The Moratorium on Nuclear Energy No Power Shortages Expected

by Claudia Kemfert and Thure Traber

With the moratorium on nuclear energy, the German federal government passed a resolution to shut down seven nuclear power plants for a period of three months. According to the calculations of DIW Berlin (German Institute for Economic Research), sufficient electricity is being produced despite the nuclear plants' removal from the grid. Electricity prices are only likely to increase slightly. The moratorium therefore does not pose a threat to the security of supply. However, with coal and gas-fired plants compensating for much of the fall in nuclear energy generation, a significant rise in greenhouse gas emissions is to be expected. An immediate shut down of all nuclear power plants is currently not an option since the remaining power plants are not able to securely provide the energy levels needed to meet demand during peak loads.

Following the catastrophe that struck Japan in March 2011, the German federal government imposed a moratorium in order to examine and discuss the role of nuclear energy in Germany. The moratorium involved disconnecting seven nuclear power plants from the grid and the continuation of the shutdown of a further power plant (Krümmel) for reasons of safety and security. The purpose of the three-month moratorium is to facilitate the reevaluation and change of the general conditions that apply within the energy sector. The German federal government will only make a decision on whether the power plants, or particular power plants, can be reconnected after the Ethics Commission, which it set up for this purpose, has presented its results. But the tougher safety regulations and resulting retrofitting requirements may, also from the viewpoint of companies, render the running of these plants economically unfeasible. Furthermore, the shutting down of the remaining active nuclear power plants is also the subject of discussion.

Scenarios for the German electricity market

The decommissioning of nuclear power plants has a direct effect on the use of fossil fuels and, thus, on the emission of the greenhouse gas CO2. It also impacts the price of electricity. The electricity market model ESYMMETRY[1], developed at DIW Berlin (German Institute for Economic Research), facilitates the calculation of the expected effects of such a scenario. To do this, we use current data relating to power plants, fuel and emissions prices, demand for electricity, and expected energy generation from renewable energy sources.

The electricity market scenarios analyzed here only vary with respect to the use of nuclear energy for electricity generation. In the scenario "Business as Usual," cal-

1 Traber, T., Kemfert, C. (2011): Gone with the Wind? – Electricity Prices and Incentives to Invest into Thermal Power Plants under Increasing Wind Energy Supply. Energy Economics, Vol. 33 (2).

Table 1

Power plant capacity and firm capacity in 2011 according to varying nuclear energy scenarios
In gigawatts of electrical output (net)

	EnBW	Eon	RWE	Vattenfall	Rest	Total	Firm Capacity
Without nuclear power plants							
Wind	0.00	0.00	0.00	0.00	27.70	27.70	2.08
Solar	0.00	0.00	0.00	0.00	17.30	17.30	0.00
Pump storage	1.01	1.02	1.02	2.89	0.46	6.40	5.76
Run-of-river	0.43	1.51	0.64	0.00	0.89	3.47	1.39
Brown coal	0.87	0.87	9.46	7.45	0.53	19.18	17.65
Hard coal	3.17	8.48	4.78	1.19	7.46	25.09	21.57
CCGT	0.55	1.33	2.04	0.73	4.71	9.38	8.06
Gas ST	0.00	2.30	2.58	0.42	1.66	6.96	5.57
Gas GT	0.00	1.33	1.68	0.92	3.69	7.63	4.58
Oil ST	0.00	1.18	0.00	0.20	0.62	2.00	1.60
Oil GT 0	0.00	0.00	0.56	0.17	0.73	0.44	0.44
Other	0.00	0.00	0.00	0.00	12.80	12.80	8.32
Nuclear power							
"Business as Usual"	4.31	6.74	5.46	0.27	1.32	18.11	15.03
"Moratorium"	3.44	3.79	3.06	0.27	1.31	11.87	9.86
Total							
"Business as Usual"	10.34	24.76	27.67	14.64	79.32	156.74	92.04
"Moratorium"	9.46	21.81	25.27	14.64	79.31	150.50	86.87
"No nuclear power plants"	6.03	18.02	22.21	14.37	78.00	138.63	77.01

Source: Calculations of DIW Berlin

Despite the moratorium on nuclear energy, there is sufficient firm capacity to meet demand during peak loads.

