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The Future Costs of Power Generation

English Summary

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Summary

Background

Some crucial decisions need to be taken in order to advance the transformation of the German power generation. The discussion of how a shift towards a low-carbon power system and the simultaneous phasing-out of nuclear energy can be achieved has taken a backseat, especially due to considerable increases in the costs of financing electricity production from renewable energy sources over recent years. This begs the question whether the costs of generating power would actually be any lower in case of a slow down or full stop of the expansion of renewable energy sources. This study shows that such an approach – i.e. preserving the status quo – would be shortsighted from a costs perspective: in that case, instead of renewable energy plants, conventional power capacity (e.g. coal- or gas-fired) would need to be added to the grid. Also in such a 'status quo' scenario, additional costs would occur for the new power plants and, in particular, operational costs would be higher than in the case of power production from renewable energy.

One must also bear in mind that the so-called "Energiewende" is not happening in isolation, but is firmly embedded in a long-term political roadmap for climate protection, i.e. CO_2 reduction targets for 2050. The recently published 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) underlines the necessity of protecting the climate from human influence. If the political target of reducing greenhouse gas emissions in Germany by 80 to 95% by 2050 in comparison to 1990 levels is to be reached, we can expect high costs to be charged for power plants run mainly on fossil fuels to avoid or offset the CO_2 emissions.

The following study addresses these issues. Based on EU and German climate protection targets, it assesses the costs of generating power for two different sets of power plants in the year 2050:

- one, where 80% of power is generated from renewable energy (EE-80-Scenario) and
- another, where 58% of electricity is generated by conventional power plants and 42% by renewable energy plants (K-42-Scenario).

Different scenarios regarding the prices of fuels and of CO_2 emissions were considered for both sets of power plants to determine cost-efficiency.

The key results

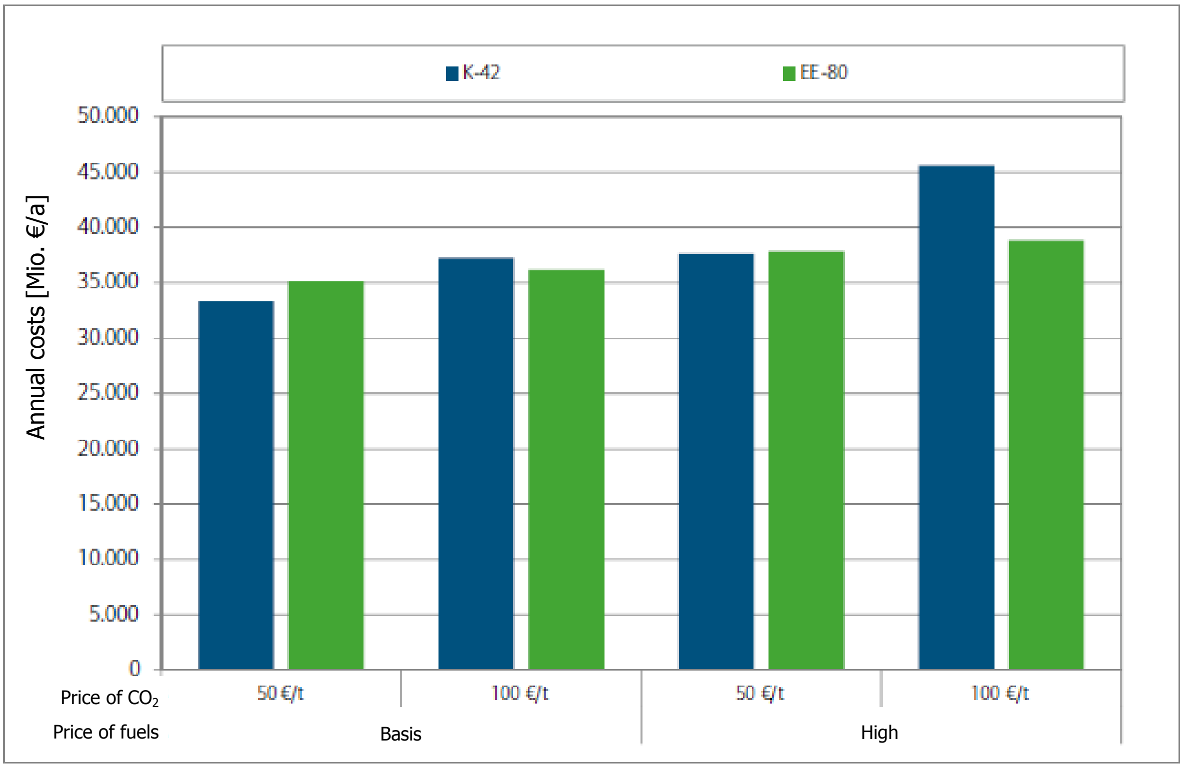
1. Within the boundaries of modeling accuracy, an 80% power generation from renewable energy is not particularly more expensive and can, under certain circumstances, even be cheaper than a scenario with over 50% power generation from fossil fuels – assuming that prices for fuel and CO_2 are the same in each scenario. This result is valid under the assumption that the existing long-term climate protection targets apply for the conventional scenario, too, and that the costs of investing in wind power and photovoltaic systems actually decrease to the extent that science and industry experts today consider possible.

