What can we learn from the German nuclear phase-out?

Wolfgang Denk, Liaison Officer, Alpiq Suisse SA, Switzerland
The 49th JAIF ANNUAL CONFERENCE, 12 April 2016
Political, technical and economical issues dominating nuclear energy

- No replacement of existing nuclear plants
- Green party: Shut down NPPs after 45 years → public vote in Nov. 2016

- Gösgen, Leibstadt operating normally, long outage in Beznau 2
- Beznau unit 1 in shut-down since March 2015 (RPV NDT testing results); restart not before July 2016
- BKW preparing 1st Swiss decommissioning project

- Low electricity prices
- Utilities wouldn’t invest in new capacity, regardless of political nuclear phase-out
Trends in public opinion are challenging

«The existing NPP’s are necessary for the security of supply.»

Source: Yearly Swiss telephone survey «Eckwertstudie»;

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What can we learn from the German nuclear phase-out?
“Ten years ago, hardly anyone would have thought it possible. Today, however, we know that the energy transition is technically and financially feasible.”
Sigmar Gabriel, German Minister for Economic Affairs and Energy in March 2016

“We want to demonstrate that sustainable energy policy makes sense both from an ecological and an economic point of view”

Three main issues around the German nuclear phase-out and energy transition

- **T** Technical feasibility
- **F** Financial reality
- **E** Environmental impact
Installed generation capacity in Germany [GW]

48% renewables - 52% fossil, nuclear & others


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The German electricity generation mix in 2015 (gross generation: 652 TWh)

- Natural gas 9.1%
- Hard coal 18.1%
- Lignite 23.8%
- Nuclear Power 14.1%
- Renewable 30.1%
- Oil, Pumped storage & others 9.1%

- Wind onshore 12.2%
- Wind offshore 1.3%
- Biomass 6.8%
- Hydro 3.0%
- Solar PV 5.9%
- Waste 0.9%

30% renewables - 70% fossil, nuclear & others

Source: BDEW
Gross electricity generation in Germany [TWh] 2000 - 2015

Yearly import/export balance:
2013: -33.8 TWh (5%)
2014: -35.6 TWh (6%)
2015: -51.8 TWh (8%)

Data: AG Energiebilanzen, BDEW
Installed capacity vs. electricity generation and consumption

- Electricity consumption stayed the same since 2000
- Conventional thermal or nuclear capacity was not replaced
  → New renewables capacity as «add-on» to existing system
  → Load factors & fuel use of conventional plants reduced
Solar PV and Wind capacity «not usable» for the balance of supply and demand

- Total Net Installed Capacity
- Available Capacity
- “Ensured Capacity”
- Systems services
- Plant failures
- “Not usable” capacity
- Outages
- Unavailable Capacity
- Remaining Capacity
- Load reduction
- Demand
- Maximum Demand

«Not usable» capacity:
- Solar PV: 100% (= 39.7 GW)
- Wind: 99% (= 43.4 GW)
- Biomass: 35% (= 3.1 GW)

https://www.bundesregierung.de/Content/Infomaterial/BMWI/bericht uebertragungsnetzbetreiber-leistungsbilanz-2015_753972.html

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Example for «technical feasibility»: 19-20 February 2016

Source: www.energy-charts.de

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With 20GW more wind on a Saturday morning, hard coal, gas and lignite have to stop generating.

Source: www.energy-charts.de

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With 20GW more wind on a Saturday morning, hard coal, gas and lignite have to stop generating.
... and 5GW are additionally exported

Source: www.energy-charts.de

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Generating 80 GW capacity can be almost zero – example 1 January 2016, 16:15pm

Source: www.energy-charts.de
Germany «outsourcing» part of its problems to the neighbours – example: 23 August 2015, 1pm

Source: www.energy-charts.de

What can we learn from the German nuclear phase-out?
Germany «outsourcing» part of its problems to the neighbours – example: 23 August 2015, 1pm

<table>
<thead>
<tr>
<th>Country</th>
<th>Output (GW)</th>
</tr>
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<tbody>
<tr>
<td>Austria</td>
<td>-3.5</td>
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<tr>
<td>Switzerland</td>
<td>-2</td>
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<tr>
<td>Czech Republic</td>
<td>-1</td>
</tr>
<tr>
<td>Denmark</td>
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</tr>
<tr>
<td>France</td>
<td>-1</td>
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<td>Netherlands</td>
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<td>Poland</td>
<td>-1.3</td>
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<tr>
<td>Sweden</td>
<td>-0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-15.8</strong></td>
</tr>
</tbody>
</table>

Source: www.energy-charts.de
The German premature nuclear phase-out: 2500-4000 TWh of electricity to be replaced

