RESTRUCTURING ELECTRICITY SUPPLY IN GERMANY

Umwelt Bundes Amt
For our Environment

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Summary

The Federal Environment Agency believes a speedy phase-out of nuclear energy use as of 2017 is both feasible and compatible with the goals of climate protection[1]. The Federal Environment Agency recommends adoption of a tiered approach:

The seventeen nuclear power plants in Germany have a total (net) capacity of 20.5 GW. The seven oldest nuclear power plants as well as the power plant Krümmel with an overall capacity of 8.4 GW should be decommissioned as quickly as possible. Security of supply is not an obstacle to this since Germany's power stations currently dispose of sufficient surplus reserve capacity of about 10 GW. According to concurring estimates made by transmission system operators and the Federal Network Agency, the current stability of the grid might be strained by decommissioning the 7+1 nuclear power stations but it is nevertheless guaranteed. In order to also ensure secure operation of the grid in the 2011-2012 winter, transmission system operators are demanding an additional increase of power plant feed-in in southern Germany of 2000 MW. This corresponds to temporary continued operation of at most two of the nuclear power stations affected by the moratorium until Spring 2012. However, since we believe that transmission system operators have apparently either not or only insufficiently considered any real alternatives, their findings are not entirely reliable. The entire range of measures that might be implemented to ensure grid security was not taken fully into account

There must be a review of the order in which the remaining nuclear power stations can be decommissioned in the near future. According to our estimates, Germany can do entirely without nuclear energy as of 2017, at which time there will be an additional capacity demand of 5 GW maximum beyond that supplied by the stations currently under construction and the additional biomass power plants scheduled to go online. This demand can be met in time by new, highly flexible and highly efficient natural gas combined cycle power plants, by measures to extend the service life of power plants already on the grid, through a more speedy expansion of renewable energies and of cogeneration, as well as additional energy efficiency measures. A complete phase-out of nuclear energy as of 2017 is also feasible as concerns safe and reliable operation of the transmission systems. Should it be necessary for the safe operation of the grid, new natural gas-combined cycle power plants could be built to replace plants in regions where nuclear power stations are currently located. With an implementation period of 3-6 years this too can be achieved by 2017.

The following recommendations represent a means to safeguard public safety, supply security for Germany and achievement of climate protection goals. An increased electricity production by coal and natural gas power plants– given nuclear power phase-out as of 2017- will not increase CO_2 emissions as they will be offset by emissions trading in the EU.

Foreign imports of nuclear power to secure supply are are not needed to guarantee security of supply. The present higher rates of imports are largely price-driven. Moreover, the nuclear power stations in neighbouring countries are ranked high enough in the European merit order to be operating at full capacity even without the moratorium imposed in Germany, and are thus unlikely to be able to react to the change on the altered German market. The import surpluses (net imports) of recent weeks are mainly a result of declining German exports of electricity. The surplus imports are price-driven and originate largely from fossil fuel-based power plants.

The effects of an accelerated phase-out of nuclear energy after 2017 on electricity prices would only be slight increases, ranging between an average 6 and 8 euros per megawatt hour (0.6 and 0.8 cents per kilowatt hour) by 2030, with negligible effects on economic growth.

Complete abandonment of nuclear energy starting 2017 would significantly reduce the dangers and risks associated with this source of energy, the social advantages of which would compensate any moderate rises in electricity price.

Shutdown of seven oldest nuclear reactors and Krümmel power plant

The seventeen nuclear power plants in Germany have a total (net[2]) capacity of 20.5 GW. The seven oldest nuclear power plants as well as the installation in Krümmel with an overall capacity of 8.4 GW can be

1 In large parts this background paper is based on the findings of the studies "Energy Target 2050 – 100% renewable electricity supply", 2011 (http://www.umweltdaten.de/publikationen/weitere_infos/3997-0.pdf) and "Climate Change Mitigation with a Secure Energy System", 2009 (http://www.umweltbundesamt.de/energie-e/archiv/cc_13_2009_kurzfassung_e.pdf).

2 All figures on plant capacity in this paper are net values.

decommissioned permanently. In terms of security of supply this measure can be implemented without placing any constraints on it as there is currently some 10 GW sufficient surplus reserve capacity available in Germany's power system.

