Nucs down in Germany – prices up in Europe?

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Published in: Energy Policy, 37, 7, p. 2492 - 2497
(doi:10.1016/ j.enpol.2009.03.024)

Abstract

Current legislation on power production from nuclear energy in Germany defines certain remaining quantities of permitted electricity production for nuclear power plants. These quantities are defined for each nuclear power plant and are measured in TWh. In the discussion about climate protection and market trend of electricity prices it is regularly stated by policy makers that the nuclear phase-out will result in an increase in electricity prices and CO_2 emissions. As a consequence a revision is proposed, especially from the Liberals (FDP) and Conservatives (CDU). The following article discusses this issue analysing the different options investors and operators under different scenarios have. It shows firstly that both emissions and power prices can indeed increase, and secondly that the mere discussion about potentially reversing the phasing-out decision can lead to an increase in electricity prices as investment behaviour may change based on expectations regarding future regulation. I conclude that – ceteris paribus – the nuclear phase out is likely to result in an increase in CO_2-emissions and prices.

Key Words

Nuclear energy; CO_2-emissions; energy policy in Germany

Introduction

According to current legislation on nuclear power generation in Germany there are remaining operational quantities in place for power generation from power plants using nuclear sources. These terms are allocated to each nuclear power plant (NPP) in the form of permitted amounts of power production.[1] While the NPP based in Stade has already been shut down, other installations will presumably generate electricity until 2022 (see also Fig. 4). Concrete data on the shut-down dates is not available as the remaining quantities of permitted electricity production can principally be transferred over time within each plant and also among different power plants.[2] The law was passed in 2002 under the coalition of the Socialists (SPD) and the Green Party. The decision to phase out nuclear power generation has been criticised over and over again for a long time[3], as concerns are brought forward regarding on the one hand the "security of supply" – as could be seen recently in the case of a closed pipeline from Russia – and on the other hand the increase of electricity prices and CO_2 emissions. A revision of the phase-out is supported by the Liberals (FDP) and the Conservatives (CDU/CSU) that currently lead in the opinion polls. Operators and investors may thus expect a possible revision for the end of 2009 when the next elections take place.

When analysing the possible increase in emissions and power prices a direct and an indirect effect can be distinguished. While the direct effect is thought of as exclusively focusing on the electricity market and the total installed capacity (also referred to as merit-order curve), the proposition of an indirect effect additionally considers the market for CO_2 emission allowances and its repercussions on the power price: if CO_2-emissions change compared to a reference scenario, its price in the

[1] See Gesetz zur geordneten Beendigung der Kernenergienutzung zur gewerblichen Erzeugung von Elektrizität [German law on orderly termination of the use of nuclear energy for the commercial generation of electricity;] of 22 April 2002, Appendix 3.

[2] § 7 (1b) of Atomgesetz [German nuclear law] states as follows: „Quantities of electricity under appendix 3, column 2 can completely or partially be transferred from one power plant to another, if the receiving power plant started commercial operation later that the transferring power plant. Sentence 1 notwithstanding quantities of electricity can also be transferred from a power plant that commenced commercial operations later, if the Federal Ministry of Environment, Nature Conservation and Nuclear Safety in consultation of the Federal Chancellery and the Federal Ministry of Economy and Technology authorises the transfer. The authorisation of sentence 2 is not necessary if the transferring plant permanently ceases operation and an application according to paragraph 3, sentence 1 to shut down the power plant has been filed." E.g. for the NPP Neckarwestheim I, which commenced commercial operations on 1 December 1976, from 1 January 2000 a remaining production quantity of 57,35 TWh has been defined. Hence, a transfer of those remaining quantities to another NPP which commenced operations after 1 December 1976 is possible without further official authorisation. A transfer of remaining quantities of another NPP to the NPP Neckarwestheim I would – without official authorisation – only be possible from NPP Biblis A, which commenced operations on 26 February 1975. For a transfer of remaining quantities of newer NPPs (operations commenced after 1 December 1976) the above mentioned authorisation by the Ministry of Environment is required. Also see footnotes 16 and 20 on that matter.

