

Cost, Price, Markets, & Support Mechanisms: Part 2

Lecture 19

MIT Fundamentals of Photovoltaics
2.626/2.627 – 11/22/2011

Prof. Tonio Buonassisi

Info About the PV Space

- Websites:
 - <http://www.greentechmedia.com>
 - <http://www.solarbuzz.com>
 - <http://www.solarnovus.com>
- Blogs / Twitter Feeds:
 - <http://guntherportfolio.com/>
 - <http://earth2tech.com/>

Today's Topics: Cost, Price, and Markets

- What sets price (and profit)
- Energy future and overview of renewable energy sources
- Economics and market dynamics
- Fluctuations in supply and demand, drivers for oversupply/undersupply conditions, and what this means for profits.
- Subsidies: Why subsidize? How much to subsidize? Role of PV in the global energy market.

Incentives!

Tax Breaks!

~~Subsidies~~

Support Mechanisms!

Summary of Support Mechanisms

Many forms of support

“best” depends on other policy objectives

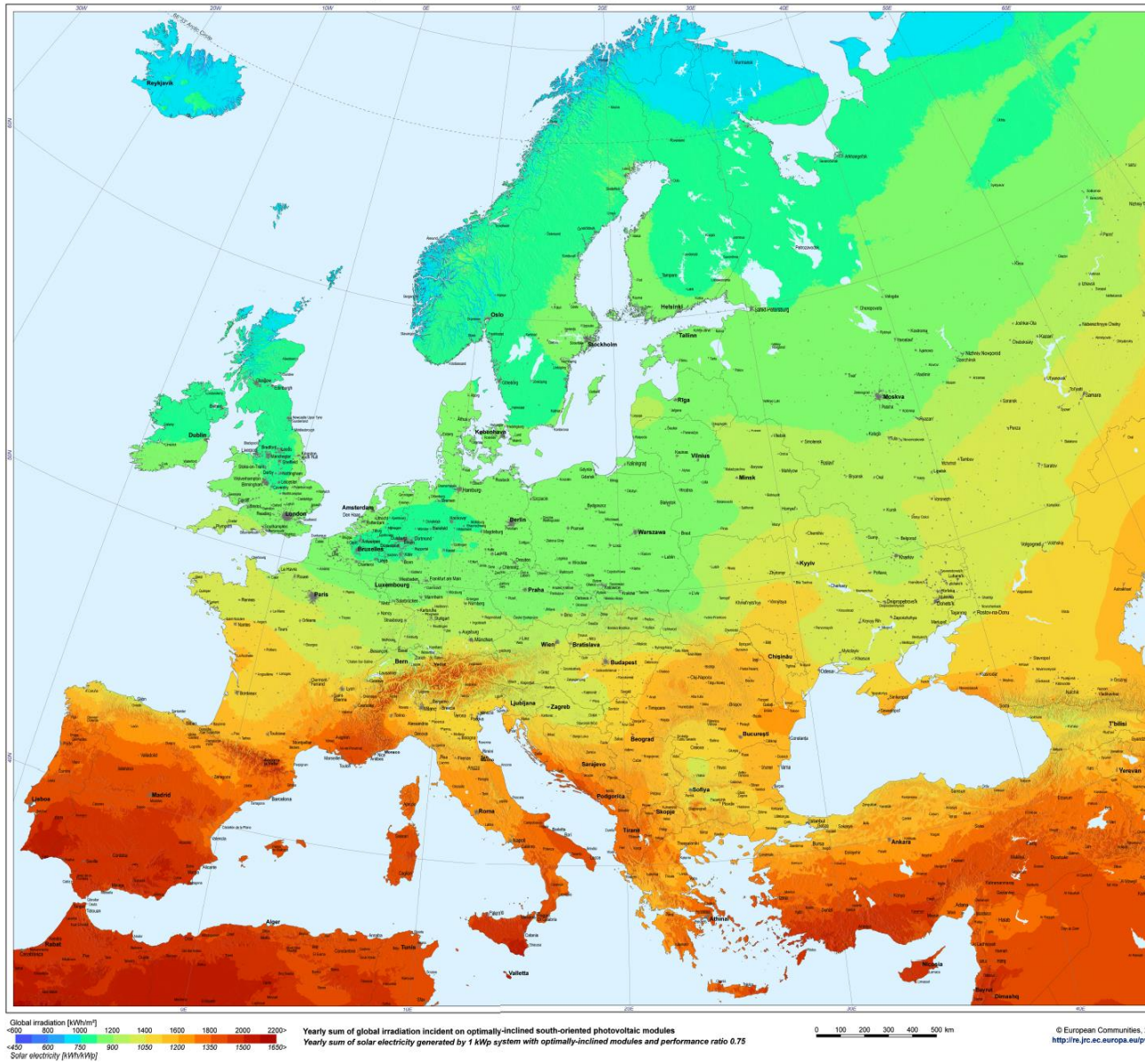
	Measure	Advantages	Disadvantages	Examples
Margin enhancement	Feed-in tariff	Stable revenues. Technology specific	Uneconomic deployment	Germany/Spain/USA
	Premium to fossil market	Greater transparency	Greater uncertainty on fossil price	UK
	Tax relief	Simple	Too easily changed by Government	USA
	Grants/soft loans	Simple	Allocation procedure	EU member states, USA
Penalties	Carbon caps	Transparent	Customers pay premium for all generation	European emissions trading
Mixture	Renewable Obligations	Transparent, market driven. Technology independent	Price uncertainty Technology independent	UK