1. Basic principles

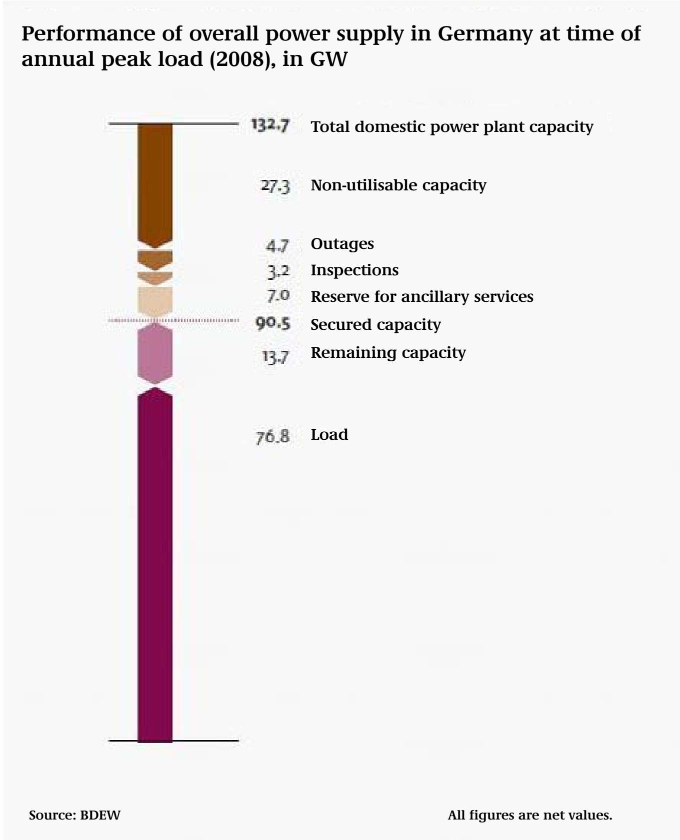
Securing supply safety depends to a large extent on ensuring there is sufficient (secured) plant capacity available to meet demand. The installed capacity of Germany's power plant park has increased sharply in recent years, especially as a result of the addition of renewable energies and new natural gas-combined cycle power plants to the mix as well as the slow pace at which fossil fuel-based plants have been taken offline. The majority of new power plant construction is in wind energy and photovoltaics, which both only contribute a minor share to the secured capacity.

The surplus reserve capacity currently available upon taking Germany's nuclear plants offline permanently is therefore calculated following a "worst case" approach. It is based on the electricity supply in Germany at time of annual peak load. The method applied is illustrated using figures for 2008[3].

The secured capacity of the power plant park is calculated by subtracting non-replaceable capacity, power plant outages, plant inspections, and the reserve capacity required for ancillary services from the installed domestic capacity. The difference between secured capacity and annual peak load represents the remaining capacity (see figure below).

As official statistics for 2009 and 2010 on performance at time of annual peak load have not yet been submitted by BDEW, we have calculated a minimum value of surplus reserve capacity for late 2010 which is available upon decommissioning of nuclear power stations. It is a conservative estimate based on the BDEW's balance sheet of overall supply published in 2008 at time of annual peak load and on figures provided by the Federal Statistical Office on the development of power plant capacity[4].

3 BDEW 2010 (German Association of Water and Energy Industries): Energiemarkt Deutschland – Zahlen und Fakten zur Gas-, Strom- und Fernwärmeversorgung, Sommer 2010 (German Association of Water and Energy Industries)
4 Results are approximate figures as data from BDEW and Federal Statistical Office differ slightly.



Source: BDEW German Association of Energy and Water Industries

2. Analysis of performance at time of annual peak load in 2008

As a first step we derive a figure for the short-term secured reserve capacity of overall supply for 2008. This free reserve capacity available at short notice can be used when power plants are taken offline.

In a conservative assumption we disregard actual annual peak load in 2008 in all calculations and consider instead maximum annual peak load in overall supply of the past ten years, which was roughly 80 GW in the years 2002 and 2010. We estimate that the peak load will not exceed this limit in the next ten years either. As a conservative analysis we also do not take into account any additional secured capacity. Annual peak load is not a fixed figure but rather a result of the balance of supply and demand on the liberalised electricity market. A spike in electricity prices during capacity shortages may result in a concurrent decrease in demand and, therefore, of annual peak load.

Available secured capacity at the 2008 peak load point was 90.5 GW. The remaining capacity, i.e. the product of the difference between secured capacity and annual peak load, was 10.5 GW in 2008.

Of this remaining capacity a reserve of about 5-7 GW should be stored in the event of unforeseen circumstances[5]. Falling below this permanent reserve capacity level, however, will not necessarily lead to power outages but may under adverse conditions trigger price-driven demand reactions or imports. The difference between remaining capacity and permanent reserve capacity in the event of unforeseen circumstances is the free reserve capacity available at short notice at the time of annual peak load; that is, about 3-5 GW in 2008.[6]

Table 1: Overview of performance at time of annual peak load (2008)

Secured capacity at time of annual peak load 2008	**90.5 GW**
Annual peak load (maximum of past 10 years)	80.0 GW
Remaining capacity	**10.5 GW**
Reserve capacity for unforeseen circumstances	7.0 GW
Free reserve capacity available at short notice, time of 2008 annual peak load	**3.5 GW**

3. Offline nuclear power plants at time of 2008 annual peak load

In a second step we take into consideration power station capacities that, whilst not in operation at the time of 2008 annual peak load, would nevertheless help to secure supply when in normal operation and thus be available for utilisation upon permanent shutdown of nuclear power stations. In 2008, the two nuclear power plants in Krümmel and Brünsbüttel with a combined capacity of 2.1 GW were not in operation at all, and the Biblis A nuclear power plant (1.2 GW) had a non-scheduled outage at the start of the year when annual peak load was observed.