[3] Already in June 2001 e.g. the chairman of RWE Power AG answered the question if the phase-out scenario would be reversible, stating that in a democratic society nothing is irreversible: "(…) the nuclear phase-out is painful to us", interview in: Welt am Sonntag of 10 June 2001, p 50. Ich weiss nicht, ob es so bleiben soll oder nicht.

European emissions trading scheme may change which in turn may have repercussions on the power price. The direct effect thus occurs regardless of whether a carbon regime is in place or not, whereas the indirect effect is based on the existence of an emissions trading scheme.

Apart from this comparative static analysis one has to be aware of the fact that the time period between the decision to build a new power plant and the power plant commencing operation can sum up to several years. This temporal dimension has rarely been considered in the political discussion in the past but will be discussed in the second part of this paper.

Direct effect: total installed capacity and electricity price

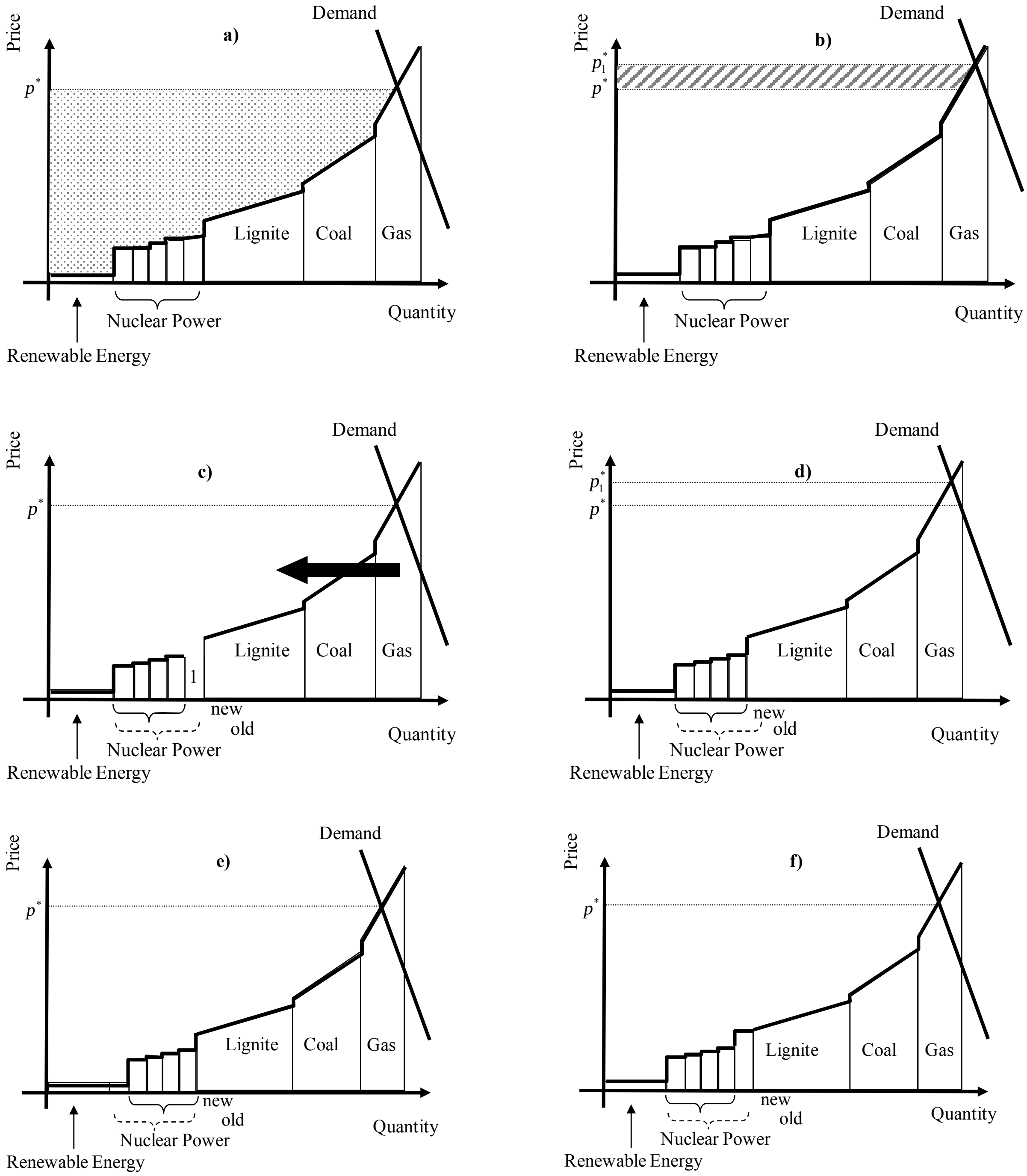
The direct effect can be observed on the electricity market as a change in the merit-order. It would also be observable in the absence of the European emissions trading scheme. According to conventional wisdom, in liberalised markets suppliers offer at marginal costs of production on the spot market.[4] The marginal costs strongly depend on the fuel employed such as coal or natural gas. But even within a 'fuel class' marginal costs vary depending on the installation's efficiency. The more efficient a power plant is the less fuel will be needed to produce a MWh electricity. The equilibrium price, referred to as p^* in the following, is given by the intersection of aggregated supply and demand curves (see Fig. 1).

