

The Challenge of Renewable Energies & Decentralized Power Systems

State of the Art, Potentials & Perspectives

Prof. Dr.-Ing. habil. Stefan Krauter

University of Paderborn
Electrical Energy Technology
Sustainable Energy Concepts

www.nek.upb.de

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% ?

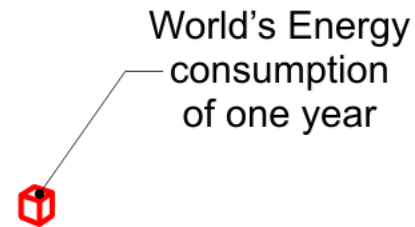
5%?

20% ?

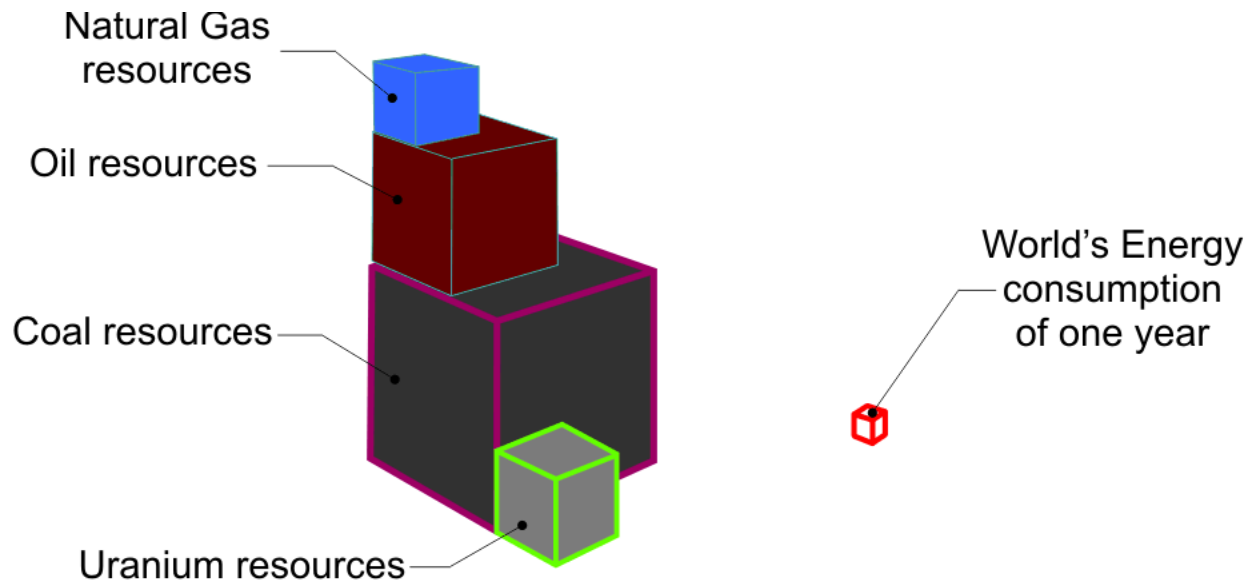
Solar energy contributes by **94%** to World's energy:
it warms up Earth from space's -273.2°C to $+14.5^{\circ}\text{C}$
- thus enabling all forms of life.