4. Power station add-ons since 2008

A third step derives the additional reserve capacities which result in late 2010 from the increase in secured capacity over 2008. Starting in early 2008, installed capacity of thermal power plants rose steadily as a result of power plants being built and shutdown and, and enhancing capacity at existing power stations. From January 2008 to late 2010 the electric utility companies' net maximum capacity from thermal power plants alone rose by about 1.9 GW[7]. Assuming a statistic maximum rate of outage of 15% produces another 1.6 GW or so of secured capacity.

5. Power stations in cold reserve

A fourth step takes a look at the power stations in cold reserve. These are power stations that have been taken off the market temporarily for reasons of surplus capacity but which are nevertheless kept on stand-by technically so as to be operable within a few months' time if necessary. These power plants are not accounted for in secured capacity and are thus classified as available if additional reserve capacity is needed. The installed capacity of the power plants in cold reserve is currently more than 1.6 GW[8], of which the majority is in the south of Germany.

6. Surplus reserve capacity in late 2010

The surplus reserve capacities available at the end of 2010 to offset the shutdown of nuclear power stations amounted to at least 10.0 GW[9]. Furthermore, a permanent reserve capacity of 7.0 GW for unforeseen circumstances was available. On top of that (although not accounted for in the calculation), the Irsching 4 power plant will go into regular operation with 0.6 GW capacity in Summer 2011. Thus, permanent shutdown of the eight nuclear stations affected by the moratorium with a combined 8.4 GW capacity would be entirely feasible in terms of secured capacity[10].

5 As per recommendation of ENTSO-E.

6 Even if these 3.5 GW in 2008 had been used to offset the decommissioning of power plants, an additional 7.0 GW of permanent reserve capacity for unforeseen circumstances would have been available.

7 Federal Statistical Office: Monthly reports on the electricity and heat generation by power plants for public supply

8 Federal Environment Agency nuclear power station database

9 As an alternative approach a calculation of secured supply lation can be based on secured capacity in 2008, with all other factors remaining equal, to derive a theoretical minimum value for available secured capacity in late 2010. The available secured capacity of Germany's power station park was at least 97.0 GW at the end of 2010 for the hypothetical case that all nuclear power stations were in operation as scheduled and power stations in cold reserve were activated. After subtracting the highest annual peak load value of the past ten years of 80 GW and figuring 7 GW of reserve capacity for unforeseen circumstances, surplus reserve capacity at the end of 2010 is 10.0 GW.

10 Data in the Scenario Outlook and System Adequacy Forecast 2011-2025 from ENTSO-E reveals similar findings, whereby Germany has a secured capacity of 93.1 GW in January 2011. Considering this figure does not include the roughly 2.1 GW from nuclear power stations in Krümmel and Brunsbüttel, which have been offline for years, and a cold reserve of 1.6 GW, an excess reserve capacity of 9.2 GW remains after subtracting an assumed annual peak load (with load management) of 80.3 GW as well as the reference margin of 7.3 GW (comparable to the permanent reserve capacity referred to here). This is clearly more than the 8.4 GW capacity of the 8 nuclear power stations affected by the moratorium.

Table 2: Surplus reserve capacities at year end, 2010

Free reserve capacity available at short notice at time of annual peak load, 2008	3.5 GW
Capacity of offline reactors in 2008 (Brunsbüttel, Krümmel, Biblis A)	3.3 GW
Net additional construction (add-ons – shutdowns) between early 2008 and late 2010	1.5 GW
Cold reserve	1.6 GW
Surplus reserve capacities, late 2010	**10.0 GW**

Even upon decommissioning 8.4 GW of nuclear power plant capacity, there is sufficient capacity to compensate for reactor inspections and other power plants in operation:

- The analysis of secured capacity and surplus reserve capacity is based on the time of annual peak load. As the monthly maximum load is considerably lower throughout most months of the year, some additional leeway for power plant inspections results during this time.
- Some of the permanent reserve capacity for unforeseen circumstances can be made use of during inspection times. Scheduled inspections at power plants should, however, be arranged in agreement with transmission grid operators so as to ensure that as few congestion management measures (e.g. redispatch) as possible for safe operation are necessary.

New construction of power plants and plant shutdowns in upcoming years

At present, there is construction in progress on new coal and natural gas-combined cycle power plants (large scale power plants only) with an installed capacity of some 11 GW (not including the legally disputed construction of the Datteln power plant with an additional 1.1 GW), thus ensuring that there are adequate reserves even upon decommissioning older fossil fuel-based and climate-damaging power plants. These new plants are scheduled to go online by 2014. UBA believes that older coal and natural gas power plants with a capacity of ca. 6 GW will be decommissioned by 2020[11,12]. Therefore, a net gain of ca. 5 GW capacity can be expected. Decisions governing the decommissioning of individual fossil fuel-fired power stations depend heavily on the service life of nuclear stations. In the event of a speedy phase-out of nuclear energy, it can be expected that retrofit measures at older existing power stations aimed at prolongation of operating time will be taken rather more often than has been foreseen by the government.