The aggregated supply curve on the market consists of the individual supply curves of all power plant operators which in turn are based on their respective marginal costs. The last power plant that enters the market is called marginal power plant. Figure 1a schematically illustrates the formation of electricity prices. The grey dotted area below the dashed price line and above the marginal costs of power generation describes the aggregated profit margin or producer surplus. The price can change due to a shift in either the demand or the supply function. As can be seen in Figure 1b an increase in prices which is triggered by a growing demand results in an increase of profit margins for all power plant operators that produce at this higher price (hatched area in Figure 1b).

With respect to the direct effect examined here, the decisive question is what happens if a NPP is shut down. In case there is no substituting power plant for the missing electricity production at similar marginal costs, a shift in the supply function to the left is induced, followed by the formation of a new equilibrium in the marketplace.

[4] In other markets this is different. In the area of primary and secondary reserve e.g. a performance-based price is paid (Nailis, D., Ritzau, M. 2006). The spot market is, however, the most important market that also provides price signals for other markets (Ockenfels, A. et al. 2008).

Figure 1: Consequences of changes to the set of power plants for the electricity price (direct effect)



If for example NPP 1 is shut down and there is no replacing power plant with marginal costs that are lower than the price (p^*), a new equilibrium price $p1^*$ is formed, which is higher than p^* – meaning the price increases (see Fig. 1c and 1d). This in turn results in an increase of profit margins for all power plants producing at that time. Altogether, the remaining operators profit from the price increase while for the operator shutting down its NPPs the respective profit margins are not realised. If the NPP belongs to a company holding lots of other (producing) power plants the respective profit margins made on-top due to price increase, may over-compensate the missing profit margin of the shut down NPP. This can lead to a positive effect for this company. However, in comparison to those companies that do not have to shut down a power plant, the player that has to shut down its power plant is worse off. In case a new (additional) power plant closes the supply gap – e.g. a facility utilising renewable energy (see Fig. 1e) or a lignite-fired power plant (see Fig. 1f), nothing changes at first sight. The equilibrium price remains the same.[5]

Electricity prices hence can increase as a result of shutting down a nuclear power plant (NPP). An increasing price can in turn be the trigger for new investments.

