Renews Special
Issue 35 / June 2010

Background information
from the German Renewable Energies Agency

Renewable Energies and Base Load Power Plants: Are They Compatible?

www.renewables-in-germany.com

Renewable Energies Agency

Author:
Janine Schmidt
Current as of: June 2010

Translation:
Phil Hill

Published by:

German Renewable
Energies Agency
Reinhardtstr. 18
10117 Berlin
Phone: +49 [0]30 200535-3
Fax: +49 [0]30 -200535-51
Kontakt@unendlich-viel-energie.de

ISSN 2190-3581

Supporters:
German Renewable Energy Federation (BEE)
German Solar Industry Association (BSW-Solar)
German Wind Energy Association (BWE)
Geothermal Energy Association (GtV)
German Bioenergy Association (BBE)
German Biogas Association
Association of German Biofuel Industries (VdB)
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
Federal Ministry for Food, Agriculture and Consumer Protection (BMELV)

Contents

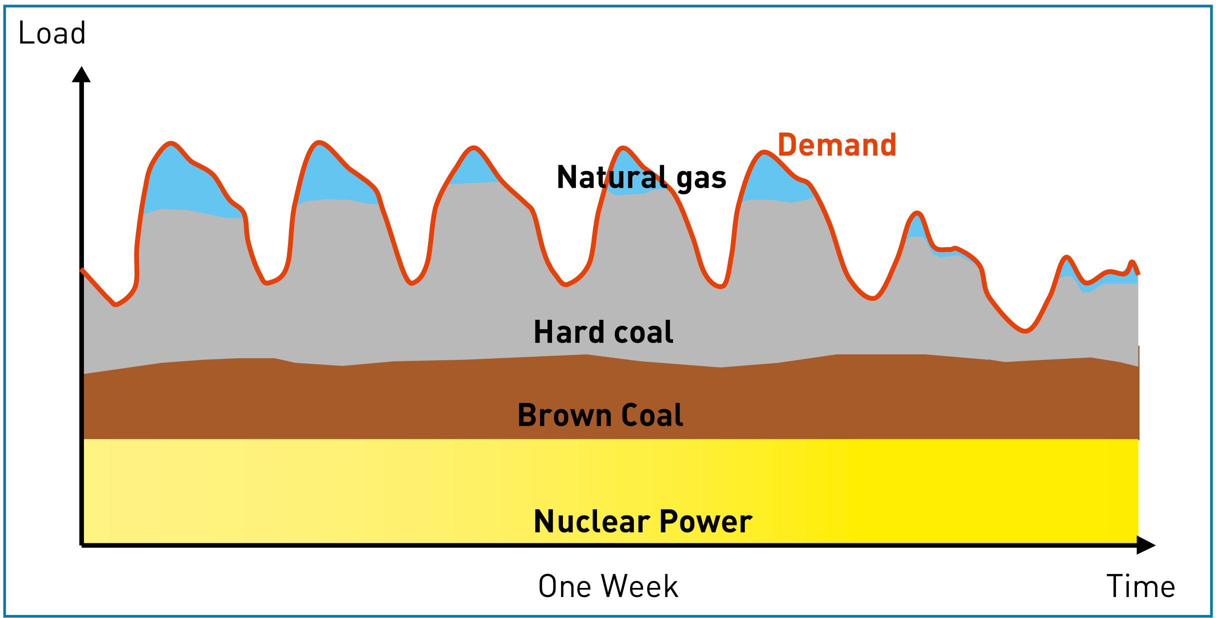
The Electric Power Generation Structures of Base Load Power Plants and of Renewable Energy Sources

Some 580 billion kWh of electricity were used in Germany in 2009. The demand for electricity fluctuates depending on the time of day: it is high, with certain consumption peaks, in the morning, at noon and in the evening, while it is generally low at night.

Since consumption is fairly easy to forecast, production has been planned accordingly: permanently operating base load power plants cover that part of the demand that exists around the clock. When that basic consumption level is exceeded, medium load power plants are additionally used. Peak load power plants are used for unforeseeable fluctuations, such as faulty consumption forecasts or power plant outages, and for certain consumption peaks, such as the "lunch peak" at noon. Their generators provide full service within a few minutes, and are therefore flexibly usable.

In the conventional power plant park, nuclear and brown coal power plants take care of the base load, since it is advantageous to run them continuously if possible, both for technical and for economic reasons. Hard coal power plants are used for the medium load, since their generating units are generally smaller and more flexible. Traditionally, gas power plants, which can feed their output into the grid within minutes, take care of the peak load.

The use of conventional power plants to meet overall demand in a power plant park without renewable energy sources