Complete nuclear energy phase-out as of 2017 possible without new coal-fired plants

Efforts must be made to determine in what order the remaining nuclear reactors can be decommissioned as quickly as possible on grounds of new power plant construction in progress whilst safeguarding safe and reliable operation of the grid. According to Federal Environment Agency estimates, Germany is able to phase out nuclear energy entirely after 2017. In addition to the construction of power stations in progress, there will be further capacity demand of 5 GW at the most, which can be met by new, highly flexible and highly efficient natural gas cogeneration or combined cycle plants, and partly by stepped up expansion of renewable energies as well as additional energy efficiency measures, or through measures to extend the service life of existing power stations.

The UBA Climate Change Mitigation with a Secure Energy System (Klimaschutz und Versorgungssicherheit) study[13] demonstrates that up until 2020 – presuming implementation of the original plan to abandon nuclear energy– there is no need to build new conventional power stations in addition to those already under construction. According to the original nuclear phase-out mandate, nuclear stations with a capacity of about 5 GW would still be in operation in 2020 and have to be replaced thereafter. However, this can already be achieved as of 2017, for example through construction of a new natural gas-cogeneration or combined cycle power plant with a total capacity of 5 GW. Given current completion time (from planning phase through to authorisation, construction, and initial operation) of 3-6 years for new natural gas-combined cycle gas power plants, it is certain this can be achieved. More rapid expansion of renewable energies,

11 This estimate is based on observation of the market and plant operators' own decommissioning schedules as publicised in the 2009 and 2010 monitoring reports of the Federal Network Agency (BNetzA). However, our own forecasts on the shutdown of lignite-fired power stations are about 3,000 MW lower as these shutdowns can be expected only if new lignite power stations above and beyond those already under construction are built to compensate for these shutdowns.

12 BET 2008: Versorgungssicherheit in der Elektrizitätsversorgung, Aachen

13 Federal Environment Agency 2009: Climate Change Mitigation with a Secure Energy System Developing a Sustainable Power Supply. Climate Change 13/2009, Dessau-Roßlau

additional efficiency measures, or retrofit measures to prolong service life can help to reduce demand for more natural gas power stations and thus establish 5 GW as a maximum limit. There is no demand for any more coal power plants beyond those now under construction. Retrofit measures to prolong the service life of older existing plants offer an especially viable alternative to the construction of new fossil-fuel based power plants.

In simple terms, substitution of the entire (net) capacity of nuclear power stations of 20.5 GW after 2017 can be stated as follows: roughly 10 GW are already available as surplus reserve capacity to compensate the shutdown of nuclear power stations. An additional 5 GW can be added from 2014 on considering the surplus of newly build capacity over decommissioned capacity.. Furthermore, the expansion of biomass power plants is expected to continue, adding about 1.4 GW capacity by 2015.[14] Secured capacity of 5 GW will also become available by 2017 through the continued development of CHP or new natural gas-combined cycle power stations[15]. Overall, this added capacity of a total 21.4 GW is already enough to replace the capacity of the entire nuclear power station park. An additional permanent reserve capacity of 7.0 GW for unforeseen circumstances would also be available. Furthermore, any capacity demand to cover peak load can be reduced by about 3 GW through use of load management, esp. positive balancing power, to make operating reserve available.

Table 3: Substitution of all nuclear power station capacities starting 2017

Surplus reserve capacities, late 2010	10.0 GW
Power plants already under construction (net add-on = 11 GW add-ons – 6 GW shutdowns)	5.0 GW
Additional power plant construction (natural gas-combined cycle or CHP), in planning	5.0 GW
Expansion of biomass power plants	1,4 GW
TOTAL	**21.4 GW**
Load management (reduction of capacity demand)	3.0 GW

14 BMU 2010: Leitstudie 2010. Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global.

15 There is currently a good deal more than 5 GW of capacity from natural gas-combined cycle power stations that is scheduled to go online by 2016 [UBA power plant database]

Provided there is a policy decree to accelerate phase-out of nuclear energy use, market forces may dictate more extensive new construction both before and after 2017 than stated here. However, the Federal Environment Agency does not believe it is necessary for the sake of ensuring supply security.

Any possible need for additional (natural gas-combined cycle or other) power stations after complete nuclear phase-out in 2017 will depend largely on development in renewable energies, specifically in geothermal energy, CHP, the expansion of storage capacities, and tapping efficiency potentials in electricity consumption.

Availability of natural gas

Adequate supply of natural gas in the coming years for additional natural gas –combined cycle plants

Supply of natural gas in Europe has greatly outstripped demand in recent years. This is mainly as a result of the expansion of liquefied natural gas (LNG) capacities and the opening up of new production capacity in the USA (shale gas). As a consequence, wholesale prices for natural gas have been somewhat decoupled from oil prices. Furthermore, more efficient heat insulation can and should reduce future natural gas consumption for heating purposes.