Indirect effect: Emissions and the electricity price

When discussing the indirect effect, the important question is which type of power plant replaces the missing capacity after a nuclear power plant has been shut down. More specifically the amount of CO_2 emissions the new power plant produces is important. In case the new plant is "carbon-free" (for example if renewable energies are extended or due to an import of electricity) the scenario stated above does not change: Carbon-free electricity production is replaced by carbon-free electricity production.
But if the new power plant emits CO_2 the following indirect effect may occur: Due to higher amounts of greenhouse gases emitted the price for CO_2 emission allowances increases, which in turn results in rising electricity prices. The indirect effect is discussed in more detail in the following:

1. Emission trading is an instrument in which the total amount of emission allowances is determined for all participants.[6] The amount of emission reduction is determined together with the emissions in a business-as-usual (BAU) scenario – i.e. the emissions in absence of

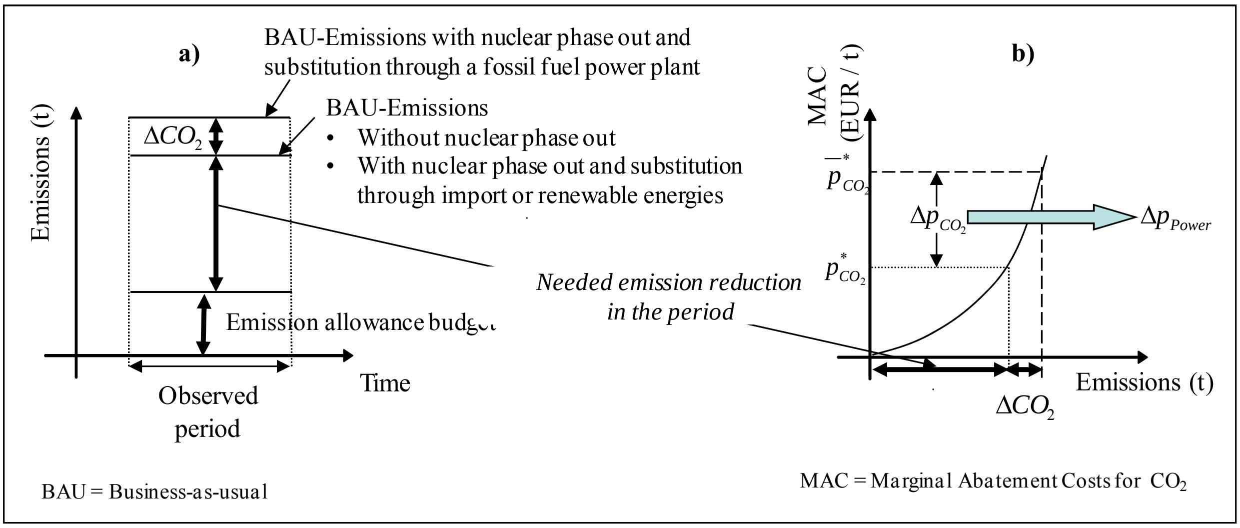
[5] The electricity price has to be distinguished from the average costs of electricity production. The latter can rise at a price remaining constant, too (EWI et al., 2005).

[6] For Germany see e.g. Zuteilungsgesetz (ZuG) 2007 [German law on allocation of emission allowances] or Zuteilungsgesetz (ZuG) 2012.

any climate policy instruments (see Figure 2a). If we now transfer this amount to the curve for aggregated marginal abatement costs for CO_2, the price on the market for emission allowances emerges (see Figure 2b). If the emissions in the BAU scenario increase – for example due to a cold winter - the price for emission allowances increases. Correspondingly, the emissions increase if a NPP is replaced by a CO_2 emitting power plant. Hence, the CO_2 price would increase (by $\Delta\, p_{CO2}$ in Figure 2b). In case the NPP is replaced by a carbon-free power plant, the CO_2 price p^*_{CO2} does not change as the CO_2 emissions remain constant.

2. Implementing an emission trading system makes the "atmosphere" sink a potentially scarce resource. If, in the BAU scenario, emissions exceed the amount of granted emission allowances, a price greater than zero forms. Operators whose plants emit CO_2 during operation now have to consider costs for CO_2 emissions (i.e. for "using" emission allowances) in their cost function and it is irrelevant if the allowances were allocated free of charge or had to be purchased.[7] This means, electricity production in CO_2 emitting power plants becomes more expensive. If now the marginal power plant emits CO_2 the marginal costs of electricity production rise and consequently the electricity price does too.[8] The price increase depends on the marginal power plant's CO_2 intensity and the CO_2 price.