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

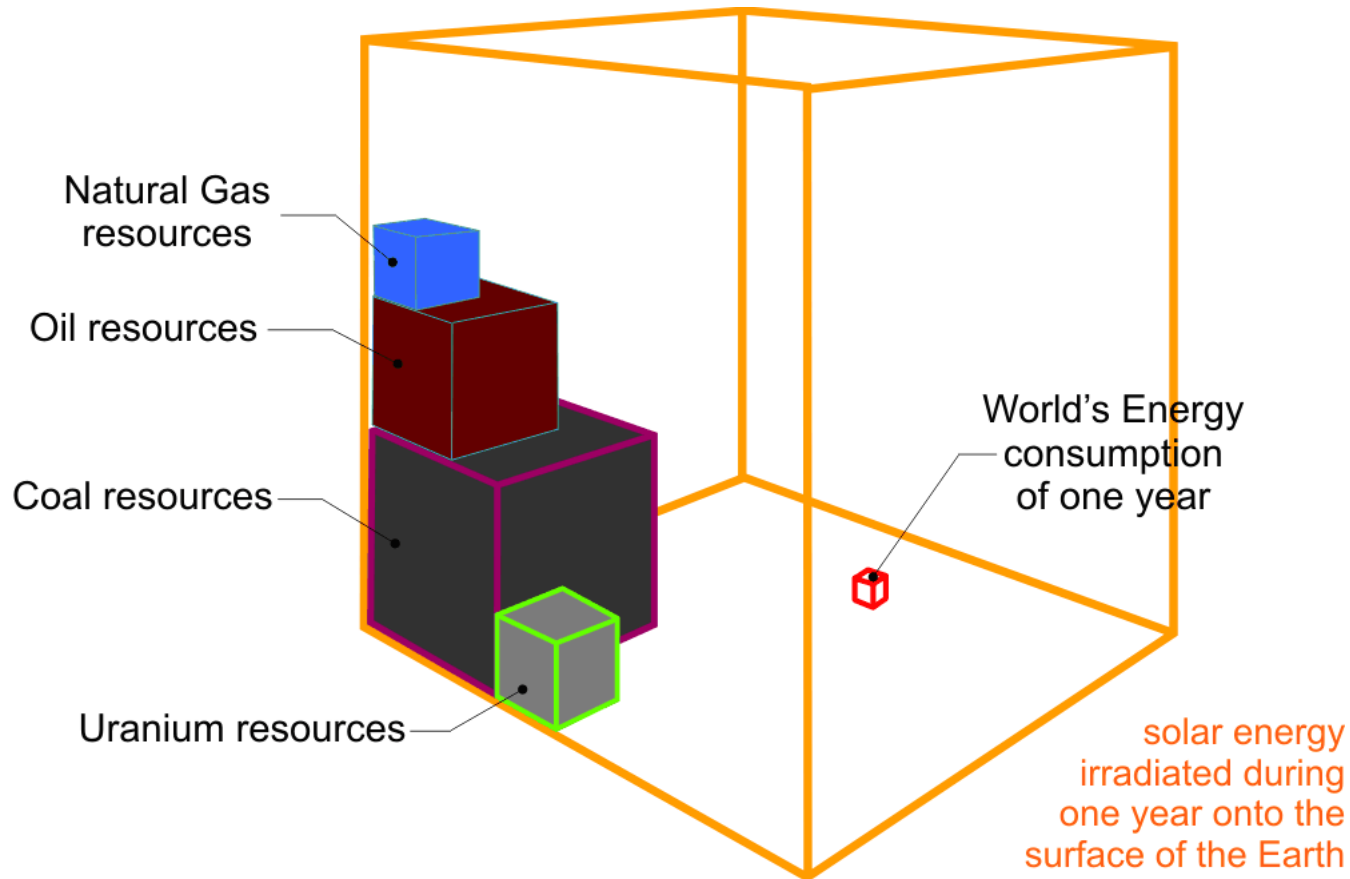
Energy consumption and resources



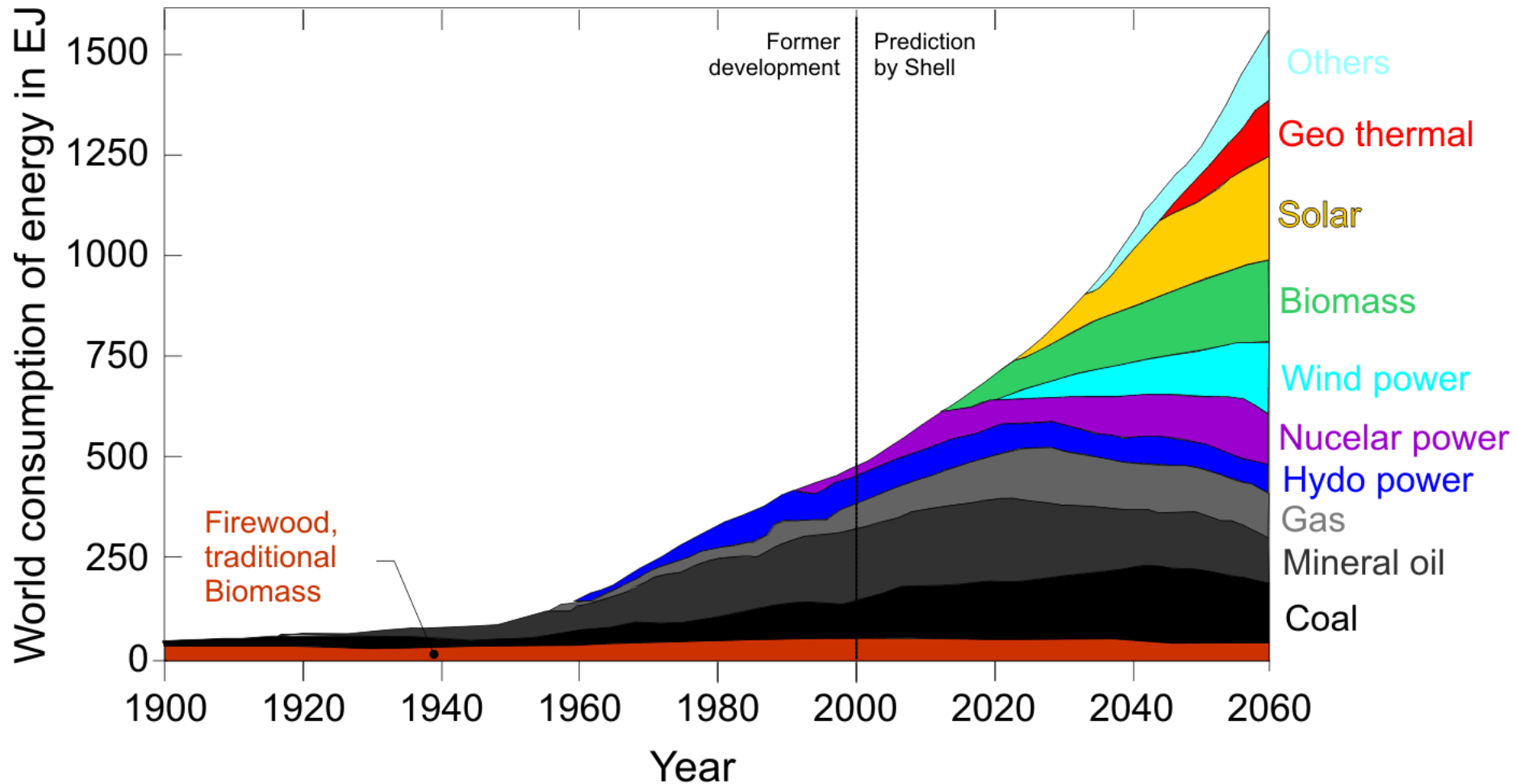
Energy consumption and resources



Energy consumption and resources



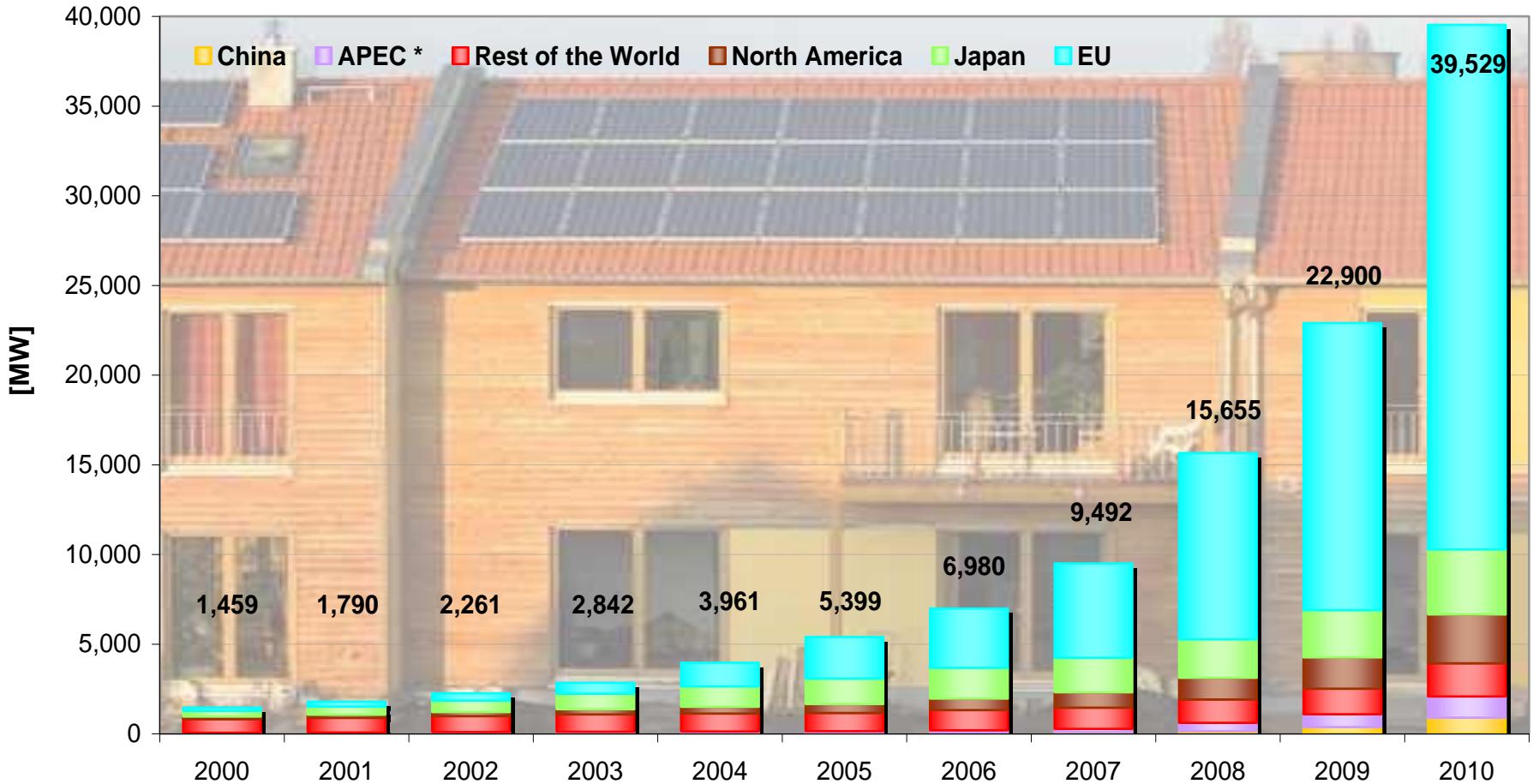
Development of energy consumption: past & future



11 MW PV power plant in Sherpa, Portugal



