For Our Environment

decarbonization through cross sectoral supply with renewable energies

Goals

40 – 100 – 100Plus - GHG N – RTD

Policy

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Head of Division I – Environmental Planning and Sustainability Strategies
The German Climate Action Programme 2020

Germany’s Energy and Climate Protection Targets

<table>
<thead>
<tr>
<th>Climate</th>
<th>Renewable Energy</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG (vs. 1990)</td>
<td>Electric power</td>
<td>Total share</td>
</tr>
<tr>
<td>2020</td>
<td>- 40%</td>
<td>35%</td>
</tr>
<tr>
<td>2030</td>
<td>- 55%</td>
<td>50%</td>
</tr>
<tr>
<td>2040</td>
<td>- 70%</td>
<td>65%</td>
</tr>
<tr>
<td>2050</td>
<td>- 80-95%</td>
<td>80%</td>
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</tbody>
</table>
The Paris Agreement

Aims (Article 4):

- “Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C”

- Peaking of greenhouse gas emissions as soon as possible
- Net zero balance in the second half of this century
The Paris Agreement

Consequences (Article 4):

- "decarbonization" of all societies...
- Germany has to increase goals ....
- 95% Greenhouse Gas Emission in 2050 (industrialized countries)
Greenhouse Gas Neutral Germany

- 95%
Approach by a systemical / holistic analysis and scenarios
Greenhouse Gas Neutral Germany

1 ton CO2 per cap

- Agriculture
- Industry
- Land Use
- Waste
- Heating Cooling
- Transport
Greenhouse Gas Neutral Germany

Efficiency

- Electricity
- Industry
- Waste
- Land Use
- Transport
- Heating Cooling
- Agriculture
Energy Demand in diff. sectors

Germany 2008 and 2050

2008

TWh

<table>
<thead>
<tr>
<th>Category</th>
<th>Demand</th>
<th>2008</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raumwärme, Kälte</td>
<td>TWh</td>
<td>898</td>
<td>974</td>
</tr>
<tr>
<td>Warmwasser</td>
<td>35%</td>
<td></td>
<td></td>
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<tr>
<td>Prozesswärme/-kälte</td>
<td>22%</td>
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<td>mechanische Energie</td>
<td>38%</td>
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<tr>
<td>Beleuchtung, IKT u. Sonstiges</td>
<td>5%</td>
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</table>

2050

TWh

<table>
<thead>
<tr>
<th>Category</th>
<th>Demand</th>
<th>2050</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raumwärme, Kälte</td>
<td>TWh</td>
<td>76</td>
<td>35%</td>
</tr>
<tr>
<td>Warmwasser</td>
<td>6%</td>
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<tr>
<td>Prozesswärme/-kälte</td>
<td>427</td>
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<tr>
<td>mechanische Energie**</td>
<td>33%</td>
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<tr>
<td>Beleuchtung, IKT u. Sonstiges</td>
<td>52%</td>
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</table>

**Note:**
- TWh: Terawatt-hours
- **: Reduced demand
Greenhouse Gas Neutral Germany

100% REN

Electricity

Agriculture

Industry

Land Use

Waste

Heating Cooling

Transport
100% Electricity Supply from REN ...
GHG Neutral Germany - Electricity

Archetypes of 100% REN

Decentralized / small

Centralized / big

International / far away

National / Local / nearby

Harry Lehmann (2009)
GHG Neutral Germany - Electricity

- Decentralized / small
- National / Local / nearby
- International / far away
- Centralized / big

- "Regions Network" (2010 - 2014)
- "Local Energy Autarky" (2013)
- "International Large Scale" (2014)
- 2050: 100% Energy target 2050; 100% renewable electricity supply
GHG Neutral Germany - Electricity

Decentralized / small

National / Local / nearby

International / far away

“Local Energy Autarky” (2013)

“International Large Scale” (in progress)

Modellierung einer vollständig auf erneuerbaren Energien basierenden Stromerzeugung im Jahr 2050 in autarken, dezentralen Strukturen
GHG Neutral Germany - Electricity

- Installed Capacity GW:
  - Photovoltaic: 23.3 GW
  - Wind energy onshore: 6.4 GW
  - Wind energy offshore: 5.2 GW
  - Hydropower: 45 GW
  - Geothermal energy: 60 GW

- Decentralized / small vs. Centralized / big
- National / Local / nearby vs. International / far away
Feed-in of renewable energy and load – per month (winter)

Feed-in [GW] of all RE and the load curve

Example „Winter month“ (December) for the feed-in of renewable energies in 2050, based on the meteorological year 2007
Feed-in of renewable energies and load – per month (summer)

Feed-in [GW] of all RE and load

Example „Summer month“ (August) for the feed-in of renewable energies in 2050, based on the meteorological year 2007
Storage needed

- Gravitational Storage
- Chemical Storage (H2 or eMethan)
- Electric Storage
Different Storage Systems in a 100% REN Elec. System

Total residual load (with load management and pump storage) in the year 2050, based on data from the meteorological year 2007