2. If, at a global scale, power generation fossil fuels remains predominant and – at the same time – CO_2 emission reductions have to be achieved to safeguard climate targets, we can expect higher (demand-driven) prices for fossil fuels and for CO_2 emissions than if the power generation was prevalently based on renewable energy. When we consider this aspect in the comparison of the two models, the EE-80-Scenario proves to be more cost-efficient.

3. The costs of producing power in the chosen base year (2050) are between 33 and 45 billion euros per annum, for both the conventional and the renewable scenario (see chart). This corresponds to full production costs of 8 to 11 ct/kWh. For the final consumer, grid fees, taxes and general levies

are added on top. However, the various levies financing renewable energies that exist today are already priced in and are no longer necessary.

Future electricity generation costs appear to be considerably higher than the prices observed today at the *electricity exchange* of 3 to 5 ct/kWh. This comparison is deceiving, as the current trading prices do not include the capital expenses of power plants. Consumers of electricity produced in EEG[1]-financed power plants see the fixed costs in the form of the EEG-levy on their electricity bill. Many conventional power plants originate from the period of regional monopolies when providers were allowed to charge customers for the full cost of generating the electricity plus a profit mark-up and have already been refinanced.



The costs of generating electricity in the K-42 and EE-80 scenarios with respect to different fuel and CO_2 prices.

4. In the majority of the price scenarios analyzed, the income from an electricity market based solely on the amount of energy ("energy-only market") is insufficient to cover the costs of generating electricity. This is the case, both when generating electricity primarily from renewable energy (EE-80-scenario) and when generating it by a predominantly conventional set of power plants (K-42-scenario).

   For some generation technologies, this holds true in all cases. In order to cover the electricity generation costs detailed above, it is therefore necessary to define additional revenue streams. The electricity exchange can still play an important role in steering the system by determining the order according to which the power plants operate (“merit order”).

[1] Renewable Energy Law (EEG)

Implications

If climate protection targets are to be met, a continuation of the low-carbon transformation of the electricity sector is reasonable. Additional costs in 2050 cannot be used as a convincing argument against renewable energies when comparing them with costs induced by a mostly conventional set of power plants.

Efforts towards efficient energy use must be strengthened in order to meet the demand level for electricity underlying our scenarios. However, the scale of demand has almost no effect on the ranking of electricity generation costs within the two scenarios under investigation.

In both cases, additional revenue streams outside the "energy-only market" must be created in order to generate incentives for investing in new electricity generation plants.

Methodology and Assumptions

The costs of electricity generation for both scenarios were determined by using a fundamental model, which simulates electricity supply over the course of a year with a resolution of one hour.

