Executive Summary

Climate Change Mitigation with a Secure Energy System

Developing a Sustainable Power Supply

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Developing a Sustainable Power Supply

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by

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Executive Summary

As early as 1992, in Rio de Janeiro, Germany was one of many countries to commit to the principle of sustainable development.

The capacity of the ecosystem sets the boundaries for the development of a sustainable energy system. Only within this framework is it possible for us to optimise other sustainability requirements such as security of power supply and economic viability.

The German Federal Environment Agency's study "Klimaschutz und Versorgungssicherheit" (Climate Change Mitigation with a Secure Energy System) demonstrates how a sustainable electricity supply can be realised in Germany. Climate change mitigation, supply security and economic viability are compatible – even with the phase-out of nuclear energy and without building additional conventional power plants that lack combined heat and power (CHP) generation in the near future.

Greenhouse Gas Emission Reduction Targets

Climate change is already a reality. Combating climate change and its dramatic consequences is one of the central challenges of this century. Drastically reducing emissions of greenhouse gases (GHG) and taking measures to adapt to the no-longer-preventable consequences of climate change constitute key areas for political action.

In order to prevent serious climate change impacts, global warming must be permanently limited to no more than 2 degrees Celsius (°C) above the pre-industrial temperature. To achieve this, global GHG emissions must fall to half the 1990 levels by 2050. For the industrialized countries including Germany, this means that they must reduce their greenhouse gas emissions by 80 to 95 percent (%) by the middle of this century, compared to 1990 levels.

In Germany, energy-related CO_2 emissions account for over 95% of total CO_2 emissions and for around 80% of all greenhouse gas emissions. Electricity generation alone, which in Germany today is still predominantly based on fossil fuels, accounts for about 40% of total CO_2 emissions in Germany. This is why electricity generation has to play a key role in reducing GHG emissions. However, reducing emissions is only one of several requirements for sustainable development.

Towards a sustainable electricity supply

If we want to achieve the long-term emission reduction targets as one component of sustainable development, electricity supply must undergo a fundamental change. Key elements of this are the continued expansion of renewable energies, reducing the demand for electricity through increased efficiency, the expansion of CHP generation and the phasing out of nuclear energy.

In the long term, renewable energies must take on the bulk of electricity production. Potential for this exists both in Germany and globally.

In a first step, we need to do the following by 2020:

- Increase the share of renewable energies in electricity production to over 30% and increase it further thereafter
- Reduce the demand for electricity by 11% compared to 2005 through increased efficiency
- Increase CHP's share of electricity production by 25%.

Since alternating current cannot be stored directly on a large scale, fluctuations between production (feed-in) and consumption (load) must be compensated at all times. This presents major challenges, due to fluctuations in feed-in and deviations from forecasts for wind energy and photovoltaic systems, which alongside geothermal energy have the largest potential in Germany.

In order to integrate large amounts of renewable energies into our electricity supply, we need to and can exploit new technical possibilities. Therefore, the question is not how much electricity from renewable energy sources (RES) today's electricity system can cope with, but how our future electricity system must be designed to integrate RES-based electricity as efficiently and cost- effectively as possible.

To this end, renewable energies as well as the demand side must be more heavily involved in generation/load balancing and in load-frequency control, for example in virtual power plants. Balancing on a large, European scale also has considerable potential for offsetting fluctuations in the feed-in of electricity from renewable energy sources. In addition, a stock of highly flexible and low-emission fossil-fuel-fired power stations will be necessary - for a transitional period – to complement renewable energies, whose share will continue to grow rapidly.

The "electricity gap" phantom

The current public debate focuses less on developing a sustainable energy supply than on the question of supply security and the future need for new power plants.

"Electricity gap" and a "deficit" of available power plant capacity are phrases often used in this debate, suggesting the risk of large-scale blackouts. This is not true, however: large-scale power failures can only occur when in extremely rare events the prescribed security reserves for operation of the network are exceeded or when requirements for secure network operation are violated, for example due to human error.

The situations referred to as an "electricity gap" and a "deficit" of available power plant capacity are actually capacity shortages. In well-functioning markets, these might lead to price peaks, but not to large-scale blackouts. The current development of the energy market gives no indication that the electricity market is ineffective at present or will be in the future.

On the other hand, supposing the market is ineffective, the approach of choice should not be to treat the symptoms – as currently under discussion with investment support for the construction of new power plants or the extension of the operating lives of nuclear power plants to offset possible capacity deficits. Instead, the possible causes of the ineffective market should be removed, for instance by adapting its design, in order to obtain permanently secure solutions.

There are a number of fundamentally different alternatives to new construction of power plants, which also enhance flexibility in the electricity market. These include for example:

- Increasing the temporal flexibility of the demand in order to increase short-term price elasticity,
- Reducing total demand through efficiency increases,
- Provision of balancing energy through controllable loads,
- Extending the lifetime of existing fossil-fuel-fired power plants, and
- Importing electricity to a certain extent for short-term balancing.