culations are based on the energy produced by nuclear power plants in operation at the end of 2010 (Table 1). These include a total of 15 nuclear power plant blocks with 18.11 gigawatts net installed capacity (GW). The two nuclear power plants Brunsbüttel and Krümmel have not been connected to the grid since 2010 for operational reasons, and are therefore not taken into account in any of the scenarios. The scenario "Moratorium" assumes that the plants affected by the moratorium are to be permanently shut down.[2] The remaining technologies have a total production capacity of 138.25 GW, of which 30% are coal-fired power plants and almost 20% gas and oil-fired plants. The total production capacity in the scenario "Business as Usual" is 156.74 GW. And the total production capacity in the scenario "Moratorium", in which Krümmel, Brunsbüttel and a further six plants under moratorium are not in operation, is 150.5 GW. In the scenario "No nuclear power plants," additional analysis into the effects of a hypothetical total withdrawal from nuclear energy is conducted (Table 1).

Based on own calculations and on current data, the following prices are assumed for the individual energy sources (EUR/MWh):[3] hard coal 11.4; natural gas 24.1; heavy fuel oil 27.3; light fuel oil 30.0. The current European emissions trading price for emissions allowances is at around 16 euros per metric ton of CO_2.[4] Taking into account the economic developments of the last few quarters, we expect the total demand for electricity in 2011 to equal that of 2008. In addition to this, the model assumes that the demand for electricity produced domestically will react to electricity price fluctuations on the stock market such that an electricity price increase of 1% will result in a fall in demand of around 0.6% (price elasticity of demand at – 0.6).[5]

All scenarios are based on the assumption that renewable energy sources will continue to be developed. In order

2 This study takes planned outages of power plants into account by corresponding seasonal availability limitations. Traber and Kemfert, at place cited.

3 Bundesamt für Ausfuhrkontrolle (Germany's Federal Office of Economic and Export Control); EWI, IER, GWS (2010): "Energieszenarien der Bundesregierung" (Energy Scenarios of the Federal Government).

4 European Energy Exchange, April 2011: www.eex.com/de/.

5 This value is the result of a calibration of the model. Traber and Kemfert, loc. cit.

to simulate individual quarters, representative weeks are used. With respect to the dynamic expansion of the solar energy market, the model is based on the assumption that half of the additional output available in each quarter as a result of new power plants is exploited. Based on an output of 17.3 GW from solar energy plants at the beginning of the year and an annual expansion of 5 GW,[6] this would mean an additional effective output of 0.63 GW in the first quarter, of 1.88 GW in the second quarter, of 3.13 GW in the third quarter and of 4.38 GW in the fourth quarter. With regard to wind power, we assume that an annual production potential of 51.7 terawatt hours (TWh), pursuant to the scenario developed by the Federal Ministry of the Environment, is the case. In order to simulate this, the model reflects a typical pattern for hourly amounts of wind-generated energy.[7]

Increased CO_2 emissions as a result of the moratorium

The scenarios for the withdrawal from nuclear energy result in varying values as regards total supply, price responsive use of power plants (i.e. operation of coal and gas-fired power plants) and, consequently, CO2 emissions (Table 2). We find that an unlimited moratorium is expected to lead to an increase in energy production from coal and gas-fired plants in particular. According to the simulations, production in coal-fired plants will increase by 21.6 TWh or 20%, and generation in combined gas and steam turbine power plants (CCGT) will rise by almost 5 TWh or 13% compared tothe "Business as Usual" scenario. The remaining gas turbine (GT) or steam turbine (ST) power plants will increase output by 47% and 57% respectively. Due to a continued moratorium, around two-thirds of the 48.4 TWh decrease in energy produced by nuclear power plants will be compensated for by an increase in energy production at fossil fuel power plants amounting to 31.7 TWh in total. However, this increase will lead to an additional 25.8 million metric tons of CO2 emissions, a rise of approximately 9%. The scenario involving the immediate shut down of all nuclear power plants, which, due to the supply difficulties this would entail, is purely hypothetical, would lead to a marked increase in emissions (Table 2).

The immediate, total withdrawal would put security of energy supply at risk

The immediate, complete withdrawal from nuclear power would put the security of energy supply at risk due to the lack of firm capacity of remaining power plants to meet the demand. In the event of such a withdrawal, the German electricity network would not be able to provide the sufficient degree of supply security for expected peak loads of around 77 GW.[8] If the relative amount of electricity retained as a safety margin is 8.2%,[9] then 83 GW of firm capacity is required. If we compare this target figure with the firm capacity in the various scenarios, then we see that the scenario "No nuclear power plants," with 76.8 GW, falls short of the firm capacity target by around 7.5%. The immediate shut down of all nuclear power plants is therefore not possible without putting the security of the electricity supply at risk. By contrast, in the scenario "Moratorium," the availability of secure power even exceeds demand – by around 5%.