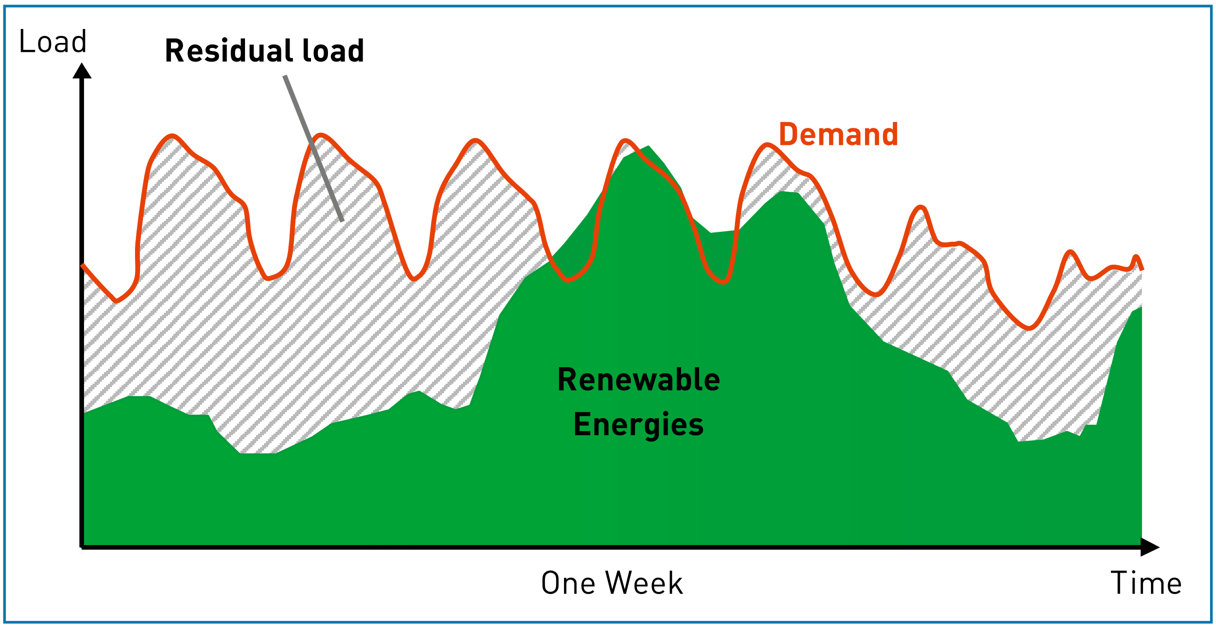


In order to assure an economically viable, reliable and ecologically sustainable energy supply, the German federal government has set the goal of continuously expanding renewable energies. That however will require restructuring the present energy supply system. In the electric power sector, the share of renewable energies is to be increased from 16% in 2009 to at least 30% by 2020.

In order to ensure the development of renewable energies, they enjoy legally guaranteed priority for feed-in into the grid. That means that the demand for power is met first from renewable sources, and that the remaining residual load – defined as electricity demand minus the amount supplied by renewable energies – is then met by such conventional sources as nuclear, coal and gas power plants. The large share provided by renewables has brought with it major fluctuations in power capacity.

The reason for that is that wind energy and solar power production vary greatly due to the weather or the time of day. The result is a growing need for flexible conventional power plants which can cover the fluctuating residual load. Gas turbine power plants are especially useful for this purpose, since they are particularly flexible.

Residual load at a power plant park with a high share of renewable energies



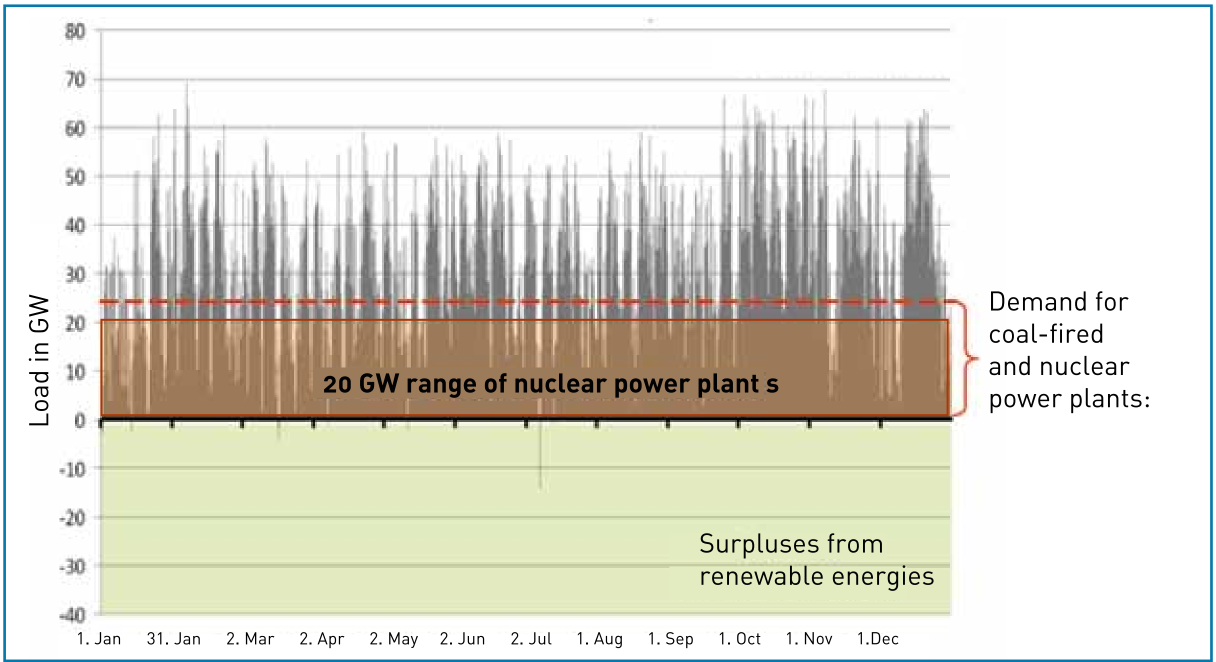
How Much Space Will Be Available for Base Load Power Plants in the Power Plant Park of the Future?

The German Federal Government assumes a 30% minimum share of renewables for electricity consumption by 2020. According to the expansion forecast "Power Supply 2020", published by the renewable energies industry, regenerative sources should even be able to deliver as much as 47% of Germany's electricity needs by that year.

The Fraunhofer Institute for Wind Energy and Energy System Technology (IWES) has matched the feed-in to be expected for 2020 under this expansion forecast with the weather data from 2007. The result of this simulation was that the requirement for large conventional power plants operating 8000 hours a year, i.e., which produce power almost continuously throughout the year, would drop to approximately half by 2020. That would mean that a conventional base load supply of only 24.5 gigawatts (GW) would be needed, compared with 43.9 GW used in 2009. The rest of the permanent electricity demand would then be covered by the basic supply of renewable energy.

The following chart shows the electricity demand which will still have to be met by the fossil-fuel and nuclear power plant park in 2020 (shown in brown).