Figure 2: Effects of increasing emissions for the price of CO_2 allowances



Source: Based on Bode (2006, pp. 971-974)

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[7] The use of emission allowances allocated free of charge in case of electricity production implies opportunity costs. In case a plant does not operate, the respective emission allowances could be sold on the market and a revenue could be realised.

[8] On the pricing rationality see the previous paragraph.

As mentioned in the discussion about the direct effect, along with the electricity price the producing operators may profit from higher margins (see Figure 1b). The inclusion of the costs for CO_2 allowances into the pricing which leads to the power suppliers skimming off the scarcity rent has already led to intense criticism in the past.[9] When emissions increase due to a CO_2 emitting power plant replacing a NPP (see ΔCO2 in Figure 2a), the price for CO_2 allowances rises (see Δ pCO2 in Figure 2b) as more emissions need to be reduced. At this time, it is irrelevant whether it is an old, existing (see Figure 1c and 1d) or a new (see Figure 1f) power plant emitting the CO_2. Due to a higher CO_2 price eventually the electricity price will also rise.[10] On the one side CO_2-free power plants (renewable energies and remaining NPPs) profit from the change, on the other side as long as emission allowances are given free of charge also CO_2 emitting power plants will profit in the form of higher profit margins. In contrast, the electricity consumers face higher prices. This indirect effect does not occur in the case a NPP is replaced by a CO_2-free plant.

Temporal dimension

With regard to the discussion on the direct effect it becomes clear that an individual NPP operator is interested in continuing electricity production in his power plants to obtain additional profit margins. Continuing production prevents a relative deterioration compared to competing operators.[11] From a technical perspective, a prolongation of permitted remaining operational time seems viable. Abroad, authorities grant permission for longer time periods than the 32 years that currently form the basis for the phase out in Germany.

Should an individual plant operator certainly know that his plant is to be shut down after the residual term currently in force, he is interested in building a power plant that replaces the shut-down one to continue obtaining profit margins and maybe profits. The decision for a new investment hence depends on the subjective likelihood the NPP operator assumes for a potential revision of the phasing-out legislation. The higher he assumes the likeliness of a revision to be, the later he will decide whether or not to invest.

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[9] It may be noted that the inclusion into the pricing is economically rational and that it is the only means by which a steering effect on prices can be imposed. The question, why the European Commission (EC) has brought forward a draft that allows emitters to skim off the scarcity rent of CO_2 allowances, remains unclear. A (part) auctioning would have the same effect and would accord the state parts of the scarcity rent, without disproportionately incriminating the companies.

[10] The modification of CO_2 prices can cause changes in the operational succession (merit order), which in turn may influence the investment behaviour or the fuel consumption and fuel import, respectively (EWI et al., 2005).

[11] In this context, the filed transfer of remaining quantities of electricity production from the NPP Neckarwestheim II to the NPP Neckarwestheim I can be pointed at, too. On this, see press release of EnBW Energie Baden-Württemberg AG of 21 December 2006.

The difficulty is that it takes several years between the decision to build and the commissioning of a new power plant (see Figure 3). This does not include the period of decision making (i.e. the time until the actual decision).