The price of electricity will only increase slightly

Had the nuclear power plants not been shut down, the average expected stock exchange price for electricity in 2011 would be 6.14 cents per kWh (Table 3). Shutting

Table 2

Production at German power plants according to differing nuclear energy scenarios in 2011
In TWh

	Business as Usual 2010	Scenarios		Difference in percent compared with Business as Usual in 2010	
		Moratorium	No nuclear power plants	Moratorium	No nuclear power plants
Production					
Nuclear energy	140.9	92.4	0.0	-34	-100
Brown coal	144.7	146.5	147.3	1	2
Hard coal	108.2	129.8	157.8	20	46
Gas CCGT	36.9	41.8	55.6	13	51
Gas ST	3.0	4.7	10.1	57	234
Gas GT	3.3	4.9	11.2	47	237
Water	23.5	23.5	23.5	0	0
Wind	51.7	51.7	51.7	0	0
Solar	16.1	16.1	16.1	0	0
Other	66.1	66.2	66.3	0	0
Total	**594.5**	**577.8**	**539.7**	**-3**	**-9**
Emissions in million t CO_2	293.7	319.5	358.1	9	22

Source: Calculations of DIW Berlin.

The moratorium on nuclear energy leads to a small decline in production and increases emissions.

6 Traber, T., Kemfert, C., Diekmann, J. (2011): German Electricity Prices: Only Modest Increase Due to Renewable Energy, DIW Weekly Report 6/2011.

7 Traber and Kemfert, loc. cit.

8 ENTSOE (2009): System Adequacy Forecast, quoted in: Monitoring report of the Federal Ministry of Economics and Technology pursuant to Section 51 EnWG (German Energy Management Act) on security of supply in grid-based electricity provision.

9 ENTSOE, ibid.

Table 3

Electricity prices according to different nuclear energy scenarios
In euro cents/kWh

	Business as Usual 2010	Scenarios		Difference in percent compared with Business as Usual in 2010	
		Moratorium	No nuclear power plants	Moratorium	No nuclear power plants
Stock exchange price	6.14	6.53	7.50	6.3	22.0
Sales, grid, billing	8.9	8.9	8.9	0.0	0.0
EEG/KWKG-apportionment[1]	2.6	2.5	2.3	-3.4	-12.6
Net electricity price	17.7	18.0	18.7	1.7	5.8
Taxes, charges	7.8	7.8	7.9	0.7	2.5
Household electricity price (total)	**25.5**	**25.8**	**26.7**	**1.4**	**4.8**

1 Apportionment (Umlage) according to the "Erneuerbare-Energien-Gesetz" (German Renewable Energy Sources Act) and the "Kraft-Wärme Kopplungsgesetz" (German Cogeneration Act).

Source: Calculations of DIW Berlin.

Despite considerable increases in the stock exchange price, households will only experience minimal electricity price increases

down the nuclear energy plants affected by the moratorium for all of 2011 would result in an average stock exchange price of 6.53 cents per kWh and thus in a 6% increase on the aforementioned 6.14 cents. This increase corresponds to approximately 1.5% of the current household electricity prices of around 26 cents per KWh, approximately a quarter of which is determined by the stock exchange price. In addition, the higher stock exchange prices would result in the renewable energy apportionment[10] falling by circa 0.1 cents.[11] On the other hand, the tax burden increases of around 0.7% would add to the total price increase for households of 1.4%.

Due to the almost balanced price increasing and price decreasing effects, the consumer price is expected to increase only slightly. The price increases for electricity on the stock exchange, strengthened by the increase in emission trading prices resulting from rising emission levels, tends to increase prices. The retrofitting requirements at power plants and the necessary grid expansion would also bring about price increases, with grid expansion being the less influential factor.[12] The growing stock exchange prices would bring about a decline in the electricity trading balance surpluses due to the increase in electricity imports. The decline in domestic production of around 17 TWh is therefore unlikely to result in a corresponding decline in domestic demand of the same size. Considering the fact that electricity from abroad is cheaper, the increase in imports will have a dampening effect on price increases. Also, higher electricity prices would cause the apportionment levied for the development of renewable energy sources to fall by about 0.1 cents. An immediate, total withdrawal from nuclear energy would cause an increase in the stock exchange price of up to 22%, or almost 1.4 cents per kWh. However, due to factors such as the lower EEG apportionment (levies as per the German Renewable Energy Sources Act), household electricity prices would only increase by a total of up to 5%.