These possibilities have, overall, significant technical potential and are mostly economically advantageous.

No need for new conventional, non-CHP power plants up to 2020

Up until 2020, there will be no need for new construction of conventional, non-CHP power plants beyond those currently under construction, even with the phase-out of nuclear power plants. This holds even if the targets for the expansion of renewable energy sources and CHP and for reducing the electricity demand were all missed by a large margin. There is, above all, no need for additional conventional base-load plants without CHP up until 2020.

Additional new conventional power plants would only be needed if electricity consumption grew considerably without a significant rise in short-term demand price elasticity and the above alternatives to new power plants were exploited only partially, and if at the same time the targets for the expansion of renewable energies and CHP were missed by a large margin. This need would be mainly for medium-load, peak-load and reserve power plants, and less for base-load plants. Should there be indications in the future that the targets will be missed by a large margin, priority should be given to adapting and complementing existing instruments such as the Renewable Energy Sources Act (EEG) and the CHP Act.

Should a substantial part of current planning for new power plants, much of which is at a very advanced stage, be realised - in addition to the power plants already under construction -, we would face the risk of economically inefficient overcapacities, especially in the base-load sector, rather than a need for new power plants. The debate about extending the operating life of nuclear power plants additionally increases the risk of massive base-load overcapacities. There has been an observed reluctance to invest in new power plants, suggesting that some investors have realised this and that the market is effective in that regard.

No need to act now

The discussions often centre around the need to decide very quickly about the construction of new conventional, non-CHP power plants or about extending the operating life of nuclear power plants. The need for quick action suggested by these debates is however not justified, since – as explained above – supply security will be ensured up until 2020 even with the phase-out of nuclear energy and without additional construction of conventional, non-CHP power plants.

Decisions to respond to a potential need for new power plants after 2020 need not be taken until around 2015, since the average period for realising new fossil-fuel-fired power plants is about three to seven years.

Hence, over the next years there will be no need to build additional conventional, non-CHP power plants or to extend the operating lives of the nuclear power plants that will still be in operation at the time.

Extending the operating life of nuclear power plants will not present a usable option for the period after 2020 either, since the use of nuclear energy seriously violates sustainable-development requirements. The use of nuclear energy should therefore cease as quickly as possible.

Decisions on new construction of conventional, non-CHP power plants can be taken some years from now, based on the requirement for new plants then expected and, especially, the best technology then available.

What about after 2020?

In the long term, in particular the time after 2020, the expansion of renewable energy sources and the increase in energy efficiency will make new demands on conventional power plants: For instance, although wind power, with its feed-in fluctuations, represents itself no base-load capacity and has a low capacity credit, it significantly reduces the residual base load, that is, that part of the base load which has to be covered by conventional power plants. The expansion of renewable energy sources will, overall, distinctly reduce the future requirement for conventional base-load power plants, meaning power plants with a high number of operating hours per year such as nuclear and new coal-fired power plants.

Although we will also need new fossil-fuel-fired power plants in the long run, this additional demand will mainly be for peak-load and reserve power plants. New medium-load power plants might also be needed to replace existing plants. A significant requirement for new construction of conventional base-load power plants after 2020 is highly unlikely, even with the phase-out of nuclear energy, especially if the Federal Government's targets for expansion of renewables and CHP are largely achieved.

Hence, extending the lifetime of nuclear power plants as is being called for in the public debate, or promoting conventional base-load power plants is not only unnecessary, but also a step in the wrong direction.

A sustainable energy system: More than just climate protection and supply security

Sustainability is more than just climate protection. To be sustainable, any energy supply system must also meet environmental and health standards and be low-risk, error-tolerant, resource-efficient as well as fully economically viable, taking external costs into account.

The use of nuclear energy is an unsustainable form of electricity generation. It should be discontinued as quickly as possible.

Coal-based electricity generation is also an unsustainable technology, for reasons of climate, landscape and resource protection.

Likewise carbon capture and storage (CCS) from generation based on fossil energy sources proves unsustainable on closer examination. It is questionable what contribution CCS at fossil-fuel-fired power plants in Germany can make to climate protection. In particular, it has yet to be examined what capacities for safe storage are actually available and what competition for the use of such storage sites exists.

Globally CCS can only be an interim technology, used during the transition to a sustainable, predominantly RES-based energy system, since geological reservoirs are limited. However, it has not yet been ensured that CCS works and this technology is not expected to be available on a commercial scale any earlier than 2020.

Achieving the long-term climate protection objectives requires drastic reductions in emissions not only from electricity generation but also from industrial sources. Therefore, the limited potential sites for storage of CO_2 should be available primarily for the reduction of process-related emissions, e.g. from steel and cement manufacture and if necessary in the future for decarbonising the atmosphere. As long as sound information on CO_2 storage capacities is not yet available, the precautionary principle demands this.