Residual load (load minus uncontrolled RE feed-in) BEE scenario 2020, based on the weather year 2007



Source: Fraunhofer IWES 2010

Clearly, on many days in the year, no traditional base load power plants – those that run year-round – will be needed at all. This will be the case if the feed-in from renewables is particularly high and consumption particularly low. The traditional base load power plants will have to be shut down completely at these times. If the residual load then increases again, i.e. if electricity generation from renewable energies drops, and/or the demand for electricity rises, power plants which can provide regular energy fast from a standstill will be needed. But that is exactly what base load power plants cannot achieve. Nuclear power plants for example have a technically mandated minimum down time of approx. 15 to 24 hours, and it takes up to 2 days to get them up and running again. Gas power plants are much more flexible, and therefore more compatible with renewable energies.

Average key data for thermal power plants

Type of power plant	Coal	Gas/oil	Nuclear
Minimum operating time	6-15 h	1-6 h	15-24 h
Minimum down time	6-15 h	1-6 h	15-24 h
Start-up duration	3-60 h	1-4 h	24-48 h

Source: Do Dortmund

If the feed-in priority for renewable energies is taken seriously, as the Coalition Agreement which is the basis for the policy of the current conservative-liberal government stipulates it should be, the existing base load function of conventional power plants will increasingly disintegrate. Only 24.5 GW of traditional base load power plant capacity will still be needed in 2020.

Which power plants will provide this capacity? The stock of newer hard and brown coal power plants – i.e., those brought on line or thoroughly refitted since 1990 – amounts to 15.6 GW. In addition, new hard and brown coal power plants with a total capacity of 11.4 GW are currently under construction. This already surpasses the forecast base load needed in 2020. Thus, any extension of the lifespans of nuclear power plants beyond the planned end of the phase-out in 2020 will lead to an oversupply of base load capacities, unless it is accompanied by shortened lifespans for coal-fired power plants.

According to the BEE/AEE industry-based development forecast, this oversupply will occur in 2020, while according to the Federal Ministry for the Environment (BMU), it will occur by the middle of the next decade (only a few years later than with the industry forecasts). Investments already concluded for gas or coal power plants, with their average lifespans of at least 40 years, would be called into question, as would the feed-in priority for renewable energies, if the nuclear phase-out were delayed. The necessary reorganization of the energy industry will also mean saying goodbye to centralistic, oligopolistic energy supply structures, and moving towards a decentralized system – as the Federal Minister of the Environment Dr. Norbert Röttgen has pointed out:

> *"It is economically nonsensical to pursue two strategies at the same time, for both a centralized and a decentralized energy supply system, since both strategies would involve enormous investment requirements. I am convinced that the investment in renewable energies is the economically more promising project. But we will have to make up our minds. We can't go down both paths at the same time." (BMU 2010)*

Nuclear Power Phase-Out Is the Only Realistic Option for Reducing Base Load Capacities

As the simulation by the Fraunhofer IWES demonstrated, the conventional electricity generating capacities of either modern coal-fired power plants or of nuclear power plants will by 2020 only be needed as a supplement to renewable energies. However, a realistic – meaning legally stipulated – phase- out option at present exists only for nuclear power. The present paper therefore addresses mainly the implications of this energy form for the further development of renewable energies.

In 2000, the four energy supply corporations RWE, E.ON, Vattenfall and EnBW accepted the so-called Nuclear Consensus, based on the decision by the government and the Bundestag to limit the lifespans of nuclear power plants to certain so-called "remaining capacity quantities". In return, the power plant operators received many concessions: nuclear fuels remained untaxed, the government refrained from demanding a contribution to the liability risk insurance for nuclear accidents, and instead of stricter safety regulations, which would have required refitting of the power plants, their existing condition was grandfathered. The 2002 amendment to the Nuclear Law legally ensured the phase-out of nuclear power.

Currently however, Germany is experiencing an intensive debate among politicians and experts over extending the legal lifespans of all of German nuclear power plants. Nuclear energy is supposedly a "bridge" to a sustainable energy system, and indispensable for accomplishing Germany's climate protection goals. A recent study by Germany's major business association, the Federation of German Industries (BDI)[1] argues that an extension would also result in lower electricity prices and economic gains for Germany. The E.ON study[2], which was conducted on behalf of the energy corporation by the Institute for Energy Economics and The Rational Use Of Energy (IER) at the University of Stuttgart, addresses the technical possibilities of regulating nuclear power plants flexibly and thus compensating for the fluctuations of renewable energies. This background paper seeks to conduct a critical examination of the arguments of both studies.

1) BDI: Ökonomische Auswirkungen einer Laufzeitverlängerung deutscher Kernkraftwerke (The economic effects of an extension of the lifespans of German nuclear power plants).
2) E.ON: Verträglichkeit von erneuerbaren Energien und Kernenergie im Erzeugungsportfolio (The compatibility of renewable energies and nuclear power in the production portfolio).

Compatibility of Nuclear Power Plants and Renewable Energy Sources

Nuclear power plants have in the past not been seen as able to provide electricity flexibly, but rather as inflexible and difficult to adjust. Nonetheless, the IER study claims that nuclear power plants are in certain respects even more flexible than gas power plants. The so-called load change gradient determines how much capacity of a power plant fed into the grid can be varied. Pressurized water reactors, which account for two thirds of the nuclear power plant park in Germany, have an output gradient of between 3.8 and 5.2%. That means this percentage of the installed power plant capacity can be increased or reduced within one minute. However, according to the IER, the prerequisite for that is that the plant be running at a level of at least 50% of its installed capacity. Boiling-water reactors, which make up the remaining one third of Germany's nuclear plants, must even be running at a level of at least 60% of installed power capacity to be able to adjust the load. Their output gradient amounts to between 1.1 and 3.8%/min.

In other words: although nuclear power plants could according to the IER throttle their capacity – for example in case of a storm which causes high wind energy feed-in – but only down to 50 or 60%, respectively, of their installed capacity. After that, they would have to be shut off completely, otherwise an oversupply of power would occur. Such oversupplies already occur today, and ever more frequently. This results in negative prices for electricity on the electric power exchange. The producers actually pay the buyers money to take their power, and pass on the additional costs to consumers.