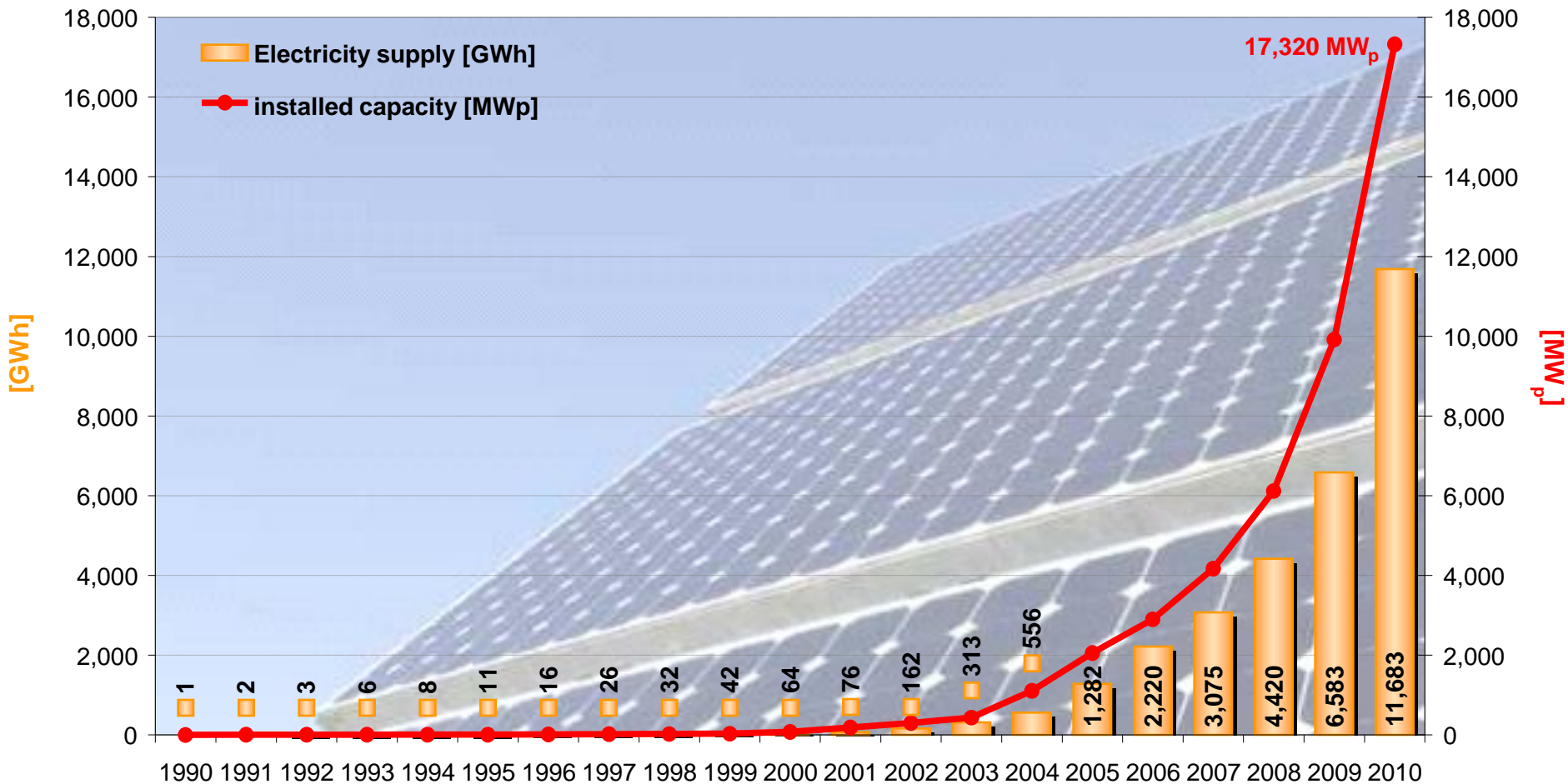
Worldmarket photovoltaics 2000 - 2009 cumulated installed capacity



Members of Asia-Pacific Economic Cooperation (APEC) are: Australia, Brunei, Canada, Indonesia, South Korea, Malaysia, New Zealand, The Philippines, Singapore, Thailand, USA, Panama, Taiwan, Hongkong, Mexico, Papua New Guinea, Chile, Peru, Russia, Vietnam plus China and Japan, visualised separatly.

