Scenarios in the EU Roadmaps

Insights for power sector roadmaps

Christian Redl
BELGRADE, 23 SEPTEMBER 2016
### Agora Energiewende – who are we?

<table>
<thead>
<tr>
<th>Think-tank with 20 experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent and non-partisan</td>
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<tr>
<td>Project duration 2012-2021</td>
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<tr>
<td>Financed by the Mercator Foundation and the European Climate Foundation</td>
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<td>Mission: How do we make the <em>Energiewende</em> in Germany a success story?</td>
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<tr>
<td>Scientific assessments</td>
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<tr>
<td>Dialogue</td>
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<tr>
<td>Putting forward proposals</td>
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</tbody>
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Long-term energy & climate targets of the European Union

Greenhouse gas emissions in the EU (1990=100%)

Reductionst of domestic EU GHG emissions by

- 20% by 2020 (binding on national level; ETS and national effort sharing for non-ETS)
- 40% by 2030 (binding on EU & national level; ETS & effort sharing for non-ETS)
- 80-95% by 2050 (EU Heads of State; Oct. 2009, Feb. 2011)

Options for transforming power systems

- Energy efficiency (EE)
- Nuclear power
- CCS
- Renewables (RES)

EE and RES for cost-efficient decarbonisation

Belgrade, 23 September 2016 | Christian Redl
Power sector scenarios of the EU’s energy & climate strategy

Greenhouse gas emissions in the EU (1990=100%)

<table>
<thead>
<tr>
<th>Year</th>
<th>1990</th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>Value</td>
<td>100</td>
<td>90</td>
<td>80</td>
<td>70</td>
<td>60</td>
<td>50</td>
<td>0</td>
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Energy Roadmap 2050

→ Reference scenario
→ Current policy initiatives
→ 5 Decarbonisation scenarios (with differing assumptions on energy efficiency, technology costs (RES, nuclear, CCS)) with a 80% reduction in domestic GHG emissions

European Commission (2011)
Power sector scenarios of the EU’s energy & climate strategy

Main results decarbonisation scenarios in the EU Energy Roadmap 2050
→ (Almost) full decarbonisation of the power sector (emissions decrease by 96 to 99%)

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→ Energy savings through increased energy efficiency lowering costs and increasing security of supply

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Main results decarbonisation scenarios in the EU Energy Roadmap 2050

→ (Almost) full decarbonisation of the power sector (emissions decrease by 96 to 99%)
→ Energy savings through increased energy efficiency lowering costs and increasing security of supply
→ Electrification of final energy demand (decarbonisation of transport and heating through RES-E)
Power sector scenarios of the EU’s energy & climate strategy

2050 range of fuel shares in primary energy consumption compared with 2005 (%); RES-E share in the power mix and Wind &PV share in the power mix

Main results decarbonisation scenarios in the EU Energy Roadmap 2050

→ (Almost) full decarbonisation of the power sector (emissions down by 96 to 99%)

→ Energy savings through increased energy efficiency lowering costs and increasing security of supply

→ Electrification of final energy demand (decarbonisation of transport and heating through RES-E)

→ RES main fuel; all other fuels show lower share in 2050 than in 2005; RES-E share: 60 to 86%; Wind & PV contribute some 2/3 of entire RES-E

European Commission (2011)
EU energy & climate targets imply significant reduction of the use of fossil fuels and decarbonisation of the power sector

EU sectoral GHG emissions (1990 = 100%) (left) and primary energy consumption in the EU 2050 energy roadmap (right)

EC (2011)
Energy system decarbonisation leaves total system costs unchanged

Average annual total energy system costs 2011-2050

Main results decarbonisation scenarios in the EU Energy Roadmap 2050

- Shift in cost structure occurs
- Increase in capital costs
- Decrease in variable costs (fuel costs and imports)
- Outdated RES cost assumptions in the EC’s Roadmap modelling: 2050 cost assumptions for solar PV where in reality already reached in 2015

European Commission (2011)
A key insight: It’s about Wind and Solar
Wind energy has become a mature technology, with windmills of 2 - 3 MW being standard

Size development of wind turbines 1990 - 2015

IEA (2013)
Due to falling module prices, costs for Solar PV dropped massively in the last 10 years. The end of the cost digression is not yet reached.

**Historical price curve for PV modules since 1980**

-80% during last 10 years

**Expected cost digression for large-scale PV systems 2014 - 2050**

40 - 75%

Fraunhofer ISE (2015)
Today, wind and solar are cost competitive to other decarbonisation options and new fossil fuel plants. 

Range* of levelised cost of electricity (LCOE) in Europe in 2015

- **Wind (onshore)**: 3 - 11 ct/kWh
- **Solar PV (large scale)**: 8 - 17 ct/kWh
- **Hard Coal**: 7 - 11 ct/kWh
- **Gas (CCGT)**: 7 - 12 ct/kWh
- **Nuclear**: 6 - 13 ct/kWh
- **Hard Coal CCS**: 13 - 16 ct/kWh

* based on varying utilization, CO₂-price and investment cost


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Serbia: Current and future cost of solar energy

Levelised cost of electricity (LCOE) from large-scale solar PV in Serbia

Calculation based on Fraunhofer ISE (2015); Ranges include differences in irradiation within the country and scenarios of technology and global market development; global market for modules, inverters and other cost components is assumed, short-term effects of higher cost in new markets (e.g. 1st GW in a specific country) not considered.

Full load hours: 1100 - 1200 kWh/kWp p.a., Cost of capital (WACC): between 5% and 10%
Global capacity additions in renewables have overtaken those of conventional sources (coal, gas, nuclear)

Share in global capacity additions 2001-2013

IRENA (2014)
Carbon pricing schemes emerge across the globe and will soon cover 25% of global emissions

Existing & emerging carbon pricing schemes

Share of global emissions covered in carbon pricing schemes

World Bank (2016)
1. The Energiewende in a nutshell – with a focus on the power sector

The 2030 European power system
Flexibility and integration at its core
Flexibility and integration are the paradigms of the new power system

Electricity generation and consumption in a sample week with 50% RES share

Insights long-term EU energy scenarios

- Energy efficiency and RES (mainly wind and PV) main enabler of power sector decarbonisation
- Flexibilising power systems key for managing variability from wind & PV
- Flexible fossil & biomass plants, demand response, storage, sector coupling important flexibility options
- Cross border system integration (grids, system operations) key for minimizing flexibility challenge
- Wind and PV are about to become the cheapest options for power generation; Integration costs are moderate

Thank you for your attention!

Questions or Comments? Feel free to contact me:
christian.redl@agora-energiewende.de

Agora Energiewende is a joint initiative of the Mercator Foundation and the European Climate Foundation.
The integration cost of wind and solar (5 to 20 EUR/MWh) are moderate

Components of integration costs

- **Backup cost**
- **Utilization effect**
- **Grid cost**
- **Balancing**
- **Additional costs for conventional power plants**

Size depending on power system and perspective chosen

- **60 – 90 EUR/MWh**
- **5 - 20 EUR/MWh**

Agora Energiewende (2015)

* part of utilization effect
Energy system decarbonisation leaves total system costs unchanged

**Average annual total energy system costs 2011-2050**

![Graph showing the development of capital costs over time for different energy sources (RES)](image)

**Main results decarbonisation scenarios in the EU Energy Roadmap 2050**

→ Conservative cost assumptions in the modelling: 2050 cost assumptions for PV where in reality already reached in 2015

European Commission (2011)