To summarize: **nuclear power plants are adjustable only when they run at least at partial load.** But with the further development of renewable energies, they will have ever less possibility to do just that, unless of course the feed-in priority for renewables is to be called into question. In that case, renewable energy facilities would have to be taken off line so that the capacities of the nuclear power plants could be fed into the grid. This would impair the investment security of the operators of those renewable energy facilities considerably, and endanger the government's development goals.

The IER study seeks to demonstrate that the extension of nuclear power plant lifespans would "not put the brake on the development of renewable energies". At the same time however, the development of renewable energies is kept at a low level in the study. For example, the assumed capacity of photovoltaic systems in 2020 is predicted at only 14.66 GW (2009: 9.8 GW; 2006: 2.8 GW). By contrast, the renewables industry forecasts a total installed photovoltaic capacity of 39.5 GW in 2020. The Federal Government's minimum goal of a 30% renewable energies share of electricity consumption by 2020 is therefore accomplished in the IER study only because it is based on net electricity production, unlike the usual practice, followed by both the EU Directives and the calculations of the Ministry of the Environment, which are based on gross consumption. Under conservative assumptions regarding pump storage power and in-plant consumption,[3] the IER's figures yield a renewable energy share of gross electricity consumption of approx. 28%, or 3 percentage points less than indicated in the study. Moreover, the study takes no efficiency gains into account, and assumes an increase in the price of crude oil by 2030 of only $75 per barrel (in 2007 dollars). Today, (June 2010) that price level has already been reached. By way of comparison, the International Energy Agency forecasts an oil price of $190 per barrel by 2030.

3) Assumptions: pump storage power use to remain constant through 2020; in-plant consumption to drop to only 30 TWh, instead of today's 39.3 TWh.

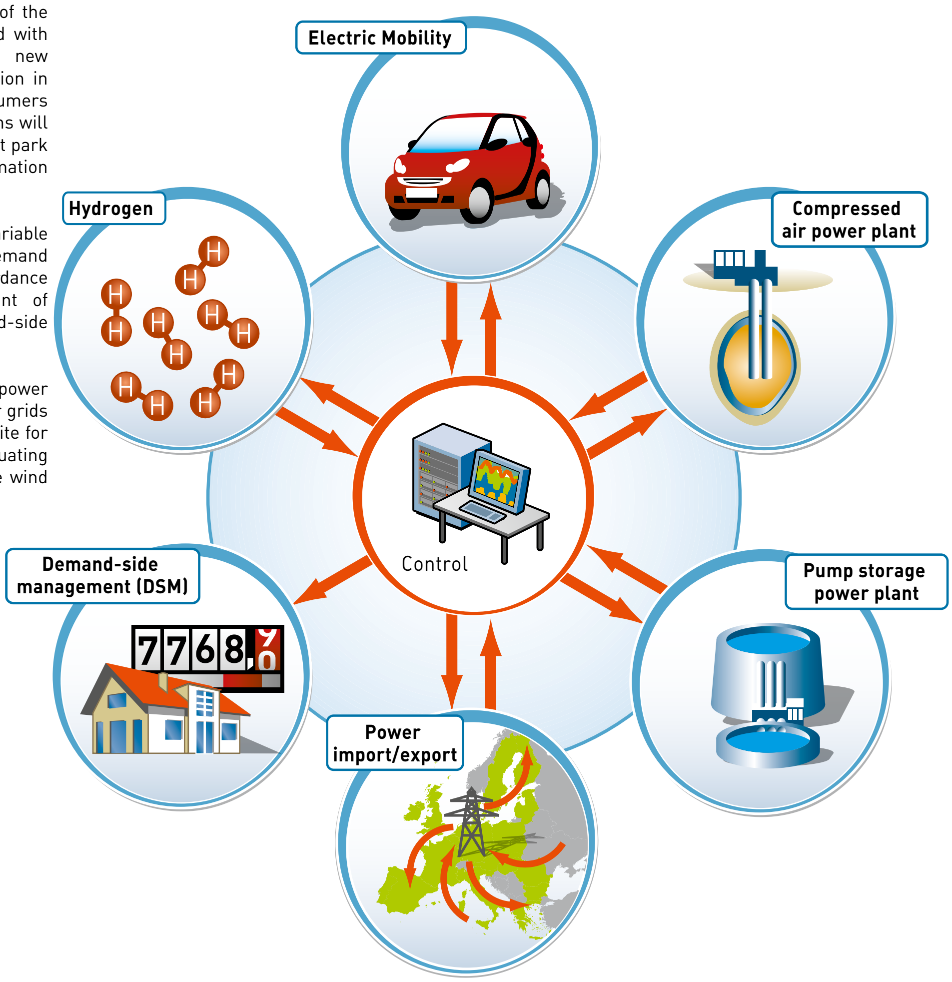
In order to meet the federal government's goal of continually increasing the share of renewables in overall electricity consumption even beyond the 30% level, we would need a complete restructuring of the energy industry. Conventional power plants which can adjust to the residual load flexibly are only one of the possibilities to compensate for the volatility of renewable energies. Such innovative concepts as computer-based "smart metres", which have been mandatory in new buildings since 2010, regenerative combination power plants (i.e. the combined renewable energy and storage systems), precise load management, and a trans-European high output grid (the "smart grid"), have already to some extent been proven in practice, and permit the adaptation of the power supply to electricity demand.

The Smart Grid

The power supply system of the near future will, compared with today's system, include new elements to bring production in line with demand. Consumers and various storage systems will be linked to the power plant park by means of modern information technology.

With the incentive of variable rates, a portion of power demand can be managed in accordance with the available amount of electricity (load or demand-side management).

Increased international power trading, and "smart" power grids are an important prerequisite for the integration of the fluctuating renewable energy from the wind and the sun.