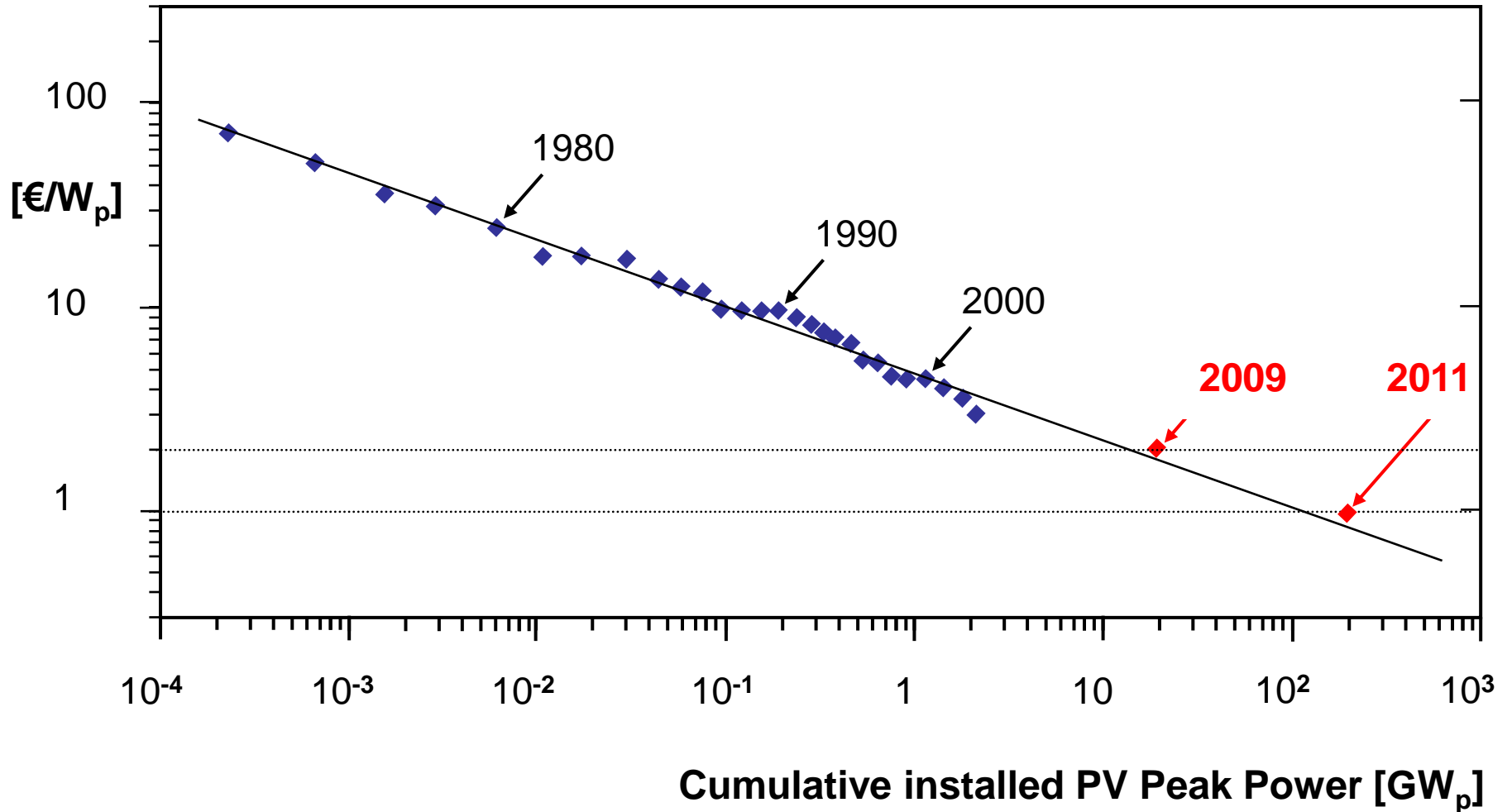
Source: European Photovoltaik Industry Association (EPIA): "Global Market Outlook for Photovoltaics until 2015"; Image: BMU / Brigitte Hiss; as at: May 2011; all figures provisional