Electricity generation based on natural gas is not strictly sustainable either. Therefore, it too should only be used for the transitional period until a system based mainly on renewable energy sources has been implemented. Gas-fired power plants have markedly lower CO_2 emissions than coal-based generation, however.

In the long run, there will be sufficient potential for a sustainable electricity supply based on renewable energy sources and energy efficiency.

Do new fossil-fuel-fired power plants help protect the climate?

One argument heard in the public debate is that modern coal-fired power plants help protect the climate because a new coal-fired plant emits less CO_2 per kilowatt hour of electricity than an old one. In order to evaluate the contribution that such a CO_2 saving can make to the necessary restructuring of the power plant sector, we need to take a look at the overall system:

The main instrument in the European Union (EU) for reducing CO_2 emissions from electricity generation is the emission trading system (ETS) – in combination with the expansion of renewable energies and increasing energy efficiency. The cap on CO_2 emissions under the ETS has been fixed until the year 2020. It must continue to fall sharply after 2020 in order to achieve the long-term climate protection objectives envisaged for 2050.

A look at the long-term European climate protection objectives and the specific CO_2 emissions of power plants shows, firstly, that in 2050 average specific CO_2 emissions must be less than a third of today's levels, i.e. must have dropped to less than 150 g/kWh. Secondly, while new coal-fired power plants are significantly more efficient and therefore emit less CO_2 per generated kilowatt hour than old coal-fired power plants, this efficiency gain is far from sufficient for reducing CO_2 on the scale necessary for climate protection purposes. Thirdly, of the fossil-fuel alternatives without CCS, it is only the replacement of old coal-fired power plants with high-efficiency combined cycle gas turbines that can achieve sufficient CO_2 reductions in the medium term.

Furthermore, heavy use of coal with today's power plant technology in the face of a steadily falling cap would inflate the price of CO_2 allowances in the long term, meaning far beyond 2020.

Since new fossil-fuel-fired power plants have a payback time of around 20 years and a technical lifetime of over 40 years, massive new construction of coal-fired power plants would carry the risk of a lock-in to an emission-intensive fossil-fuelled power plant sector and of investment failures for power plant operators.

The continued operation of existing fossil-fuel-fired power plants in Europe up until 2020 will not be associated with higher emissions due to the cap on total CO2 emissions in the ETS during this period.

Since we will need significantly fewer conventional base-load power stations in future, it would, overall, be advantageous, with a view to long-term favourable CO_2 prices, to keep a number of existing fossil-fuel-fired power plants in operation for some time, should these capacities be needed, rather than build new emission-intensive base-load power stations.

Economic viability of electricity supply

If electricity supply is to meet the criterion of comprehensive economic viability, the full external costs of energy use must be taken into account, as is already being done in part in emissions trading with regard to the external costs of CO_2 emissions.

When including the external environmental costs, the total economic costs of electricity generation from different renewable energy sources, such as wind power with around 8.0 ct/kWh, are already lower today than those of fossil-based electricity generation. In future, the cost ratio will continue to improve in favour of renewable energy sources.

The restructuring of the power plant sector in the interests of sustainability will be associated with extensive, but economically advantageous investments. Therefore, we should now seize this opportunity to reshape the energy system to make it fit for the future.

Removing market barriers and expanding electricity grids

Where the market has not been fully effective, the relevant barriers should be removed. This holds especially for the gas market, where liberalisation is still less advanced, but also for the electricity market. The Europe-wide and regional expansion of electricity grids must be promoted in order to create a pan-European electricity market, continue to integrate renewable energies in future and be able to make best-possible use of the potential presented by renewable energies throughout Europe.

Recommendations for action

In summary, the following recommendations for policy action result from the long-term objectives for a sustainable power plant sector:

- The expansion of renewable energy sources and CHP should be further encouraged,
- The demand for electricity should be reduced through efficiency increases,
- The effectiveness of instruments for the promotion of renewable energy sources, CHP and efficiency should be monitored,
- The phase-out of nuclear energy should be continued as mandated by law,
- The cap applied in the emission trading system should be reduced substantially in the long term,
- The operating life of existing fossil-fuel-fired power plants should not be limited,
- New construction of non-CHP power plants should not be supported,
- The liberalisation of the natural-gas market should be continued,
- Transport routes and suppliers of natural gas should be diversified,
- Natural gas should be saved through measures to increase efficiency, particularly in the heat sector,
- Expansion of the electricity grid should be further encouraged.

The criteria of sustainability and, in particular, climate protection demand a fundamental overhaul of electricity supply. This will take time and be associated with major investments, which however will be economically worthwhile.

The decisions we make today on the future development of the power plant sector will reach at least into the middle of the century. Therefore, we should chart the right course for sustainable development now.