However, these important prerequisites for an energy supply with a high share of renewable energies have not been considered in the IER study. Rather, it is apparent that with an extension of the phase-out of nuclear power plants, these would block a large share of Germany's storage capacities at many times during the year. But these capacities are an important factor for integrating volatile renewable energies into the future energy supply system, and for avoiding burdens on consumers – such as negative prices for electricity.

More still: reinforcing the anachronistic power plant park would greatly slow down the necessary reorganization of the energy industry. A study by Greenpeace shows that an extension of the nuclear phase-out would prevent some €200 billion in investments in renewable energies through 2030.

What Are the Practical Effects of the Limited Adjustability of Nuclear Power Plants?

The scenario for "phase-out extension" in the IER study assumes 17 nuclear power plants in its forecasts for both 2020 and 2030 – the number that exist today. It moreover assumes that all 17 nuclear power plants will be able to run in so-called load cycle operation – adjusting continually to load changes. In practice, only a few nuclear power plants have done so to date; in 2008 it was only three, and only over a short period of time[4]. Still, according to the IER study, all power plants were already designed to run in load cycle operation, so that "no additional upgrading of the systems will have to be carried out."[5]

In other words, the IER claims, nuclear power plants built during the 1970s, when a renewable energies share of less than 3% existed, were already designed to handle a residual load in situations with an environmentally-friendly electricity share of at least 30%. This seems more than questionable. The study even admits that capacity changes at the speeds mentioned are possible only with "a mode of operation which does not overburden the system".[6] How a nuclear power plant is to be run in such a gentle manner is not explained.

In order to guarantee the energy supply, power plants which provide the residual load must operate especially safely and reliably. The Nuclear Consensus of 2000 specified remaining lifespans for nuclear power plants in terms of remaining capacity quantities, which translated into a lifespan of approx. 32 years per power plant, given a continuation of average operation of the systems. By way of comparison, the worldwide average age at which nuclear power plants go off-line is 23 years.[7] An extension of the phase- out would also mean a safety risk, because one result of a longer lifespan is that age related defects are increasingly frequent, according to the report of the "Management for ageing technical facilities in systems of the E.ON Kernkraft [nuclear power] GmbH". The business association BDI too explicitly points out in its above mentioned study that "an extension of lifespans to 60 years has **not yet been technically tested to date, and is thus fraught with uncertainties"[8].**

Moreover, there are no research results regarding system safety in case of increased adjustment of nuclear power plants, and only very little practical experience in this regard. Frequent adjustment of the systems, including shut-downs and restarts, would be needed, if they were to be operated so as to complement fluctuating renewable energies.

4) atw – Internationale Zeitschrift für Kernenergie (2009): Betriebsergebnisse 2008 (Business results for 2008).
5) IER, op cit., p. 25.
6) ibid, p. 28.
7) World Nuclear Industry Status Report, 2007
8) BDI, op cit. p. 68.

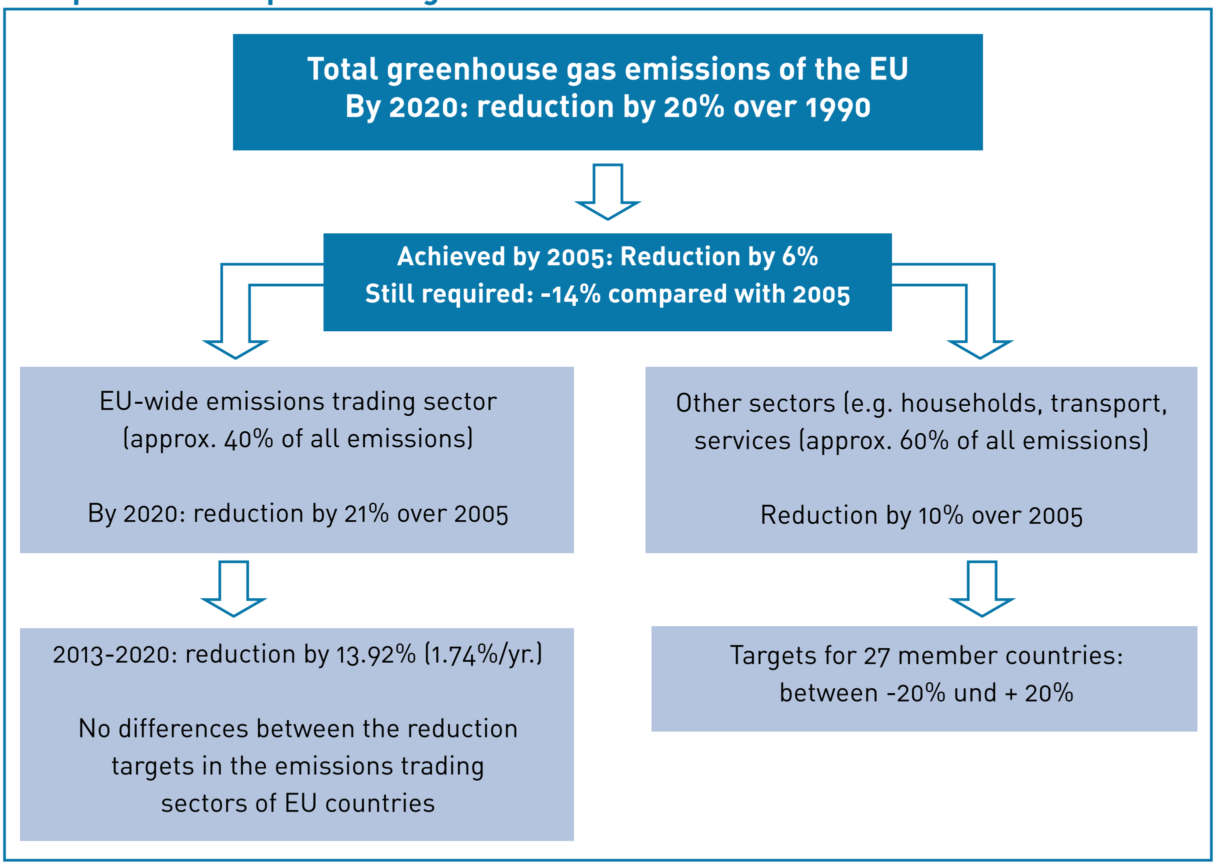
No Climate Protection Effects from Phase-Out Extension

Nuclear energy is not a CO2-free technology; merely a CO2-poor one, for throughout the entire production cycle, from power plant construction through operation to waste disposal, and especially uranium extraction and fuel production, considerable quantities of greenhouse gases are produced. These are considerably higher than it is the case with electricity generation by means of wind energy or hydroelectric facilities.

