives. The Bundestag could then decide after a full public debate on the alternatives and legislate.

The debate on practicable alternatives is one of the key conditions of a successful social learning process. Such a procedure would not only make the grounds for policy targets comprehensible, but also increase the transparency and thus the legitimacy of policy decisions.

Furthermore, the collection of relevant data, such as cost development with regard to renewable energy, as well as a comparative project for the systematic analysis of energy policy scenarios in terms of German and European energy models similar to the US Energy Modeling Forum (EMF) would constitute a worthwhile complement of the German energy policy debate. A transparent information process is essential for ensuring broad social legitimacy and thus the long-term stability of energy policy decision-making.

Practical options with regard to transparency and scientific monitoring:

- Establishment of a standing committee of experts for energy and climate protection.
- Launch of a comparison of models with regard to long-term energy transformation paths for Germany.

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