Figure 3: Average realisation terms for large-scale thermal power plants

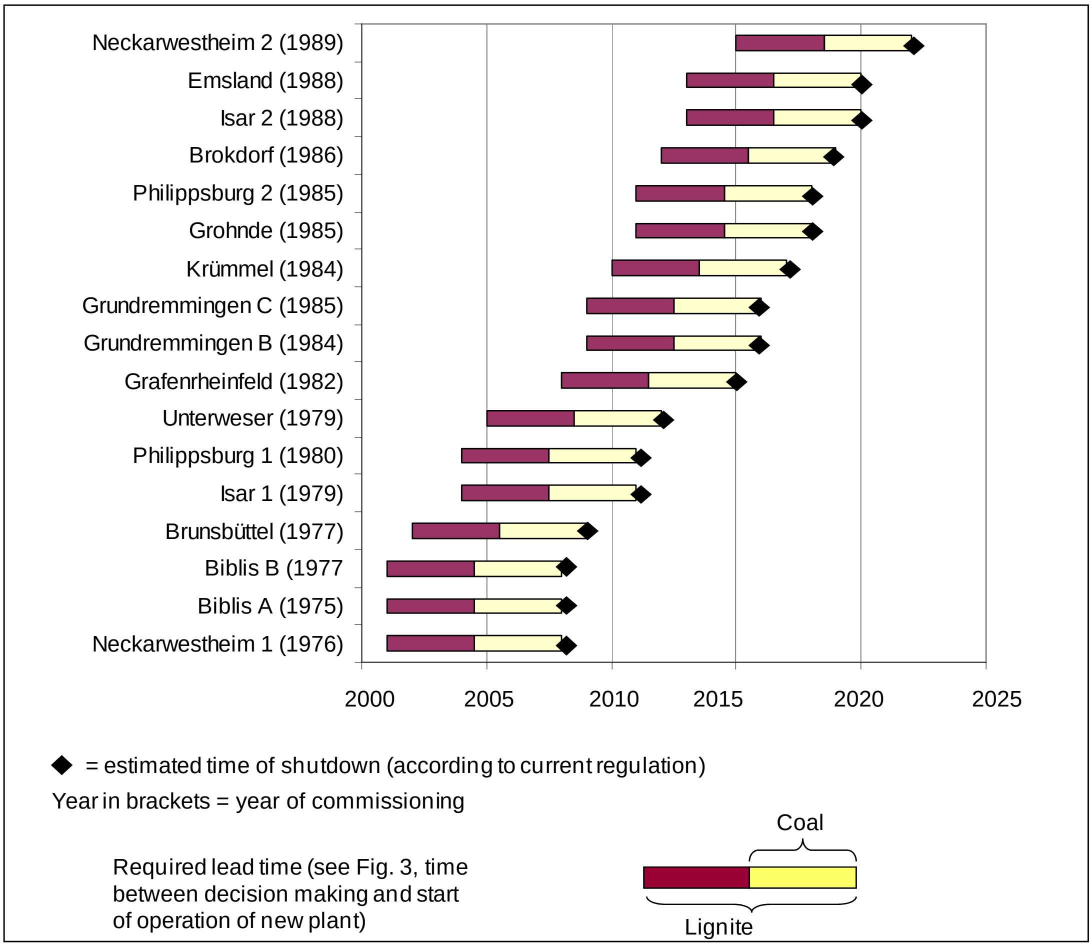
Source: Based on Bode et al. (2005).

If a NPP operator postpones the decision on a replacing investment assuming there will be a revision of the phasing-out legislation – but the legislation is not revised contrary to expectations because it is not politically enforceable – a gap of several years can occur between the NPP's shut down and the commissioning of a new, replacing power plant.[12] This would then again – as shown above (see Fig. 1c and 1 d) – lead to increasing electricity prices. With regard to a "low" electricity price the current discussion about a potential revision insofar is not exactly helpful.

If the NPP is operated by a company running other power plants the situation does not inevitably worsen. The profit margins which can no longer be realised by the NPP can – as shown above – be overcompensated by the additional profit margins from the other plants gained due to the increased electricity prices.

[12] Triggers may be e.g. problems as recently in Forsmark, Sweden.

Figure 4: Latest date for an investment decision in favour of a new power plant (In the case the start of operation of the new power plant is scheduled immediately after shut-down of nuclear power plant.)



If we combine the building times (shown in Figure 3) with the estimated dates of shut-down for the different NPPs in Germany "windows of opportunity" result (see Figure 4). As can be seen from Figure 4, investment decisions for the replacement of a plant should already have been made for some power plants if the aim is a "smooth transition" of shut down and commissioning. The current uncertain general conditions in terms of climate policy – especially regarding post 2012 policies– complicate this type of investment decisions. A massive expansion of electricity production from renewable energies which exceeds current plans could ease the situation from the producers' side, but requires investments into the electricity grid, which also take a certain time from decision-making to start of operations.