Even if nuclear power emits relatively little CO2 by comparison with fossil fuel-based generation, the phase-out extension itself would have no climate protection effects, as the following analysis indicates: If, according to the BDI study, lifespans were extended by eight years over those of the Nuclear Consensus, CO2 emissions could be reduced by up to 57 million tonnes per year in Germany. By way of comparison, renewable energies already avoided almost double that amount – 109 million tonnes – in 2009.

However, much more important than the relatively low climate protection effect, compared with those of renewable energies, is the fact that the emissions are not actually avoided, but simple shifted geographically. Therefore, the output of CO2 from electricity production is regulated in Europe by emissions trading. For the time period through 2012, the emissions goals have already been conclusively defined. The third emissions trading period starts as of 2013, and the basic rules applicable through 2020 have existed in the form of the EU Climate Package since December 2008 (Directive 2009/29/EU). Under this package, there is to be a common budget for all member states in future, and no more country-by-country allocations. The overall CO2 budget, and hence the total number of certificates issued, is to decrease by 1.74% per year. The goal is to reduce emissions falling under the trading system by a total of 21% by 2020, over the base year 2005.

European climate protection goals



Source: DEHSt

These basic conditions were established at a time when the Nuclear Consensus was not yet being questioned. The additional emissions avoided by a possible extension of the phase-out have therefore not been taken into account in the pan-European budget. That means that the nuclear power plants could indeed replace the emissions of fossil-fuel power plants in Germany, but the emission certificates thus freed up would simply be redistributed: **"... the CO2 emissions saved by a longer lifespan of nuclear power plants in the German energy sector will be additionally emitted by other industries and by other participating countries"[9]** . In other words, an extension of the phase-out would have no positive climate protection effects – unlike renewable energies, for their continuous development have already been taken into account in the calculation of the number of certificates for the third trading period.

The principle of emissions trading can have a supporting effect on innovation. The auctioning of the certificates with a shrinking budget, as will be the case as of 2013, will cause the price for the certificates to rise. That means that power plant operators or industrial plants have a choice between buying certificates or investing in new technologies which avoid greenhouse gases. This incentive to invest in innovations, and in the long run, to emit less CO2, would be reduced if the phase-out were extended, since the certificates freed up would boost the supply and thus cause the price to drop. That would have the Europe-wide effect of reducing incentives to cut emissions elsewhere, such as boosting the development of renewable energies, or taking greater efficiency measures in high-input industries.

A drop in the price of the certificates – which would be undesirable from a climate policy perspective – due to an extension of the German nuclear phase-out could only be avoided in the context of the present mechanisms and rules of the emissions trading, if emission rights are withdrawn from the market on the same scale as CO2 emissions are reduced by longer nuclear power plant lifespans. This would cause less need for emission entitlements to be balanced by an equivalently lower supply. This could for example be implemented by deleting unused emission rights from the national auction budget. Such a measure could stabilize the CO2 price, and the climate policy effectiveness of the phase- out extension would then correspond to the level of emissions entitlements. At the same time however, such a renunciation of certificate sales would mean that **the government would face an annual drop in revenue well into the triple-digit million euro range.**

An extension of the phase-out could have a climate protection effect if the EU countries could agree on a stricter overall emissions reduction target, and the German phase-out extension were then taken into account in the emissions budget. However, new climate policy negotiations would also mean a further delay in achieving climate protection.

9] Ibid, p. 2.

No Lower Power Prices from Phase-Out Extension

The BDI forecasts an up to 11% lower price for CO2 certificates in the case of an extension of lifespans to 40 years, compared with that under a continued nuclear phase-out. This price would then again approach that of the exit scenario during the period through 2030. According to the forecasts of the proponents of an extension of the phase-out, the lesser increase in the CO2 price should also cause the wholesale price of electricity to rise less sharply. While this would be logical under the theory of perfect competition, the German energy industry is in fact still far away from this state, despite its progress towards liberalization.

The market dominance of the four oligopoly corporations

	Share of German power plant capacity	Electricity produced	Share of the large-customer market
RWE	Together 82%	Together 89%	more than 20%
E.ON			more than 15%
Vatenfall			well less than 10%
EnBW			less than 15%

Source: IZES/Leprich 2009

The four major power supply corporations RWE, E.On, Vatenfall and EnBW own 82% of Germany's power plant capacity, including all the nuclear power plants. An open competition is severely restricted due to the lack of competition and the high barriers to market entry. If the nuclear phase-out were extended, this oligopolistic market structure would in fact be solidified still further. It thus seems questionable that lower CO2 costs would be passed on to customers in the form of lower electricity prices than those under the phase-out, as forecast by the BDI. The Federal Cartel Authority and the Monopolies Commission share these doubts.[10]

Nonetheless, the BDI study assumes that an extension of the phase-out would dampen prices, both in wholesale trading of electricity and for CO2 certificates, providing major economic relief: Given a lifespan extension of eight years, the cost of electricity for the average household (consumption: 3,500 kWh/yr.) would allegedly drop by up to €7 per month by 2020, and the accumulated cost relief for all economic sectors through 2030 would amount to approx. €110 billion (nominal), with lifespans thus extended to 40 years. The expenditures for radioactive waste disposal and the necessary safety refitting of the reactors were not included in this calculation.

