A 100% Renewable Electricity Supply by 2050: Climate-friendly, Reliable, and Affordable

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The German Advisory Council on the Environment:

Providing scientific policy advice since 1971

- independent, inter-disciplinary scientific council nominated by the Federal Cabinet
- comprised of 7 professors (natural science, engineering, economics, law, political science)
- Broad mandate to provide early warning of negative trends and new ideas for furthering environmental policy and inform the wider public
- SRU is an active member of the European Environment Advisory Councils (EEAC)
The Challenge: Full Decarbonisation

WBGU, 2009: Solving the Climate Dilemma: the Budget Approach

Per-capita emissions paths

- Excluding emissions trading
- Including emissions trading

1. Country group 1
2. Country group 2
3. Country group 3

Emissions [t CO₂ per capita per year]

Year

2005 2010 2015 2020 2025 2030 2035 2040 2045 2050

WBGU, 2009: Solving the Climate Dilemma: the Budget Approach
Conclusions

• 100% renewable electricity is achievable by 2050
• Security of supply can be assured at a competitive cost
• Initial higher costs (compared to conventional energies) is an investment in the transition to a least cost solution
• (Offshore) wind energy will be the most important single contributor to a 100% renewable electricity system
• Pumpstorage capacity in Scandinavia will play a critical role in balancing supply and demand
• An energy transition without new coal plants or extended nuclear running times can be modelled
• Expanding supply of renewable energy from 2020 onwards requires flexible base load energy
Conclusion: Renewable energy is the least controversial and most sustainable option for decarbonisation.
Deutschen Zentrum für Luft- und Raumfahrt (DLR) Scenarios

Backcasting Approach

REMIX-Europe
(Renewable Energy Mix for Sustainable Electricity Supply in Europe)

Inventory of Resources
GIS (Geographic Information System), C

Power Needs and Load
GIS, C

Linear Optimisation
GAMS (General Algebraic Modeling System)
Key model assumption: Learning Cost Curves

In the middle range of literature
Low cost potential: Europe NorthAfrica (EUNA)

(ca. factor 8-10x forecasted demand)
### 100% renewable electricity

#### 8 scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Demand Germany 2050: 500 TWh</th>
<th>Demand Germany 2050: 700 TWh</th>
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<tbody>
<tr>
<td><strong>Self-Sufficiency</strong></td>
<td>Scenario 1.a DE-100 % SS-500</td>
<td>Scenario 1.b DE-100 % SS-700</td>
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<td><strong>Net self-sufficiency including trade with DK/NO</strong></td>
<td>Scenario 2.1.a DE-NO/DK-100 % SS-500</td>
<td>Scenario 2.1.b DE-NO/DK-100 % SS-700</td>
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<td><strong>Max 15% Net import from DK/NO</strong></td>
<td>Scenario 2.2.a DE-NO/DK-85 % SS-500</td>
<td>Scenario 2.2.b DE-NO/DK-85 % SS-700</td>
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<td><strong>Max 15% Net import from EUNA</strong></td>
<td>Scenario 3.a DE-EUNA-85 % SS-500</td>
<td>Scenario 3.b DE-EUNA-85 % SS-700</td>
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</table>
System Cost can be kept below 7ct/Kwh assuming stabilisation of electricity consumption and trade.
The cost development

Compared to a conventional supply scenario (Germany)

Specific electricity costs over time (Szenario 2.1.a)

- Konventionelle Energieträger (Leitstudie 2008, Szenario A)
- Erneuerbare Energien (inkl. Speicher & Transport)
- Anteil Speicher & Transport
- Konventionelle Energieträger (Leitstudie 2008 Szenario B)
- HVDC innerhalb Deutschlands
- Erneuerbare Energien (inkl. Speicher und Transport (nat. und int.))
Hourly results 2050 DE-DK-N

100% national production, 15% exchange
TEN-E Needs by 2050

and the key role of the nordic „power house“

Maximum transmission capacity in GW (Scenario 3.a)
Development of renewable energy mix
in Germany until 2050

Entwicklung der Bruttostromerzeugung 2005 bis 2050
konventionelle Erzeugung und regenerative Energiequellen (für 509 TWh/a in 2050)
Fluctuating supply over stretches nuclear plant flexibility already in 2020

- Nuclear ca. 20 GW
- Complete run down below 10 GW
- Überschüsse aus erneuerbaren Energien
Planning for the Future

- Develop a binding climate and carbon neutral electricity target linked to emissions trading for 2050 (important for providing economic signals)
- Promote further measures for energy efficiency—the most important bridging “technology”
- Introduce measures at both the European and national levels to support the expansion of renewables, including continuation of a reformed feed-in-tariff and development of 2030 renewables targets
- Avoid the construction of new conventional power plants as they are neither consistent with a low carbon energy goal nor with the need for a flexible base load power supply
- Initiate planning for and develop incentives to foster the development of a new, expanded electricity grid
- Cooperate with Scandinavia in the development of hydro pump storage capacity
BACKUP
Load Management needs are anticyclical to natural fluctuation of hydropower capacity

Pumpstorage in Norway:

Max. Füllstand 84 TWh

Min. Füllstand 0 TWh

NO real 2008
Minimale Speicherkapazität 1990-2007
Maximale Speicherkapazität 1990-2008
Szenario 2.1a
Szenario 2.1b
DLR REMix Regions

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