Installed capacity and energy supply from photovoltaic installations in Germany



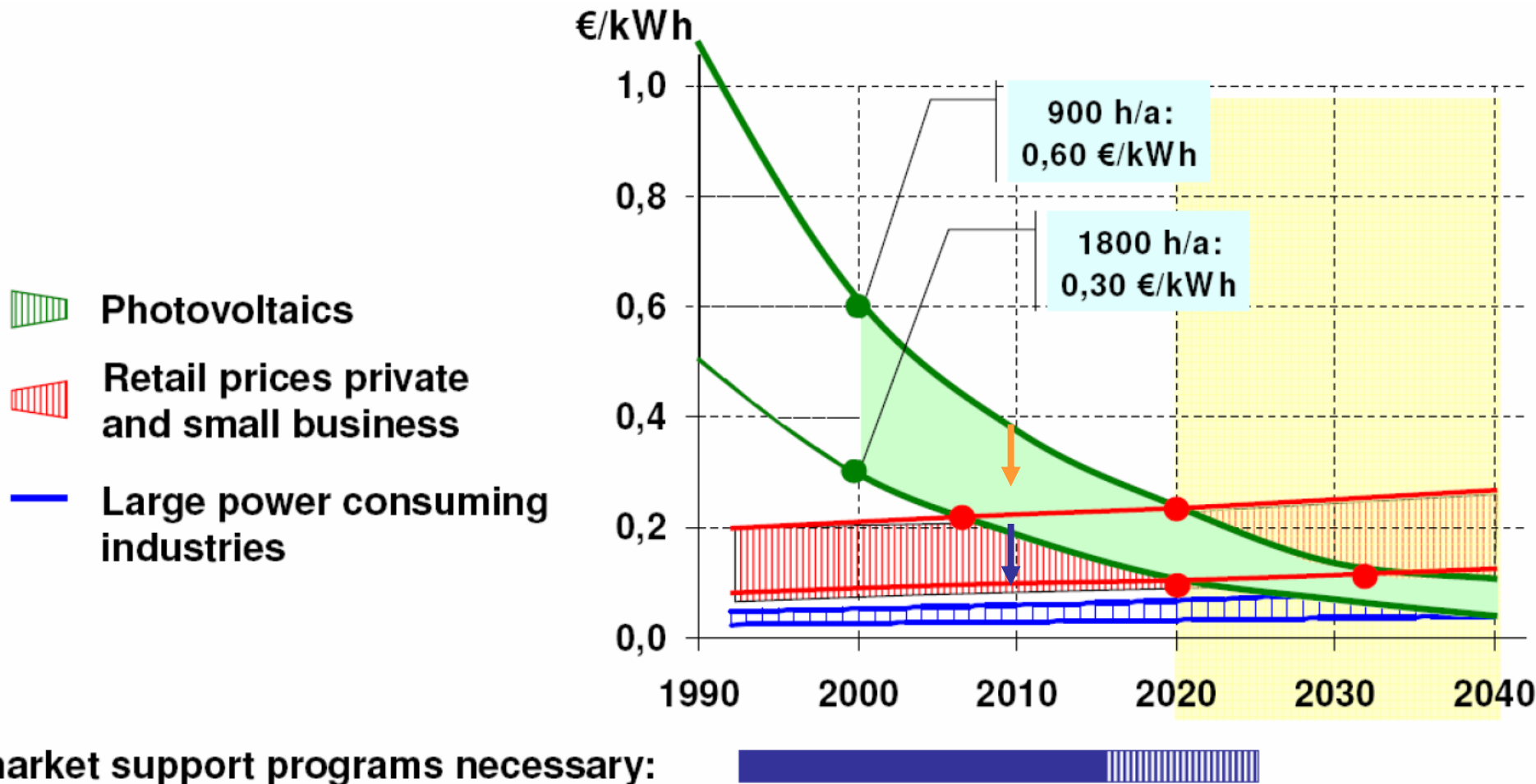
Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat);
 1 GWh = 1 Mill. kWh; 1 MW = 1 Mill. Watt; image: BMU / Bernd Müller; as at: July 2011; all figures provisional

„Learning curve“ of PV (for crystalline Si-wafer based PV)



Cumulative installed PV Peak Power [GW_p]