Conclusion

The shutdown of the nuclear power plants affected by the moratorium will not switch off the lights in Germany . The existing power plant capacity is sufficient to compensate for these gaps. However, should further nuclear power plants be taken from the grid in the next years, measures that improve grid stability have to be taken. With a maximum expected increase of 1.4%, the effects of the moratorium on household electricity prices are minor. And this increase is predominantly the result of stock exchange price increases of around 0.4 cents per kWh (6%). Without the expansion and replacement of power plant capacity, firm capacity would reduce to 77 gigawatts in the event of a total withdrawal from nuclear energy, an capacity level unable to secure current power supply. Renewable energy sources can potentially close the gap, provided that development of the corresponding infrastructure and storage facilities is intensified.

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10 The EEG apportionment was computed in accordance with the calculations in Traber, Kemfert, Diekmann (2011) at the place cited. Only the scenarios relating to stock exchange electricity prices were adjusted according to the values specified here. Compared with the 3.5 cent apportionment, which was determined in 2010 for 2011, there is a difference of approximately 1 cent per kWh. The resulting excess income can be used to reduce EEG apportionments in subsequent years.

11 A possible increase in grid charges has not been taken into account.

12 Investments of one billion euros would only cause the electricity price to rise by between 0.3 and 0.5 cents per kWh; cf. "Dena Netzstudie II: Deutsche Energieagentur dena-Netzstudie II" (Power grid study conducted by German energy agency Dena) – "Integration erneuerbarer Energien in die deutsche Stromversorgung im Zeitraum 2015–2020 mit Ausblick 2025, Berlin 2010". (Integration of renewable energy into the German electricity network in the period from 2015 to 2020 with a view to 2025, Berlin 2010.")

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»The Lights Won't Go Out«

1. Prof. Kemfert, seven nuclear power stations were removed from the grid for a three-month moratorium. Will the lights go out in Germany if these power plants are never reconnected? No, the lights won't go out. The fact is that we produce more electricity in Germany than we consume and, even in the past, we have exported much more than we have imported. Naturally, the exports are now dwindling. The utilization of existing power plants is also increasing. Overall, while we still have overcapacities, these are shrinking appreciably.

2. What would be the repercussions of leaving these power stations shut down for the long term? Keeping these nuclear power stations shut down for the long term should mean minor increases in electricity prices. This would primarily be due to the trading prices rising. On the other hand, if the trading price climbs, then the share of costs for funding renewable energies will fall. These two effects would offset each other, so that the result would be an only minor increase in prices.

3. Would it be possible to withdraw from nuclear power immediately? No. That wouldn't work, because then we wouldn't have enough output to cover demand at all times. We have to bear in mind the issue of grid stability. A large portion of the nuclear power plants leaving the grid are in southern Germany. This shortage has to be compensated by other power plants, and these can't simply be constructed in one year. However, it would be possible to initiate the plans of the Red-Green Coalition, which stipulate that all nuclear power stations will be taken offline by the year 2021/22.

4. How strongly would electricity prices increase if all nuclear power plants are taken offline within the next ten years? We forecast that the trading price of electricity would rise by about 22%. That's only the trading price, though. This would again be partly offset by a reduction in the share of costs for funding renewable energy. In addition, let's not forget that the grids have to be expanded, which will also be a cost factor - though only a moderate one. The greater proportion of electricity generated using coal would increase the CO_2 price, though cheaper imports would increase in turn. Overall, households would only have to face a minor increase in the price of electricity, somewhere between 1.5% and, at most, 6%. When we consider the offsetting factors as well, you can see that the expected price increase is quite moderate.

5. What impact would the diverse withdrawal scenarios have on CO_2 emissions and the government's climate targets? This would now depend on how many of the old, inefficient coal-fired power plants we reactivated. Our own scenario predicts that more gas-fired power plants will be used in addition to the coal-fired plants. CO_2 emissions would increase by up to 9%, which is approximately 26 million metric tons.

6. Can we make up for the shortage of energy caused by gradually shutting down the nuclear power plants if we expand renewable energy more quickly? Over the next ten years, we'll be able to double the contribution of renewable energy from the current 17% to 35%. This is in line with the volumes of nuclear energy. The question is what other power stations are being used. They still account for 65% of our energy needs, and most of them are coal-fired. The best thing would be to reduce the volumes from coal and replace them with better gas-fired plants because the latter generate less CO_2 and can be better combined with renewable energy.

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