Defizite: 62 TWh
Überschüsse: -111 TWh

pumped Storage (today)

42 Mio. electric vehicles (theory)

Capacity gas grid (today)

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PtL - The Process

INPUT:  
- RENEWABLE ENERGIES  
- PURIFIED CO₂  
- WATER

OUTPUT:  
- SYNTHETIC LIQUID FUELS  
- OXYGEN

www.sunfire.de

Established from Coal-to-liquid processes (South Africa)
Security of Supply

Strom-Importe sowie Einsatz von Elektrolyse und Rückverstromung (Meteo-Jahr 2006-2009)

maximale Residuallast: 57.3 GW

Elektrolyse-Leistung: 44 GW

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Greenhouse Gas Neutral Germany
Greenhouse Gas Neutral Germany
Greenhouse Gas Neutral Germany

Power to X

- Electricity
- Agriculture
- Industry
- Land Use
- Waste
- Heating Cooling
- Transport
Power to Mobility – direct use of electricity and PTL

Electricity (incl. Plug-in-Hybrid)

- Passenger car
- Trucks short haul
- possibly Trucks long haul as overhead wire
- Urban buses
- Rail traffic

PTL: methanol, kerosene, gasoline, diesel,
Power to Mobility – Scenario 2050 + (1.600 PJ)

Greenhouse Gas Neutral Germany

Power to X

- Electricity
- Agriculture
- Industry
- Land Use
- Waste
- Heating Cooling
- Transport
2050 scenarios with different renovation standards

Quelle: UBA – ÖkoInstitut – Fraunhofer Institut 2016
2050 scenarios with different renovation standards

Quelle: UBA – ÖkoInstitut – Fraunhofer Institut 2016
Greenhouse Gas Neutral Germany

- Electricity
- Industry
- Agriculture
- Land Use
- Waste
- Heating
- Cooling
- Transport

PT H
PT G
PT L
PT C
Greenhouse Gas Neutral Germany

- Agriculture
- Industry
- Land Use
- Waste
- Heating Cooling
- Transport

PT H
PT G
PT L
PT C
Greenhouse Gas Neutral Germany

1 ton CO2 per cap
Possible range of GHG-neutral final energy sources

Source UBA, 2014/2016
Qualitative representation of the energy flow in the UBA THGND 2050 Scenario
Elements of a Greenhouse Gas Neutral Society

Per capita emissions of just one metric ton of CO$_2$eq in 2050
Final energy demand in 2050 reduced by 50 % versus 2010

Sector coupling via “Power to Gas” and “Power to Liquid” implies a steep rise in electricity consumption

The net energy to be generated amounts to approximately 3.000 TWh p.a. predominantly produced by wind and PV installations (2014: 511 TWh)

No use of neither energy crops nor CCS nor nuclear energy is assumed
Greenhouse Gas Neutral Germany
Globale Primärrohstoffentnahme

Can we reduce resource use to sustainable levels at the same time?
The new project of UBA – RTD2050:

Pathways towards a greenhouse gas neutral and resource efficient country till 2050

- 100 % renewable energy in power, heat, traffic and industry
- especially technical measures for the reduction of ghg emission in all areas
- Ecological and sustainable Agriculture
- Changed meat consumption
- High recycling rates (80%) and use of secondary materials
- Reductions along the whole value chain
- Different Scenarios – e.g. less Efficiency ... More Import ... ???
Climate Action Plan 2050

Target
- 80 to 95% reduction of greenhouse gas emissions by 2050 (below 1990 levels)

Strategies
- Identification of robust strategies and possible transformative pathways

Measures
- Building on dialogue and participation
- Recommendations to the government
- Government to assess, comment on recommendations, draft climate action plan by summer 2016
All sectors contribute to emissions reduction

- Energy
- Private Households
- Other emissions (waste, ...)
- Cross-sectoral measures
- Agriculture
- Industry Commerce Trade Services
- Transport
UBA Position paper to the Climate Action Plan 2050

- Designing the transformation process to a GHG neutral society
- Ambitious GHG reduction of 95% (below 1990 levels)
- Recommendation of 32 measures to the German government

English version of this position paper is forthcoming.
UBA Position paper to the Climate Action Plan 2050

Climate Action Plan 2050

English version of this position paper is forthcoming.
Thanks!


Dr. Harry Lehmann (harry.lehmann@uba.de)

http://www.umweltbundesamt.de/en

• Germany 2050 - A Greenhouse Gas-Neutral Country
  https://www.umweltbundesamt.de/publikationen/germany-2050-a-greenhouse-gas-neutral-country

• Integration of Power to Gas/ Power to Liquids into the ongoing transformation process
  https://www.umweltbundesamt.de/publikationen/integration-of-power-to-gas-power-to-liquids-into

• Proceedings of the Workshop „Decarbonisation – 100 % Renewable Energy and more“ from November 2015
  https://www.umweltbundesamt.de/en/publikationen/proceedings-of-the-workshop-decarbonisation-100