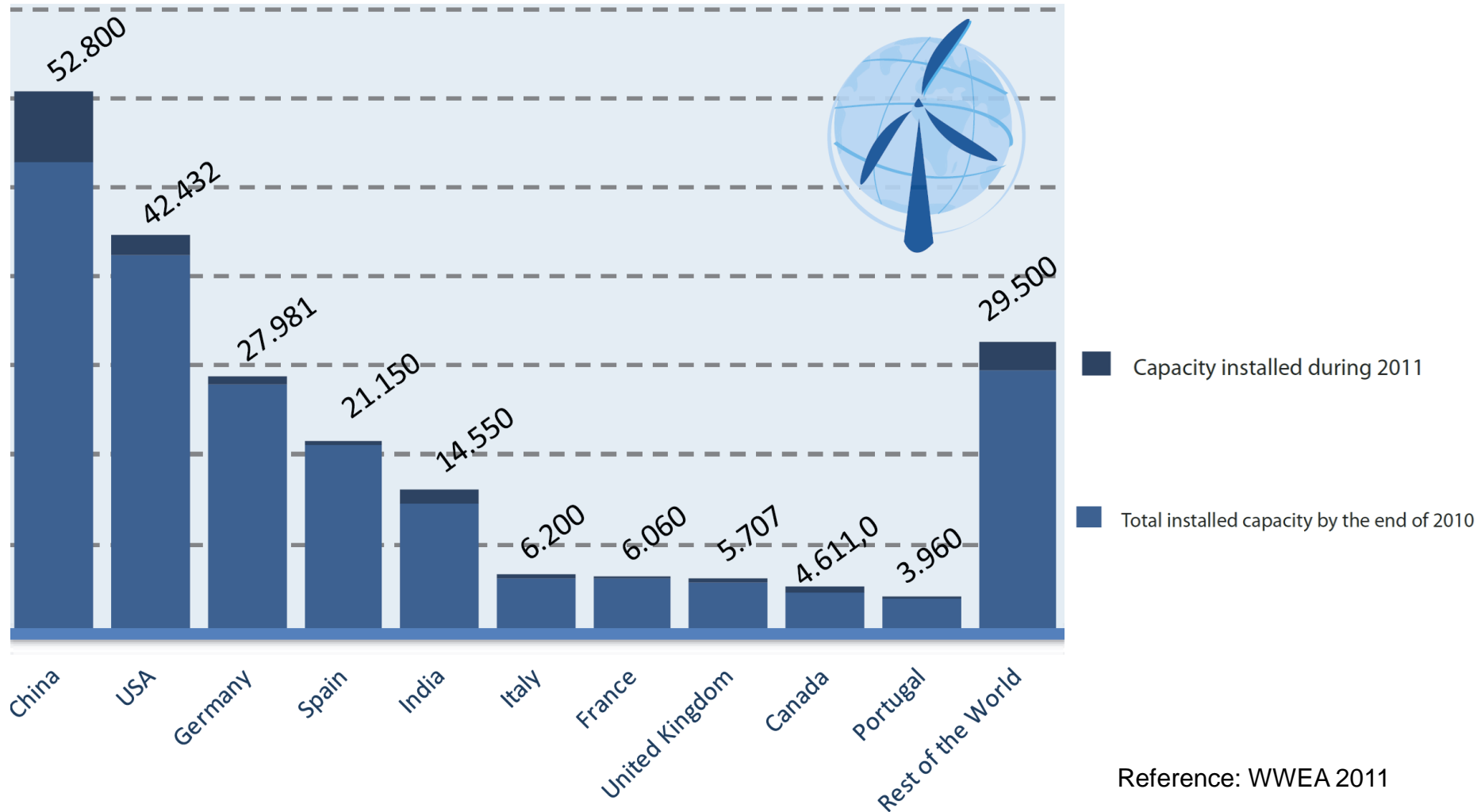
Roadmap to „grid parity“ of PV



Ref: W. Hoffmann, personal estimates, 1999

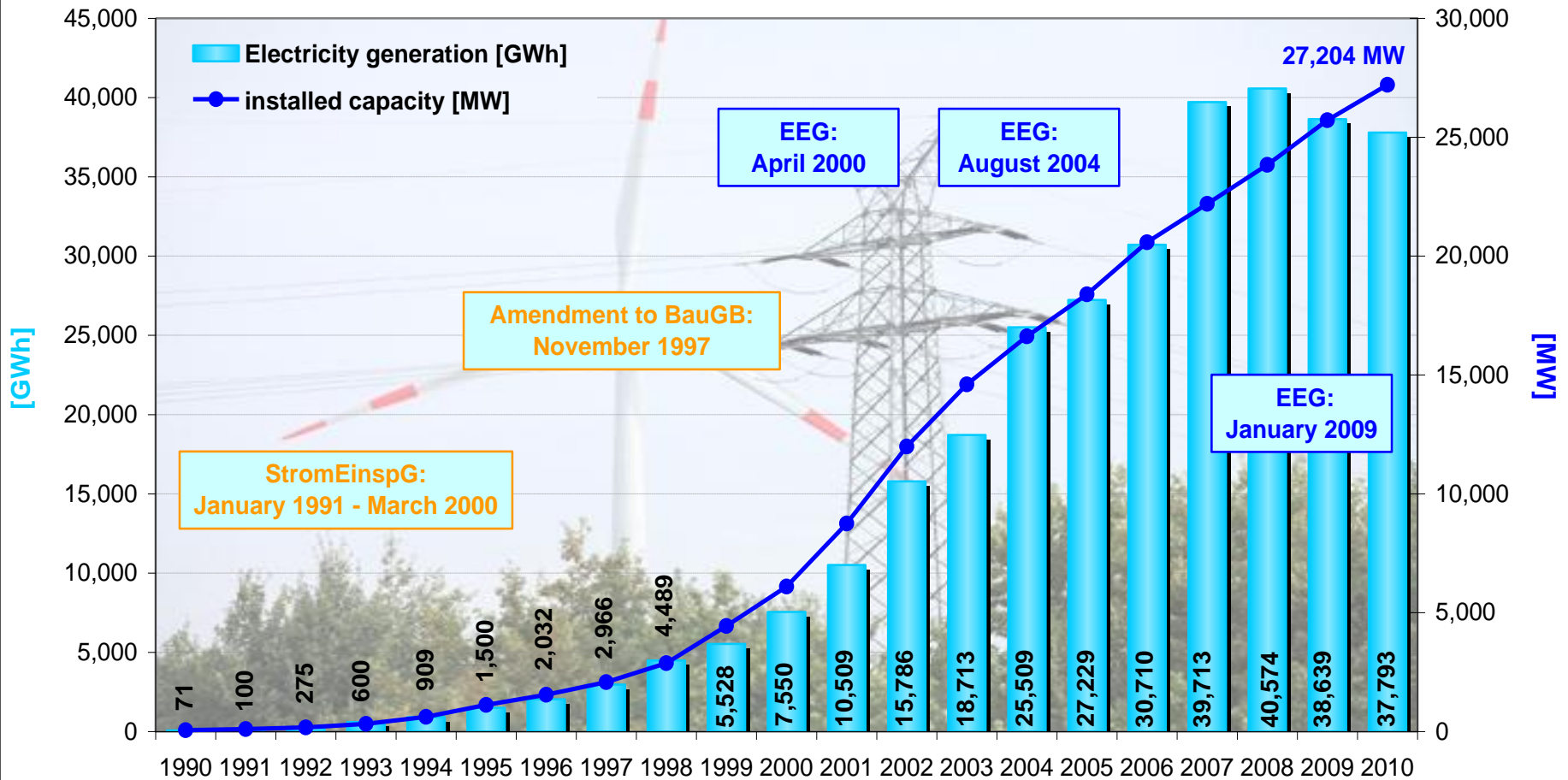
Installed windpower worldwide (215 GW June 2011)

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



Reference: WWEA 2011

Development of electricity production and installed capacity of wind energy plants in Germany