Grid security is guaranteed upon nuclear energy phase-out in 2017

In order to assure secure operation of the grid in the coming months, transmission system operators in concert with power plant operators must resort to all suitable measures to sustain grid security.

The Energy Industry Act (*Energiewirtschaftsgesetz - EnWG*) mandates responsibility for safe operation of the grid to transmission system operators and the Federal Network Agency as regulatory authority. Security of supply depends to a great extent on safe and steady operation of the power grid. What this means in essence is that electricity can be transported from the power plant to consumers at all times. However, this is restricted by the existing transmission capacities of the power lines. Furthermore, there must be sufficient reactive power available regionally on the grid. Both these conditions are complicated by the discontinued operation of the nuclear power stations due to the moratorium as they are by and large located in southern Germany. Transmission system operators and the Federal Network Agency[16,17] believe that shutdown of the seven oldest nuclear power stations and the facility in Krümmel would perhaps place a strain on grid stability at the present time but nevertheless remain under control. The challenges faced in May 2011[18], when up to five nuclear power stations went offline temporarily for inspection, were met thanks to lower load typical in spring and to a high feed-in rate from photovoltaic installations.

A new challenge to be met is when the Brokdorf nuclear power plant in the Hamburg area goes offline for inspection in June.[19] Notably, grid operators and the Federal Network Agency predict the situation in the winter of 2011-2012 will be especially difficult due to increased demand. The time remaining until then should be used to review and allow for preparation of any measures necessary to maintain grid security.

Transmission system operators, supported by power plant operators, must implement these measures in due time.

In addition to “classic” congestion management, additional grid safety measures[20] should be implemented, at least temporarily, to avoid critical situations. These include:

- Coordination and optimisation of inspection scheduling at all power plants,
- Optimisation of grid operation (and overhead line temperature monitoring) and coordinated grid operation management among all transmission system operators,
- Utilisation of storage power stations for auxiliary grid support and relief
- Activation of operational power plants in critical situations (incl. some 1.6 GW cold reserve [21] in southern Germany and from smaller-scale power plants in the distribution grid that have not yet gone online)
- Review of the decision reached by EON shortly before the moratorium to decommission the Pleinting oil-fueled power plant in southern Germany with 0.7 GW indefinitely.
- Utilisation of other grid security measures, such as adjustment of wind power feed-in
- Reduction of electricity exports
- Temporary electricity imports to southern Germany to relieve the load on the transmission network.

Severe impasses occur only very seldom and when they do, for only a few hours at a time. For example, the load on overall supply throughout 2008-2010 was only greater than 75 GW for a total of 62 hours, greater than 77 GW for 8 hours, with peak load at 80 GW[22]. This low figure for number of hours creates additional room for manoeuvre:

- Temporary activation of emergency power systems (experts estimate that Germany disposes of more than 20 GW in emergency power aggregates, a large share of which are part of systems connected to the grid, especially in the industry and commerce sectors, which could be activated for a few hours a year as auxiliary support of the grid)
- Utilisation of load management potentials.

According to the current draft amendment of the Energy Industry Act, network operators will also be given enhanced means to control how power plants are operated, a change which the Federal Environment Agency sees as positive. The Federal Network Agency should also take measures that enable transmission system operators to enter into provident deals with suitable suppliers of load management potentials and emergency power aggregates.

Situation in Winter 2011-2012

According to current prognoses by transmission system operators, grid stability will deteriorate in Winter 2011-2012. In order to ensure secure operation of the grid during this time, transmission system operators are demanding an increase of power plant feed-in in southern Germany of 2000 MW over the

16 Federal Network Agency (2011): Auswirkungen des Kernkraftwerk-Moratoriums auf die Übertragungsnetze und die Versorgungssicherheit. Bericht der Bundesnetzagentur an das Bundesministerium für Wirtschaft und Technologie, 63 pages.

17 Federal Network Agency (2011): Press conference, 27 May 2011. Fortschreibung des Berichts der Bundesnetzagentur zu den Auswirkungen des Kernkraftwerks-Moratoriums auf die Übertragungsnetze und die Versorgungssicherheit. Bonn

18 It is not uncommon for power plant inspections to be scheduled mainly in spring. .

19 Inspection at the Borkdorf nuclear power station is also scheduled in June. As both the Brunsbüttel and Krümmel stations will already be offline, a regional bottleneck is expected. This is not an entirely unknown situation as the two nuclear power plants at Brunsbüttel and Brokdorf were offline for almost all of 2008-2010, and the nuclear station in Brokdorf was down for inspection in 2008 and 2009 for about two weeks each year. In addition, special measures are planned such as the installation of compensation coils which improve grid stability.

20 As per EnWG Art. 13

21 1.6 GW power plants in cold reserve, not including the Pleinting plant slated for decommissioning.