<table>
<thead>
<tr>
<th>Plant</th>
<th>Type</th>
<th>MWnet</th>
<th>Years shutdown before reaching 50 years [y]</th>
<th>Years shutdown before reaching 60 years [y]</th>
<th>Theoretical yearly generation with capacity factor of 85% [TWh]</th>
<th>Total generation &quot;lost&quot; compared to 50 years of operation [TWh]</th>
<th>Total generation &quot;lost&quot; compared to 60 years of operation [TWh]</th>
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<tbody>
<tr>
<td>Biblis A</td>
<td>PWR</td>
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<td>1400</td>
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<td>25.3</td>
<td>10.4</td>
<td>160</td>
<td>264</td>
</tr>
<tr>
<td>Neckarwestheim II</td>
<td>PWR</td>
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<td>159</td>
<td>257</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>20480</strong></td>
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<td></td>
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<td><strong>2530</strong></td>
<td><strong>4055</strong></td>
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</tbody>
</table>
The parable of the broken window:
Money spent on broken windows cannot be spent on other things
→ Opportunity costs should be recognized

Frédéric Bastiat, 1801-1850
What do you call a system where 80% of the final price is being determined by government?

Total: 28.7 EURct./kWh, RES subsidies: 6.35 EURct./kWh

Average composition of the electricity price 2016 for a household in Germany with 3,500 kWh yearly consumption:

- Taxes, Fees and allocations: 54.1%
- Regulated Grid Fees (incl. measurement, billing, etc.): 24.6%
- Electricity generation and distribution: 21.3%
- 2.9% Others
- 22.2% RES subsidies («EEG»)
- 7.2% Electricity tax
- 5.8% Concession payment
- 16.0% VAT

Market driven

Source: graph based on BDEW

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What can we learn from the German nuclear phase-out?
Total subsidies per new renewable technology over the total installed capacities in Germany

Source: graph by BDEW, remarks added by W. Denk; as of 2015: Grid operators forecast

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What can we learn from the German nuclear phase-out?
Subsidies paid under EEG vs. Electricity produced

Cumulated (until 2016):
190 bn. EUR for
1’360 TWh electricity
(average of 140 EUR/MWh)

Source: BDEW
Estimation of subsidies paid & committed for all capacity that came online from 2000 until 2016

Cumulated: 510 bn. EUR for 3'600 TWh electricity

Source: estimation W. Denk based on BDEW data
Environmental impact of new renewables

- Materials use for plant capacity
- Visual impact (onshore wind turbines)
- Noise emissions (onshore wind turbines)
- Impact on animal life (wind turbines)
- Increase of food prices and monoculture (biomass)
- Additional grid capacity to be built
- Reducing of load factors of existing capacity is increasing environmental impact per kWh
- Dedicated smart metering capacity to be built
- Dedicated battery capacity to be built
→ New renewables have substantial environmental impact
19th century Gothic style castle Braunfels, Hesse: “It looks a bit like from a fairy tale, but it’s real!”

What can we learn from the German nuclear phase-out?

Castle Braunfels with seven wind turbines in Hohenahr (16 km away)

Source: http://www.burgerbe.de/2014/01/21/windrader-vor-schloss-braunfels/; Photo: Meinolf Schmidt

Capacity: 7 x 2.4 MW
Rotor diameter: 117m
Hub height: 140 m
Public Electricity and Heat Production in EU-28: 
CO₂-emissions from solid fuels

Germany emits by far the largest amount (282 million tons)

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What can we learn from the German nuclear phase-out and energy transition?

1. None of the shut-down nuclear capacity has been replaced by solar PV or wind capacity.
2. Solar PV and Wind do not contribute to supply and demand balance of transmission grid operators.
3. The technical feasibility is not ensured and already now relies on neighbouring countries.
4. Massive subsidies have lead to a planned-economy style system with numerous unintended consequences.
5. The level of Solar PV subsidies is being reduced but is still absurdly high compared to market prices.
6. If reducing CO₂ emissions would have been a top priority, then fossil capacity should have been reduced.
Does the German energy policy «make sense both from an ecological and an economic point of view?»

<table>
<thead>
<tr>
<th>German energy policy</th>
<th>One possible alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>510 bn EUR</td>
<td>510 bn EUR</td>
</tr>
<tr>
<td>86 GW new renewable capacity added on top</td>
<td>85 GW of new nuclear capacity* replacing coal &amp; gas</td>
</tr>
<tr>
<td>3’600 TWh («free», random profile, disregarding demand)</td>
<td>38’000 TWh** («market», base-load, plannable)</td>
</tr>
<tr>
<td>«Broken» system, «Broken» market, CO₂-emissions high</td>
<td>System and market mechanisms intact, ultra-low CO₂</td>
</tr>
</tbody>
</table>

* Assuming the construction of a fleet of 57 nuclear units with (1’500 MW, 9 bn EUR per unit)
** Assuming 85% capacity factor (= 633 TWh/a) and 60 years life-time
Thank you very much!

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