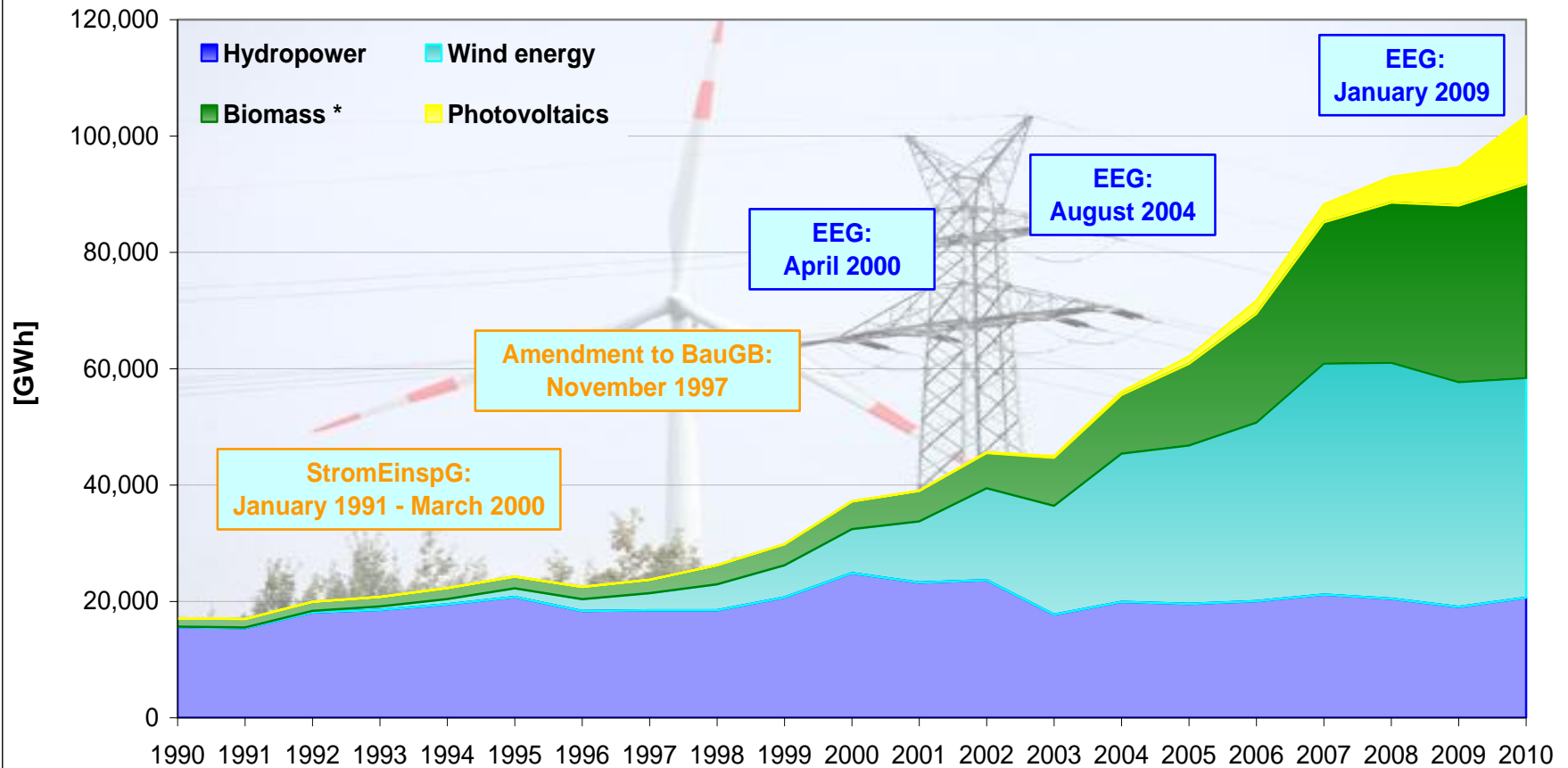
Sources: C. Ender: "Wind Energy Use in Germany - Status 31.12.2010"; Deutsches Windenergie-Institut (DEWI);

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

Installed capacity for electricity generation from renewable energy sources in Germany

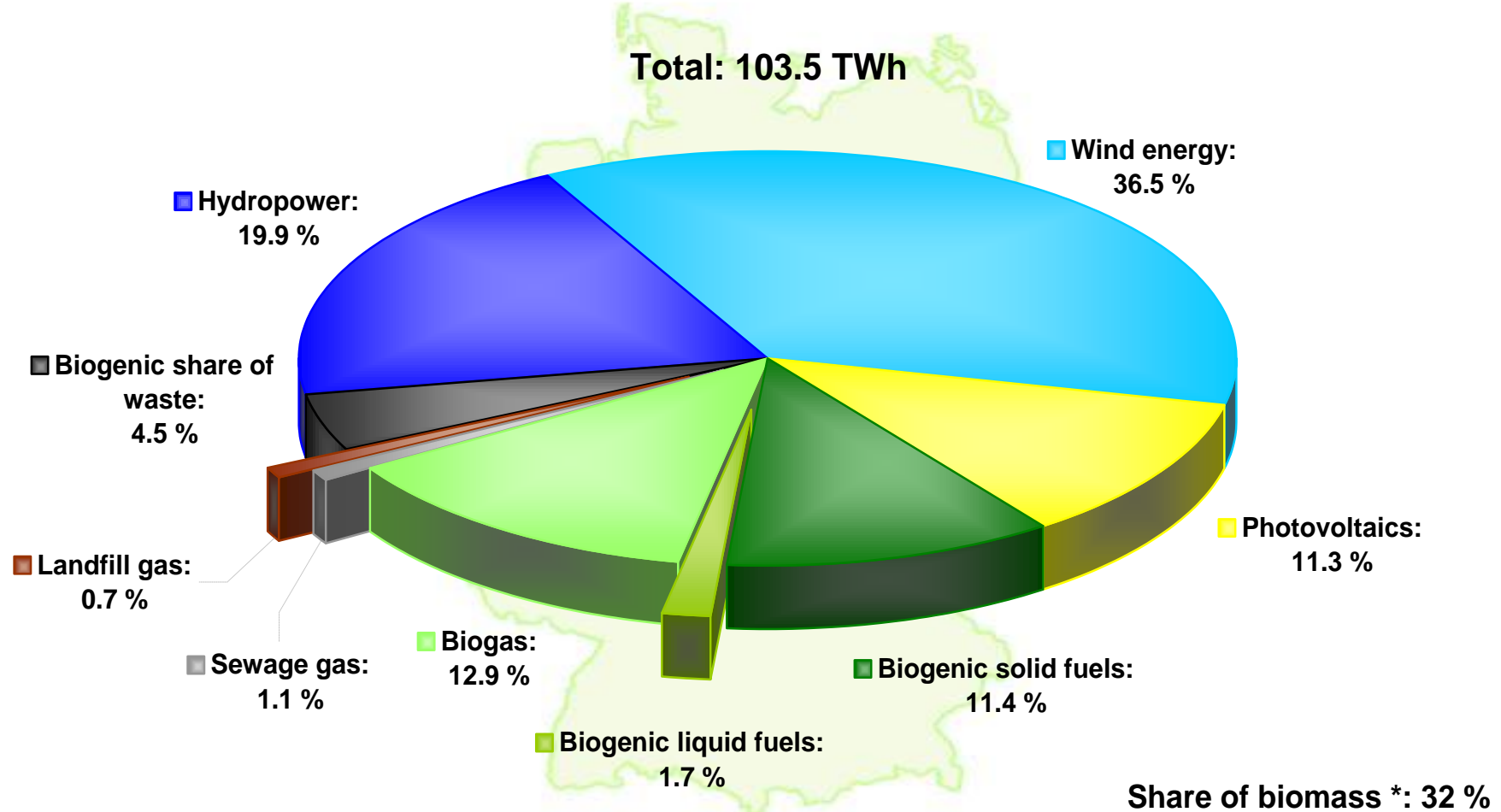
	Hydropower	Wind energy	Biomass ¹⁾	Biogenic share of waste ²⁾	Photovoltaics	Geothermal energy	Total capacity
	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]	[MW]
1990	4,403	55	85	499	1	0	5,043
1991	4,446	106	9	499	2	0	5,149
1992	4,489	174	105	499	3	0	5,270
1993	4,509	326	144	499	5	0	5,483
1994	4,529	618	178	499	6	0	5,830
1995	4,546	1,121	215	525	8	0	6,415
1996	4,563	1,549	253	551	11	0	6,927
1997	4,578	2,080	318	527	18	0	7,521
1998	4,600	2,877	432	540	23	0	8,472
1999	4,547	4,439	467	555	32	0	10,040
2000	4,600	6,097	579	585	76	0	11,937
2001	4,600	8,750	696	585	186	0	14,817
2002	4,620	11,989	843	585	296	0	18,333
2003	4,640	14,604	1,091	847	435	0	21,617
2004	4,660	16,623	1,444	1,016	1,105	0.2	24,848
2005	4,680	18,390	1,964	1,210	2,056	0.2	28,300
2006	4,700	20,579	2,620	1,250	2,899	0.2	32,048
2007	4,720	22,194	3,434	1,330	4,170	3.2	35,851
2008	4,740	23,836	3,969	1,440	6,120	3.2	40,108
2009	4,760	25,716	4,519	1,550	9,914	7.5	46,467
2010	4,780	27,204	4,960	1,650	17,320	7.5	55,922