The Arrhenius Institute for Energy and Climate Policy has also calculated that an extension of lifespans by eight years would cause the price of electricity on the energy exchange to increase less sharply. However, the amount of the reduction would be only a little more than half that forecast in the BDI study – 0.7ct/ kWh, as opposed to the BDI's 1.2 ct/kWh.

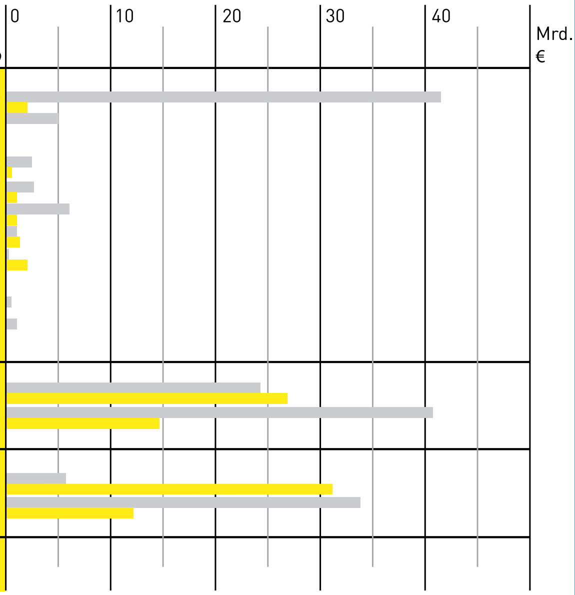
10) The former (Bundeskartellamt) is the fair competition federal office, the latter a federal advisory panel.

Subsidizing Nuclear Power Raises Costs

A study by Green Budget Germany (FÖS) shows the costs incurred by taxpayers to date due to nuclear power, and those to be incurred if the nuclear phase-out is upheld. Government subsidies between 1950 and 2008 amounted to at least €164.7 billion, the major share of which came in the form of tax breaks for nuclear power plant operators. The future additional costs of nuclear power, given adherence to the phase-out, with its 32-year lifespans, are already at least €92.5 billion, and hence at around the same level as the economic reliefs which the BDI calculates an extension would yield. Such an extension could be assumed to bring further cost increases, which would cause the BDI's claimed benefits to disappear.

Government support for nuclear power (additional costs in billions of euros)

	Subsidies, 1950-2008	Future subsidies after 2009
Financial aid	**>6.8**	**>7.1**
Research in Germany	41.2	1.4
Expenditures by the German states	5.2	n/s
Guarantees	>0.14*	n/s
Euratom & PHARE (German share)	2.5	0.5
Shutdown of East German nuclear reactors	>2.7*	1.0
Rehabilitation of Wismut (E. Ger. uranium mine)	6.1	1.1
Morsleben (E. Ger. nuclear waste disposal site)	>1.0*	1.2
Asse (proposed W. Ger. nuclear waste disposal site)	>0.3*	2.0
Site search for final waste disposal site	0	0
Chernobyl effects	>0.5*	n/s
Dues to international organizations	>1.2*	n/s
Tax incentives	**>64.8**	**42.0**
Reserves	24.4	27.4
Net energy tax incentive	40.5	14.6
Off-budget government stipulations	**>39.1**	**43.4**
Energy price increase due to emissions trading	6.2	31.0
Restricted competition in the electricity industry	33.0	12.4
Total: all supports except external costs	**>167.7**	**>92.5**
Average in ct/kWhr of electricity	>3.9	>2.2



Source: FÖS/Greenpeace 2009

Renewable Energies and Base Load Power Plants Are Essentially Incompatible

In sum, an exact analysis of the Federation of German Industries (BDI) study proves that an extension of the nuclear phase-out can be justified neither on climate policy grounds nor with the promise of economic relief. The IER study shows that nuclear power plants are incompatible with renewable energies, since they are flexibly adjustable only in partial load operation.

Moreover, an extension of the phase-out would strengthen the market dominance of the four major energy corporations. Effective competition, resulting in competition based prices, would be at least delayed, if not permanently prevented.

In Great Britain, this intrinsic conflict is already being addressed by the major energy companies behind the scenes: According to the daily newspaper The Guardian, the energy companies EDF and E.ON threatened the British government in the spring of 2009 with cancellation of the construction of new nuclear power plants unless the development goals for renewable energies were cut back. In a statement on "Renewables Consultation", EDF said: "Our detailed analysis shows that, as the intermittent renewable capacity approaches the Government's 32% proposed target, if wind is not to be constrained (in order to meet the renewable target), it would be necessary to attempt to constrain nuclear power more than is practicable."[11]

Not only technologically, but economically as well, base load power plants are incompatible with renewable energies. This is confirmed by the German Advisory Council on the Environment (SRU): "In a supply strategy based on coal power plants (with or without CCS) and nuclear power plants, the share of regenerative energy sources must be strictly limited if these base load power plants are to be economically rationally run."[12] New base load power plants, or an extension of the lifespans of the existing ones, would endanger the development of renewable energies, and would not constitute a bridge to the energy supply system of the future.

11) Quoted in Environmental Research Web, http://environmentalresearchweb.org/blog/2009/05/wind-versus-nuclear.html.
12) SRU: Setting the Course for a Sustainable Electricity System, 2009. "CSS" means "carbon sequestration and storage", a proposed but controversial plan to deposit CO2 underground.

Sources and Further Information

German Renewable Energies Agency (AEE)/ German Renewable Energy Federation (BEE):
Stromversorgung 2020. Wege in eine moderne Energiewirtschaft (Power supply 2020: Paths to a modern energy industry. Berlin, January 2009.

Arrhenius Institute for Energy and Climate Policy (Thomas Bruckner, Hendrik Kondziella & Sven Bode):
Auswirkung einer Laufzeitverlängerung der Kernkraftwerke auf die Preise und die Wettbewerbsstruktur im deutschen Strommarkt (The effects of a lifespan extension for nuclear power plants on prices and the structure of competition in the German electricity market). Hamburg, April 2010.

atw, Internationale Zeitschrift für Kernenergie:
– Alterungsmanagement bei technischen Einrichtungen in Anlagen der E.ON Kernkraft GmbH (Ageing management for technological facilities in systems of E.ON Kernkraft GmbH). Berlin, November 2009.
– Kernkraftwerke in Deutschland. Betriebsergebnisse (Nuclear power plants in Germany. Business results) 2008 Berlin, 2009.