In each case, the target state was examined (which, for example, might be reached in 2050), but not the transformation into this state. The reason for taking this approach lies in the fact that when looking at the transformation process, results would be distorted by the high investment needs for the use of renewable energy sources, but the big advantage of using such sources – the low operating costs – would only have a small effect. If we just considered the transformation phase, the EE-scenario with its higher investment needs would be put at great disadvantage, as the relationship between investment costs and operating costs differs so fundamentally between the two scenarios. This approach also seems reasonable because all capacities used for generating electricity would need to be replaced in both scenarios until the target state is reached. Hence, a distortion of the figures by depreciated power plants, previously accrued costs of renewable energy (in both scenarios), subsidies for fossil-fuel power plants, etc. can be avoided.

The present cost comparison focuses on the costs of generating electricity and encompasses mostly the investment costs (spread over individual years of economic lifetime), the costs of fuel and the costs of minimizing CO_2 emissions. Maintenance costs only play a minor role. The expansion of the grid has not been considered. According to the national grid development plan, the costs of expanding the transmission grid are approximately one dimension (i.e. a factor of 10) below the costs of the electricity generation plants and can therefore be disregarded in first approximation. To what extent this expansion is actually required is also disputed. It has been supposed, however, that the grid expansion will be implemented where it is actually necessary. For both scenarios, significant progress in the efficient use of electricity is assumed resulting in a net electricity demand of just 400 TWh/a. The EE-80 scenario is defined by an 80% share of renewable energy sources of electricity generated. According to today's scientific knowledge and technology, any proportion higher than 80% would only be possible if long-term energy storage systems were introduced, which allow the reconversion of electricity. To decrease the currently high costs of such storage systems like 'power-to-gas', basic innovations are needed, of which there are no signs yet. As the usage of storage systems does not yet have to be decided upon, these systems are disregarded. The residual demand – that is, the amount of electricity that cannot be covered by renewable energy resources – is delivered in the EE-scenario by gas-fired power plants employed on a flexible basis. The K-42 scenario assumes that the installed capacity to generate power from renewable energy resources remains at the same level as today. However all systems will be replaced with ones reflecting future technological advances. As a result, the share of renewable energies is 42%. The remaining demand will be covered by coal- and gas-fired power plants, which in the model are chosen according to economic criteria. It is assumed that the costs of investing in wind power and photovoltaic systems decreases as rapidly as the industry promises; hence, the electricity generation costs for non-curtailed systems are between 6 and 7 ct/kWh.

Besides comparing the two technical alternatives, the framework considered in the study is made up of four different scenarios for the prices of fuels and CO_2 emissions (see table). These are not price projections but a pre-determined range, which on the one hand was compatible with the basic assumptions of the investigation and also allowed reflection of crucial tipping-points.

The scenarios for the prices of fossil fuels and CO_2.

	Price of fossil fuels [€ / MWh]			**Price of CO_2 [€/t]**
	Black coal	Brown coal	Natural gas	
Basis	12	1.5	25	50
High	24	3.0	50	100

The "Basis" prices of the fossil fuels correspond to the price levels for 2015 predicted by Prognos, which are hardly any different from today's prices. For the "High" scenario, these prices were doubled. The "Basis" price for CO_2 was set to 50 €/t. For the "High" scenario this price was again doubled, to 100 €/t. Both values are much higher than the current price level of around 5 €/t. The basic reasoning behind these high prices is the assumption that even in a conventional scenario, in which more than 50% of electricity is generated in power plants fired with fossil fuels, greenhouse gas emissions must be reduced by 80-95% to achieve climate protection targets. How such a reduction of greenhouse gases can be achieved is not addressed by this investigation. One possibility would be for instance the introduction of carbon capture and storage (CCS), which brings with it questions regarding the technical implementation, the associated environmental dangers, and the political acceptance. Alternatively, the CO_2 emissions could be offset by paying for the respective amount of reduction certificates or emission rights from other economic sectors or from other countries. The price set for CO_2 here represents the costs for any of these solutions.

The likelihood of the price scenarios set out here differs greatly from one to the next. High prices for fossil fuels and CO_2 emissions can be expected if more stringent climate protection laws are combined with a predominantly conventional scenario. However, low prices for both operating resources are likely if there is an expansion in the use of renewable energy in power generation worldwide (EE-80 scenario).