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



* 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

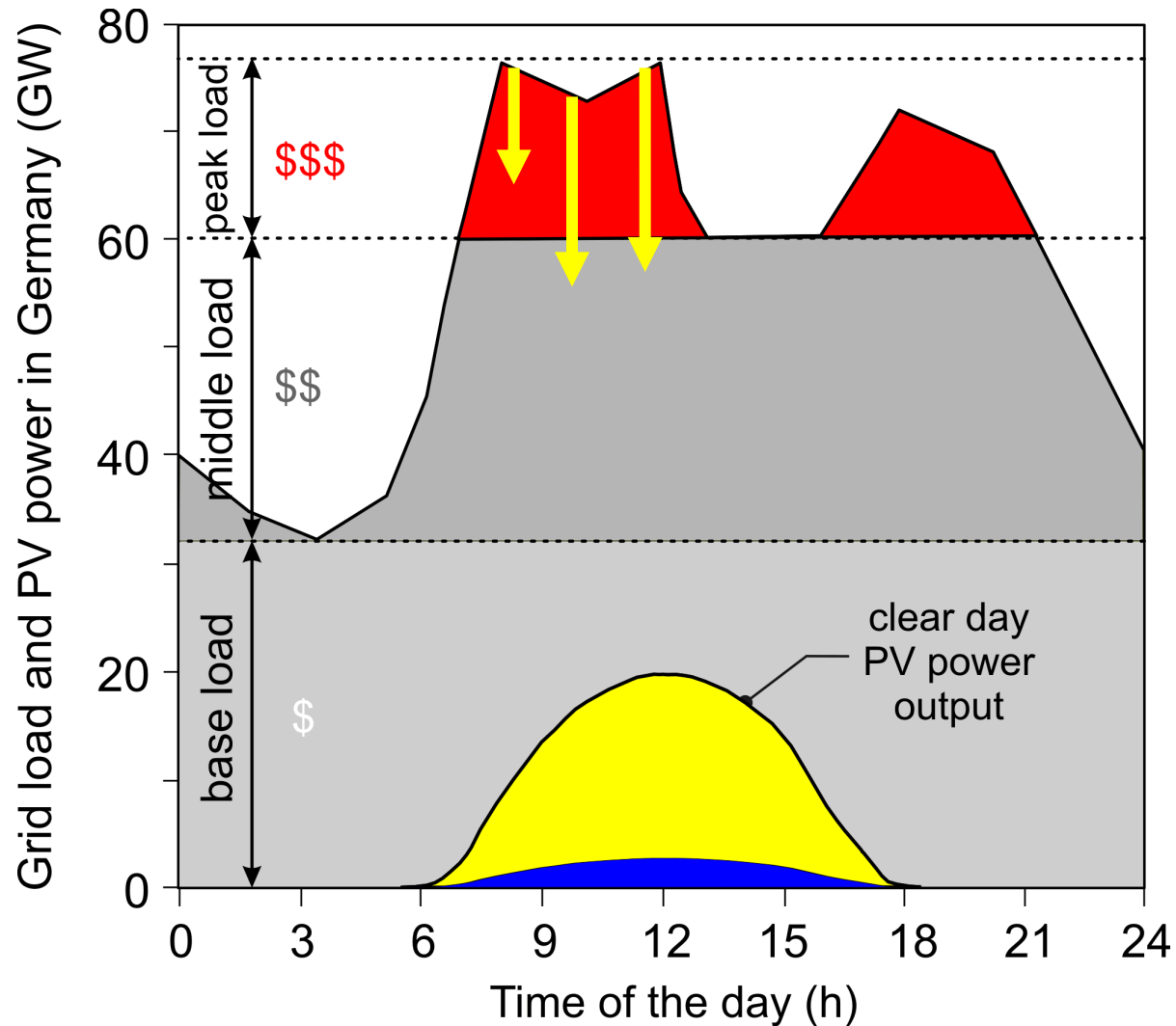
Example: Hydro storage

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



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 !