22 Assessment of load data published by ENTSO-E.

moratorium currently in effect[23]. This corresponds to the temporary continued operation of at most two of the nuclear power stations affected by the moratorium until Spring 2012. In reverse conclusion, however, transmission system operators also believe that secure grid operation is possible when at least six of the nuclear power plants affected by the moratorium are decommissioned permanently. Network operators predict that the situation will improve again in the following winter (2012-2013), especially once generator units currently under construction go into operation, upon completion of network support measures and installation of reactive power compensation systems that have been planned.

However, since transmission system operators have apparently not- or only insufficiently- considered any real alternatives[24], we believe their findings are not entirely reliable. The entire range of measures that might be implemented to ensure grid security was not taken fully into account. The Federal Network Agency also came to the conclusion that - without further review – the need for an additional 2000 MW in power plant performance is not apparent. A review of other measures that might be implemented to ensure secure operation of the grid must take place.

The investigations done by transmission systems operators apparently do not take account of either the complete activation of the 1.6 GW capacity of power plants in cold reserve or the retrofitting of individual generators from decommissioned nuclear power stations for use in phase shift mode,[25] or utilisation of load management or emergency electricity systems in industry and trade. The Federal Network Agency also believes it is unclear whether all pumped storage plants and all power plants that are connected to the distribution network were taken into account in the determination of the demand for additional power capacity.

Grid operators have investigated very rare extreme situations, as is the custom in the industry. Whilst the assumed maximum load scenario is relevant to the cause, it only occurs for very few hours per year as described above.

Furthermore, maximum load is not an absolute number but rather the result of supply and demand on the market. In real terms, with very tight production capacity and concurrent highly costly marginal power plants, maximum load is considerably lower than in times of excess supply. Timely allotment of the reserve power plant capacities in southern Germany for grid security measures undertaken by transmission system operators can influence the degree of peak loads, by both the merit order effect or by transmissions system operators themselves. This market-based means of optimising load management potentials can significantly reduce the additional demand for peak load capacities called for by transmission system operators.

Improvement of grid stability requires extensive medium- and long-term investment schemes

In the medium and long term, grid stability will have to be improved by means of additional measures. Key measures include:

- Stepped up completion of network sections currently under construction[26]
- Extension of production-independent installations to provide auxiliary power to the grid (switchable capacitors and compensation coils, FACTS[27], phase shift generators, in conjunction with flywheel storage units as needed)
- Accelerated expansion of transmission grids
- Strengthening of existing and new construction of pumped-storage power plants

The measures necessary in the medium and long term should be initiated and implemented as soon as possible.

23 Statement by transmission system operators of 19 May 2011 „Auswirkungen des Kernkraftwerk-Moratorium auf das elektrische System im Jahr 2011/2012 und Empfehlungen der Übertragungsnetzbetreiber zur Aufrechterhaltung eines sicheren Netzbetriebs“ (Effects of nuclear power plant moratorium on the electricity system in 2011-2012 and recommendations of transmission system operators for sustaining secure operation of the grid)

24 Moreover, there is some doubt as to the consistency of the load and power plant data applied.

25 In principle, every power plant generator can also serve as an engine and, just as in generator operation, supply reactive power. Therefore, all the generators from decommissioned power plants can be converted to phase shift (engine) operation. Transmission system operators believe the conversion of power plant generators is technically feasible, requiring: e.g. auxiliary engine for start-up and for grid synchronisation. In grid-synchronised engine operation generators consume less than 1% of their nominal capacity.

26 This applies especially to the Görries-Krümmel (ENLAG-Project Nr. 9) segment. Its completion will improve grid stability through supply of reactive power in the Hamburg region, and, by relieving the other 3 transmission lines between the 50 hertz control areas and Tennet, throughout Germany.

27 Flexible alternating current transmission systems

Complete phase-out of nuclear energy starting 2017 also feasible with respect to safe and reliable grid operation

Even if investments as mentioned above are slow to start, complete nuclear energy phase-out is feasible starting 2017. Insofar as it is necessary for the safe operation of the grid, new natural gas-combined cycle power plants could be built to augment supply in regions where nuclear power stations are currently located. With a three-to-six-year completion time this can be achieved as of 2017. These substituting power plants could in the worst case even assume the auxiliary support function that nuclear power stations serve.

No need for electricity imports

Germany does not rely on electricity imports to secure its power supply. Current imports are purely price-driven.

German exports of electricity exceeded imports in recent years. However, there have been import surpluses (net imports) in the past months.

Even with the permanent shutdown of the eight power plants currently offline owing to the moratorium (see above), there is sufficient domestic production capacity to meet power demand in Germany at all times.

The present rate of higher net imports is exclusively price-driven and normal in a liberalised European electricity market. Apparently, electricity produced in foreign power plants is currently less expensive than that produced in German reserve plants.

The additional imports do not necessarily consist of newly generated nuclear power[28]. Rather, the nuclear power stations in neighbouring countries are ranked so high in the European merit order that they are operating at near full capacity even without the moratorium imposed in Germany. They are thus unlikely to react to the change on the altered German market[29]. The additional net imports consist mostly of electricity produced in fossil fuel-based power plants. Simulations by BET[30] confirm these findings for the time period up to 2030, too.