Federal Ministry of the Environment (BMU): Was bedeutet Fortschritt heute? Perspektiven einer zukunftsfähigen Umwelt- und Energiepolitik (What does progress mean today? Prospects for a future-oriented environmental and energy policy). Berlin, April 2010.

Federation of German Industries (BDI): Ökonomische Auswirkungen einer Laufzeitverlängerung deutscher Kernkraftwerke (Economic effects of an extension of the phase-out of German nuclear power plants). Cologne, Münster, January 2010.

BET (Office for the Energy Industry and Technical Planning): Versorgungssicherheit in der Elektrizitätsversorgung. Kritische Würdigung der dena-Kurzanalyse zur Kraftwerks- und Netzplanung in Deutschland bis 2020 (Supply security in electricity supply. A critical appraisal of the brief analysis by DENA of power plant and network planning in Germany through 2020). Aachen, December 2008.

German Emissions Trading Authority (DEHSt):
Emissionshandel: Die Zuteilung von Emissionsberechtigungen in der Handelsperiode 2008-2012 (Emissions trading: The allocation of emissions entitlements during the 2008-2012 trading period), Berlin, 2008.

Green Budget Germany (FÖS)/Greenpeace: Staatliche Förderungen der Atomenergie im Zeit¬raum 1950 – 2008 (Government Subsidies for Nuclear Power during the Period 1950 – 2008), Berlin/Hamburg, August 2009.

Fraunhofer IWES: Dynamische Simulation der Stromversorgung in Deutschland nach dem BEE-Szenario „Stromversorgung 2020" (Dynamic simulation of the power supply in Germany according to the BEE scenario "Power supply 2020"), Berlin, September 2009.

Greenpeace: Klimaschutz: Plan B 2050. Energiekonzept für Deutschland (Climate Protection: Plan B 2050. An Energy Concept for Germany). Aachen, 2009.

Handelsblatt: Kartellwächter gegen längere AKW-Laufzeiten (Competition watchdogs oppose longer nuclear power plant lifespans). Düsseldorf, September 11, 2009. http://www.handelsblatt.com/politik/deutschland/kartellwaechter-gegen-laengere-akwlaufzeiten;2467654 [accessed June 1, 2010].

Hoffschmidt, Bernhardt/Marco Lanz et al.: Struktur und Dynamik einer Stromversorgung mit einem hohen Anteil erneuerbarer Energieerzeuger (Structure and dynamics of a power supply with a high share of renewable energy producers. Aachen, August 2009.

Institute for Energy Economics and Efficient Energy Use (IER): Verträglichkeit von erneuerbaren Energien und Kernenergie im Erzeugungsportfolio (The compatibility of renewable energies and nuclear power in the production portfolio). Stuttgart, October 2009.

Monopolies Commission: Strom und Gas 2009: Energiemärkte im Spannungsfeld von Politik und Wettbewerb (Power and gas 2009: Energy markets caught between government policy and competition). Bonn, July 2009.

Nitsch, Joachim/Bernd Wenzel: Langfristszenarien und Strategien für den Ausbau erneuerbarer Energien in Deutschland (Long term scenarios and strategies for the development of renewable energies in Germany). Scenario 2009, Stuttgart/Teltow, August 2009.

Institute for Applied Ecology (Öko-Institut): Streitpunkt Kernenergie. Eine neue Debatte über alte Probleme (The nuclear power conflict. A new debate about old problems), Freiburg, September 2009.

Institute for Applied Ecology (Öko-Institut): Laufzeitverlängerungen für die deutschen Kernkraftwerke? Kurzanalyse zu den potenziellen Strompreiseffekten(Lifespan Extensions for German nuclear power plants? A brief analysis to the potential effects on the price of electricity). Freiburg, June 2009.

German Advisory Council on the Environment (SRU): Weichenstellungen für eine nachhaltige Stromversorgung (Setting the Course for a Sustainable Electricity System), Berlin, May 2009.

Schneider, Mycle/Antony Froggatt: The World Nuclear Industry Status Report 2007, Brussels, London, Paris, January 2008.

Dortmund University of Technology/Faculty of Electrical Engineering and Information Technology: Wirtschaftlich optimale Kraftwerkseinsatzplanung und Lastaufteilung eines Kraftwerksbetreibers (Economically optimized power plant operational planning and load apportionment of a power plant operator), Dortmund, May 2009.

The Guardian: Green Lobby and Nuclear Groups Clash over Role of Renewable Energy. London, March 16, 2009. [accessed: June 1, 2010]

Wuppertal Institute/Federal Ministry of the Environment: Hindernis Atomkraft – Die Auswirkungen einer Laufzeitverlängerung der Atomkraftwerke auf erneuerbare Energien (The obstacle of nuclear power: The effects of a lifespan extension for nuclear power plants on renewable energies), Berlin, April 2009.

The following issues of Renews Special are available in English

Title	Issue	Date
Value Creation for Local Communities through Renewable Energies	46	Dec 10
Twenty Years of Support for Electric Power from Renewable Energies in Germany: A Success Story	41	Sept 10
Innovative development of renewable energies	37	Aug 10
Basic load power stations and renewable energies: A systemic conflict?	35	June 10

Please visit: http://www.renewables-in-germany.com for a full list of all issues.

German Renewable
Energies Agency
Reinhardtstr. 18
10117 Berlin
Phone: +49 [0]30 200535-3
Fax: +49 [0]30 -200535-51
kontakt@unendlich-viel-energie.de

ISSN 2190-3581

www.renewables-in-germany.com

Renewable
Energies
Agency