Assessing scenarios

So far the different options on what could happen have been discussed. These options are referred to by supporters and opponents of a revision of the phase out. Opponents most importantly point out the reduced capacity of the NNP can be replace by renewable energies. Indeed, the increase of RE capacity in the past has been massive. The effectiveness of the underlying feed-in tariff was so convincing that it has been imported by numerous countries throughout the world.[13] It is almost certain that this success continues. The Proposal by the EU Commission on Renewable Energies (EU COM 2008) provided an important element for future production of RE in Germany. There are also long-term targets for the year 2050 that are already discussed today, though not agreed yet (BMU 2007).

However, the important question to ask is, if (and how) the incentive to invest in (additional) renewable energies can be affected by the decision on a possible revision of the phase out? Tab 1 provides an overview on different factors that are considered during investment decisions. As can be seen apart from the need for capital there is almost no interaction between the factors of these technologies. And with regard to capital one should remember that the discussion is on an extension of the production life time of existing plants. Additional capital for nuclear power plants is thus not required.

Tab. 1: Drivers for investment decisions for different types of plants

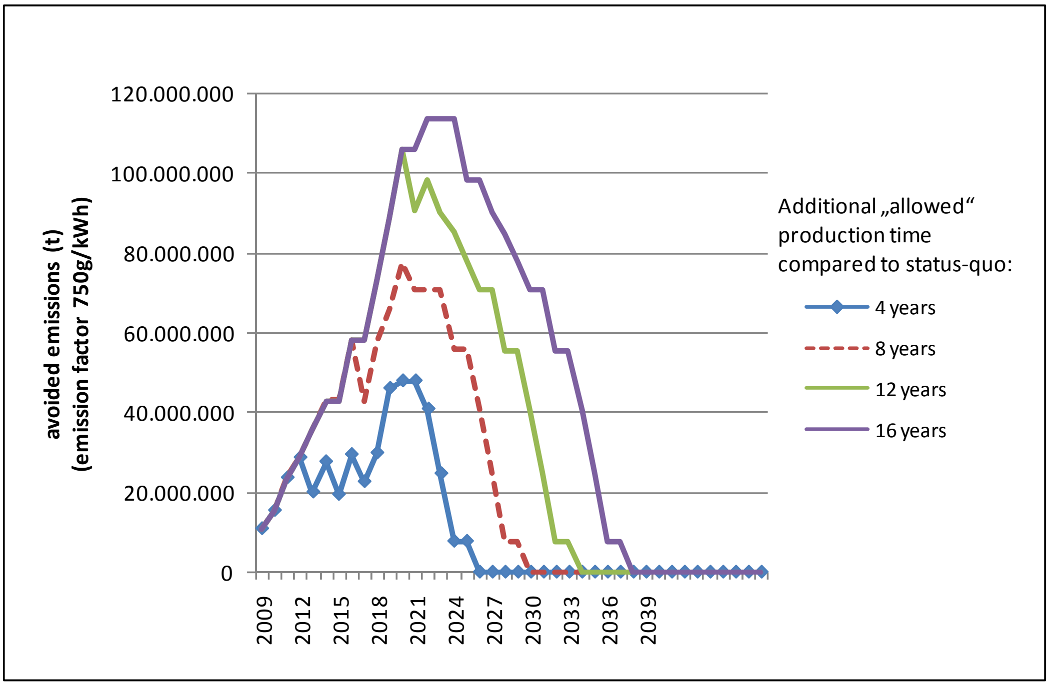
		RE (here wind)	Nuclear
Costs	fix	Capital cost	Capital cost
	variable	zero (Wind)	Uranium price
Revenues		Feed-in tariff	Power price