28 Ökoinstitut 2011: Atomstrom aus Frankreich? Kurzfristige Abschaltungen deutscher Kernkraftwerke und die Entwicklung des Strom-Austauschs mit dem Ausland. Berlin

29 Furthermore, France is hardly in a position to supply Germany with electricity due to its own high demand in winter and scarce cooling water resources in summer.

30 BET: Büro für Energiewirtschaft und technische Planung GmbH, Aachen

The relatively small-scale import of recent weeks also indicates that most of the electricity production suddenly missing from the eight offline nuclear power stations was balanced out by domestic power plants (which had previously exported), not by imported electricity. As soon as the fossil fuel-based power plants with a total capacity of 11 GW currently under construction are operational (expected in 2014), the temporarily high level of imports is expected to subside again. This will signal the point at which more nuclear power plants can be shut down permanently without making Germany dependent on electricity imports to secure supply.

The addition of 5 GW from newly built natural gas-combined cycle power plants as well as accelerated expansion of renewable energies will also keep price-driven electricity imports to a minimum in the long term. However, optimal utilisation of electricity produced from renewable energies requires rapid expansion of Germany's power grids.

No negative consequences for climate protection efforts

Despite heightened operation of coal and natural gas power plants (and presuming complete phase-out of nuclear energy starting 2017), total greenhouse gas emissions will not increase thanks to EU emissions trading. Overall CO_2 emissions from the installations subject to emissions trading in Europe will remain constant since emissions trading establishes a cap on CO_2 emissions from these installations (energy conversion, industrial production, and any other installations included in the emissions trading system). This will offset increased CO_2 emissions from coal power generation with CO_2 emissions reductions elsewhere. The mechanism enabling adaptation is the price of emission certificates. Excess CO_2 emissions produced by coal- or natural gas-fired power plants are expected to result in an increase of CO_2 certificate prices, which will tend to raise the economic incentives to institute CO_2 emissions reduction measures elsewhere.

A complete phase-out of nuclear energy in Germany as of 2017 is expected to result in a relatively moderate increase in CO_2 certificate prices as compared to that under current extension of power plant operation time. As electricity production at Germany's nuclear power stations currently accounts for a mere 5% of total European production, the hike in certificate price[31] is limited. Moreover, emissions trading includes electricity production as well as industrial GHG emissions (e.g. N_2O and HFCs). According to modelling by BET[32] and the Öko-Institut[33], the rise in certificate price upon accelerated nuclear energy phase-out as of 2017 would range on average between 2 and 4 euros maximum per tonne CO_2[34].

Only moderate rise in electricity prices expected

Early indications of the impact of nuclear phase-out on electricity price have been reflected by price fluctuations on the electricity exchange. March base- and peak load prices shot up by about 5-6 euros per MWh upon announcement of the moratorium on 14 March 2011[35]. A considerable chunk of these price hikes results not from the moratorium resolution but instead from the higher prices for coal and natural gas after the earthquake in Japan. Despite these electricity price increases, wholesale power prices remain below 2008 levels[36].

Scientific analyses predict only moderate price rises as a result of accelerated phase-out of nuclear energy[37]. According to calculations done by consultants at BET in Aachen, the price effect of accelerated phase-out by 2017 would be an average 6-8 euros per megawatt hour (0.6-0.8 cents per kilowatt hour) over the next 20 years[38].

31 The electricity production capacity of about 150 TWh/a at Germany's nuclear power plants (in standard operation) represents only about 5% of overall electricity production of ca. 3,000 TWh/a in Europe.
32 BET: Büro für Energiewirtschaft und technische Planung GmbH, Aachen
33 Personal statement by Mr Matthes (Öko-Institut, 7 April 2011).
34 On average up until 2030. After 2030, CO_2 prices readjust as plant operation time expires.
35 Base- and peak load futures for 2012 on EEX.
36 In the first half of 2008 base load prices on the electricity exchange stabilised at about 90 euros/MWh, cf. Federal Network Agency, Markt undWettbewerb Energie. Kennzahlen 2010, http://www.bundesnetzagentur.de/cae/servlet/contentblob/191696/publicationFile/9378/BroschüreMarktWettbewerbEnergieKennzahlen2010pdf.pdf.
37 Pricing mechanisms on the electricity exchange determine market price based on differential costs of the marginal unit in the merit order.
38 Average price increase for base load product. Average electricity price rise of 6 euros/MWh results from accelerated expansion of wind energy and add-ons of combined cycle power plants on the scale detailed above. Average price increase of 8 euros/MWh are expected upon phase-out without additional measures

Modelling by Öko-Institut also demonstrates that electricity price effects will likely be moderate and fall within the identified range[39].

Electricity price effects on this scale are considerably less pronounced than reactions owing to the fluctuations in natural gas and hard coal prices in recent years. After 2030 electricity prices readjust upon early nuclear phase-out and extension of operating time.

