The Challenge of Renewable Energies & Decentralized Power Systems

State of the Art, Potentials & Perspectives

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Electrical Energy Technology
Sustainable Energy Concepts

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Overview

1. Energy Resources & Potentials

Development of Energy use

Present status of Renewables (Worldwide & Germany)

Challenges for the Energy Structure
Solar energy contribution to our living:

1% ?
5%?
20% ?

Solar energy contributes by 94% to World’s energy:
it warms up Earth from space’s –273.2°C to +14.5°C
- thus enabling all forms of life.

To allow a human habitat without sun we would need 15 times more commercial energy than we consume today (15 \cdot 429.4 \text{ EJ}).
Energy consumption and resources
Energy consumption and resources

Natural Gas resources
Oil resources
Coal resources
Uranium resources

World's Energy consumption of one year
Energy consumption and resources

Natural Gas resources
Oil resources
Coal resources
Uranium resources

World’s Energy consumption of one year
solar energy irradiated during one year onto the surface of the Earth
Development of energy consumption: past & future

World consumption of energy in EJ

Year

1900 1920 1940 1960 1980 2000 2020 2040 2060

Former development
Prediction by Shell

Others
Geo thermal
Solar
Biomass
Wind power
Nucelar power
Hydo power
Gas
Mineral oil
Coal

Firewood, traditional Biomass
11 MW PV power plant in Sherpa, Portugal
Members of Asia-Pacific Economic Cooperation (APEC) are: Australia, Brunei, Canada, Indonesia, South Korea, Malaysia, New Zealand, The Philippines, Singapore, Thailand, USA, Panama, Taiwan, Hong Kong, Mexico, Papua New Guinea, Chile, Peru, Russia, Vietnam plus China and Japan, visualised separately.

Source: European Photovoltaik Industry Association (EPIA); "Global Market Outlook for Photovoltaics until 2015"; Image: BMU / Brigitte Hiss; as at: May 2011; all figures provisional.
Installed capacity and energy supply from photovoltaic installations in Germany

Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat);
1 GWh = 1 Mill. kWh; 1 MW = 1 Mill. Watt; image: BMU / Bernd Müller; as at: July 2011; all figures provisional

Electricity supply [GWh]
installed capacity [MWp]

[17,320 MWp]
„Learning curve“ of PV
(for crystalline Si-wafer based PV)

Cumulative installed PV Peak Power [GW_p] vs. [€/W_p]

1980
1990
2000
2009
2011
Roadmap to „grid parity“ of PV

Market support programs necessary:

Ref: W. Hoffmann, personal estimates, 1999
Installed windpower worldwide (215 GW June 2011)

Total installed capacity by the end of June 2011 [MW]

- China: 52.800
- USA: 42.432
- Germany: 27.981
- Spain: 21.150
- India: 14.550
- Italy: 6.200
- France: 6.060
- United Kingdom: 5.707
- Canada: 4.62
- Portugal: 3.96
- Rest of the World: 29.500

Reference: WWEA 2011
Development of electricity production and installed capacity of wind energy plants in Germany

![Graph showing development of electricity generation and installed capacity from 1990 to 2010.](image)

- **Electricity generation [GWh]**
- **Installed capacity [MW]**

**Sources:**
- C. Ender: "Wind Energy Use in Germany - Status 31.12.2010"; Deutsches Windenergie-Institut (DEWI);
- BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat);
- 1 GWh = 1 Mill. kWh; 1 MW = 1 Mill. Watt;
- Image: BMU / Christoph Edelhoff; all figures provisional.

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**Development of renewable energy sources in Germany in 2010**

- Amendment to BauGB: November 1997
- EEG: April 2000
- EEG: August 2004
- EEG: January 2009
- EEG: August 2004
- 27,204 MW

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**Decentralized Power Systems - DPS 2011**

Prof. Dr. Stefan Krauter

Sustainable Energy Concepts

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### Installed capacity for electricity generation from renewable energy sources in Germany

<table>
<thead>
<tr>
<th></th>
<th>Hydropower</th>
<th>Wind energy</th>
<th>Biomass (^1)</th>
<th>Biogenic share of waste (^2)</th>
<th>Photovoltaics (^5)</th>
<th>Geothermal energy</th>
<th>Total capacity</th>
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1) Biogenic share of waste
2) Estimated at 50%
Contribution of renewable energy sources to electricity supply in Germany

* Solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste; electricity from geothermal energy not presented due to negligible quantities produced; 1 GWh = 1 Mill. kWh;

StromEinspG: Act on the Sale of Electricity to the Grid; BauGB: Construction Code; EEG: Renewable Energy Sources Act;

Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); image: BMU / Christoph Edelhoff; as at: July 2011; all figures provisional
Structure of electricity supply from renewable energy sources in Germany 2010

Total: 103.5 TWh

- Hydropower: 19.9%
- Wind energy: 36.5%
- Photovoltaics: 11.3%
- Biogenic solid fuels: 11.4%
- Biogenic liquid fuels: 1.7%
- Biogas: 12.9%
- Sewage gas: 1.1%
- Landfill gas: 0.7%
- Biogenic share of waste: 4.5%

Share of biomass*: 32%

* Solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste; electricity from geothermal energy not presented due to negligible quantities produced; deviations in the totals are due to rounding; 1 TWh = 1 Bill. kWh; Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); as at: July 2011; all figures provisional
Contribution of Renewables to Electricity Generation in Germany

Germany 2001: 6.7%

Germany 2006: 11.6%

Germany 2010: 16.8%

Germany 2011: 20.0% (Press declaration by German’s Environmental Minister Rötgen, 30th of August 2011)
Change in energy structures

Example: Hydro storage

La Muela I&II at Río Jucar (Spain) extended by 850 MW via four 213 MW pumping turbines.

This storage was principally set-up to increase availability of electricity due to increasing wind power share in Spain.
Grid load in Germany and actual PV power generation

Grid load in Germany (GW)

Time of the day (h)

Peak load

Middle load

Base load

PV power output

Clear day
Challenge to initiate use of smart loads

Technical solutions:
• Intelligent loads which adapt to grid load condition
• Intelligent combination of different energy sources and storage

User awareness:
• Decision-making: which loads should be controlled by the user, which loads can be controlled the grid

Grid access & Trading:
• Creation of a fair market for real-time trading of energy, even in small amounts
The organization team wishes you a fruitful conference!