Consequently, I would argue, that a change in investment behaviour for RE installations as a function of a possible revision of the phase-out cannot not be expected. RE capacity will develop independently from the phase-out discussion. The (exogenously) increasing RE capacity shifts the nuclear power plant rightwards in the merit order. The only question is then whether the reduced nuclear capacity is replaced by existing plants (see Fig. 2 c and d) or by a new plant (see Fig. 2 f). In the first case one would expect both the direct and the indirect effect to occur. In the second case only the indirect effect would be observable. This is due to the fact that even a new efficient fossil

[13] Under the German feed-in tariff producers of power from certain renewable energies receive an ex-ante fixed remuneration for each kWh fed into the grid. Grid operators are forced to give priority to this green power. Consequently, RE operator do not face a volume risk but rather a quantity risk only (i. e. no wind this year for example) today.

fuelled power plant emits more CO_2 than an old nuclear power plant. Only if carbon capture and storage is widely available for the replacing plant could the indirect effect be negligible. One should, however, note that CCS is not expected to be widely available before 2020 – the important period with regard to the German nuclear discussion. This is also why it is difficult to estimate additional emissions if the production time of the nuclear plants is not extended. Fig. 5 provides indicative numbers for is situation where the replacing plant emission 750 g CO_2/ kWh. This figure may be too small for the early years and to high for the later years. Still, one can see that the additional emissions may amount to more than 100 million tonnes of CO_2.

Fig. 5: Avoided emissions if phase-out is postponed for different numbers of years



Global effects

If the nuclear phase-out leads to more emissions and consequently to an increasing CO_2 price, the phase-out and its effects are no longer a purely German matter but rather bear a global dimension. The higher carbon prices primarily affect all installations that fall under the EU emission trading directive.[14] As plant operators – according to the so-called Linking Directive (EU COM 2004) – can also use emission allowances generated under the Kyoto protocol to fulfil their emission target, the

[14] Altogether, these are over 11,000 facilities, 1850 of which are based in Germany (for more information see www.dehst.de).

EU emission trading system (ETS) is directly linked to the international market for greenhouse gases. An increasing price in the EU ETS consequently leads to an increase of emission allowance prices on the global market. With regard to the price increase there are winners and losers:[15] while all buyers of emission allowances are confronted by higher CO_2 prices and therefore have higher costs to achieve their targets, the sellers can realise higher prices and count under the winners. Among the sellers are the developing countries that can generate emission allowances through the Clean Development Mechanism (CDM).[16] The additional CO_2 emissions that could be emitted by a nuclear phase-out in Germany could therefore be compensated by additional emission reductions in developing countries - provided the international climate regime persists in a similar form after 2012.

Summary

In the discussion about a potential revision of the phase-out legislation on the operation of nuclear power plant the proponents mention (among other arguments) increasing electricity prices and emissions. The arguments put forward have been discussed. During the analysis a direct and an indirect effect have been distinguished. While the direct effect describes an increase of electricity prices due to the replacement of power plants bearing higher marginal costs than the previous one, the indirect effect is characterised by a potential increase in CO_2 emissions due to the substitution of nuclear power plants through ones that use fossil fuels. Potential additional emissions lead to higher CO_2 prices and hence (among other factors) to a higher electricity price. A supply gap is more likely if NPP operators count on a revision of the nuclear phase-out legislation for electricity production that does not take place in the end. This is due to long periods of time elapsing between the decision to invest and the commissioning of new power plants. With regard to potential delays in the investment decisions of power plant operators, there has to be a clear signal for or against a revision of nuclear phase-out legislation from politics now. The argument of the opponents of a revision, the fact that renewable energies will replace the reduced capacity was dismissed. Undoubtedly, RE capacity will increase considerably in the next years and decades in Germany, however, it is difficult to find any reason why the business-as-usual increase in RE capacity should be affected by a possible revision of the phase-out. Both, costs and revenues are determined completely differently for the two technologies. Consequently, an increase in emissions and thus in carbon and power prices can be expected if the phase-out is not revised. If renewable energy is to replace the reduced capacity of the nuclear power plants shut down, additional support mechanisms would be are necessary.

[15] For a combination of emission trading systems see for example Bode (2005)

[16] See § 12 of Kyoto protocol.

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