Impact on retail prices is moderate only
Wholesale price increases can be passed on in part or entirely to end users, the scale depending mainly on competitiveness and end user willingness to switch utilities. Even with complete cost transferof stock exchange electricity prices to households and industry, price changes on the stock market will have a muted effect on end users. A price rise of 0.8 cents per kWh (based on prices in early March 2011, this would mean a price increase of about 14% on the stock exchange) raises the price for households by only slightly more than 4%[40] as production costs and sales account for only a small share of electricity price charged to households. The majority share of the price is instead traceable to grid fees, licence fees, taxes, the EEG levy, and other additional costs. A price increase on the exchange of 0.8 cents per kWh would coincide with a price hike of about 8% for industrial customers, assuming a complete passing on of higher stock exchange electricity rates and current price levels as the norm[41].

In addition, price damping effects of higher prices on the wholesale market are expected on the EEG levy. Complete nuclear energy phase-out as of 2017 would thereby tend to result in reduced EEG differential costs through higher stock exchange electricity rates.

39 Öko-Institut (2011): Schneller Ausstieg aus der Kernenergie in Deutschland. Kurzfristige Ersatzoptionen, Strom- und CO2-Preiseffekte, http://www.oeko.de/oekodoc/1121/2011-008-de.pdf
40 Base load prices per MWh on the EEX for the first half March 2011 were averaged 56 euros/MWh. According to the Federal Network Agency, household electricity prices in 2010 (see Markt und Wettbewerb Energie, Kennzahlen 2010) were about 23 cents/kWh in 2010 and have since risen to an average 25 cents/kWh, according to BDEW figures. Öko-Institut (2011) indicates a plausible shift factor of 0.25 for households and 0.5 for industry. This falls in the same range as the rough estimates made here.
41 Federal Network Agency quotes 2010 industrial electricity prices at slightly above 12 cents/kWh (incl. VAT). Reference value is again a base load price of 56 euros/MWh.

Energy efficiency and other measures can foster accelerated nuclear energy phase-out

Additional measures to save electricity and boost energy efficiency will greatly minimise the impact of accelerated nuclear energy phase-out on electricity rates. Less demand for electricity will also lower CO_2 certificate prices. The EU Commission and numerous studies have pointed to considerable GHG savings potential in energy efficiency, measures which are already by and large economically feasible.[42]

More rapid development of renewable energies is yet another means to substitute nuclear power production, for it will reduce CO_2 certificate prices and price-driven imports of electricity.

More intensive efforts to increase the capacity of cross-border interconnectors are also a means to counteract electricity price increases. The closer linking of national submarkets anticipated in the next few years alone, which will be promoted by grid development, will have a significant damping effect on electricity price. At the same time, nuclear phase-out will boost competitiveness in Germany, which in turn is expected to trigger price damping.

Accelerated phase-out of nuclear energy benefits society as a whole

There will be no noteworthy setbacks in economic growth as a result of phase-out starting 2017. The federal government's various 2010 energy scenarios underscore the fact that the impact of different operating times on Germany's gross domestic product (GDP) is rather negligible. Its effects on growth are on a scale of fractions and are further reduced once nuclear power stations are obliged to comply with higher safety standards.[43] Since complete phase-out by 2017 would only lead to moderate price increases on the electricity exchange, the impact on GDP is expected to be very small.

42 EU commission staff working document (2011): Impact assessment Energy Efficiency Plan 2011, SEC(2011) 277 final, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0277:FIN:EN:PDF

43 GDP effects are greatest in the event that operating time is extended by 20 years (compared to scenario with a shorter extension of four years), reaching a maximum of 0.46% in 2030. With moderately higher safety standards this maximum effect drops to 0.34%. Positive effects are significantly less tangible in all other years and scenarios. A long-term scenario up to 2050 in particular even indicates negative effects on GDP. [Prognos, EWI, GWS (2010): Energieszenarien für ein Energiekonzept der Bundesregierung]

Complete nuclear energy phase-out as of 2017 significantly reduces danger and risks of nuclear energy. Whilst this gain in safety will lead to moderate additional costs on the one hand, phase-out will avoid the immense costs that society would have to bear in the event of a large-scale nuclear accident on the other. Estimates of the damage incurred by a meltdown in Germany amounting to up to 5 trillion Euros illustrate this fact.[44]

Complete abandonment of nuclear energy starting 2017 would therefore greatly benefit society and compensate for moderate rises in electricity rates.

Conclusion

According to new calculations by the Federal Environment Agency, all of Germany's nuclear power stations could be taken offline permanently by 2017. This is not expected to result either in supply bottlenecks or in appreciably higher electricity prices. Furthermore, Germany's climate protection targets would not be compromised and Imports of nuclear power from abroad are not necessary.

44 Umweltbundesamt (2007): Ökonomische Bewertung von Umweltschäden. Methodenkonvention zur Schätzung externer Umweltkosten, http://www.umweltdaten.de/publikationen/fpdf-l/3193.pdf