Slide courtesy D. Kammen, UC Berkeley

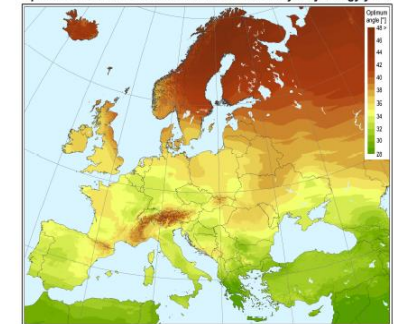
Courtesy of Prof. Daniel M. Kammen, UC Berkeley. Used with permission.

Deep Dive: The Germany Case

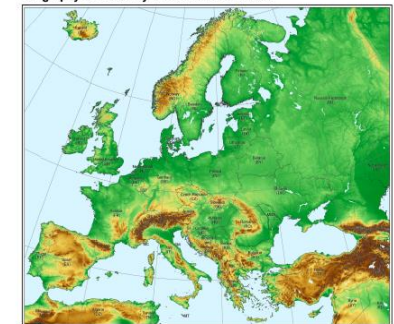
Photovoltaic Solar Electricity Potential in European Countries



Optimum inclination of PV modules to maximize yearly energy yield



Orography and country names with ISO codes



Data description

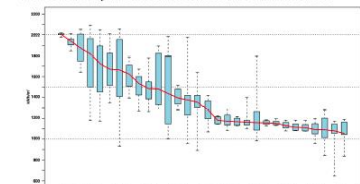
The PVGIS database is developed from measurements at 566 meteorological stations by combination of solar radiation model *r* sun and spatial interpolation. It contains monthly and yearly averages representing the period 1981-1990. Grid resolution (enhanced by terrain): 1 km x 1 km. Map projection: Lambert azimuthal equal area, WGS 84, lat 48°, lon 18°.

Auxiliary data

- GISCO database © Eurostat 2006
- CORINE Land Cover 2000 (<http://terrestrial.eionet.europa.eu/CLC2000>)
- Global Land Cover 2000 (<http://www.glm.jrc.it/glc2000/>)
- Digital terrain model (SRTM30) (<http://seamless.usgs.gov/>)
- City Population © Thomas Brinkhoff 2006 (<http://www.citypopulation.de/>)

Note: the delineation of the international boundaries and geographical names must not be considered authoritative.

Comparison of yearly global irradiation incident on optimally-inclined photovoltaic modules in 25 European Union member countries and 5 candidate countries



The country averages are connected by the red line. The minima/maxima in each country are shown as dashed lines, while the boxes show the range in which 50% of built-up areas in the country fit.

Authors

Marcel Šuri, Thomas A. Huld, Ewan D. Dunlop, Tomáš Cebeauer
 European Commission - DG Joint Research Centre, Institute for Environment and Sustainability
 Renewable Energies Unit, TP 450, I-21020 Ispra (VA), Italy

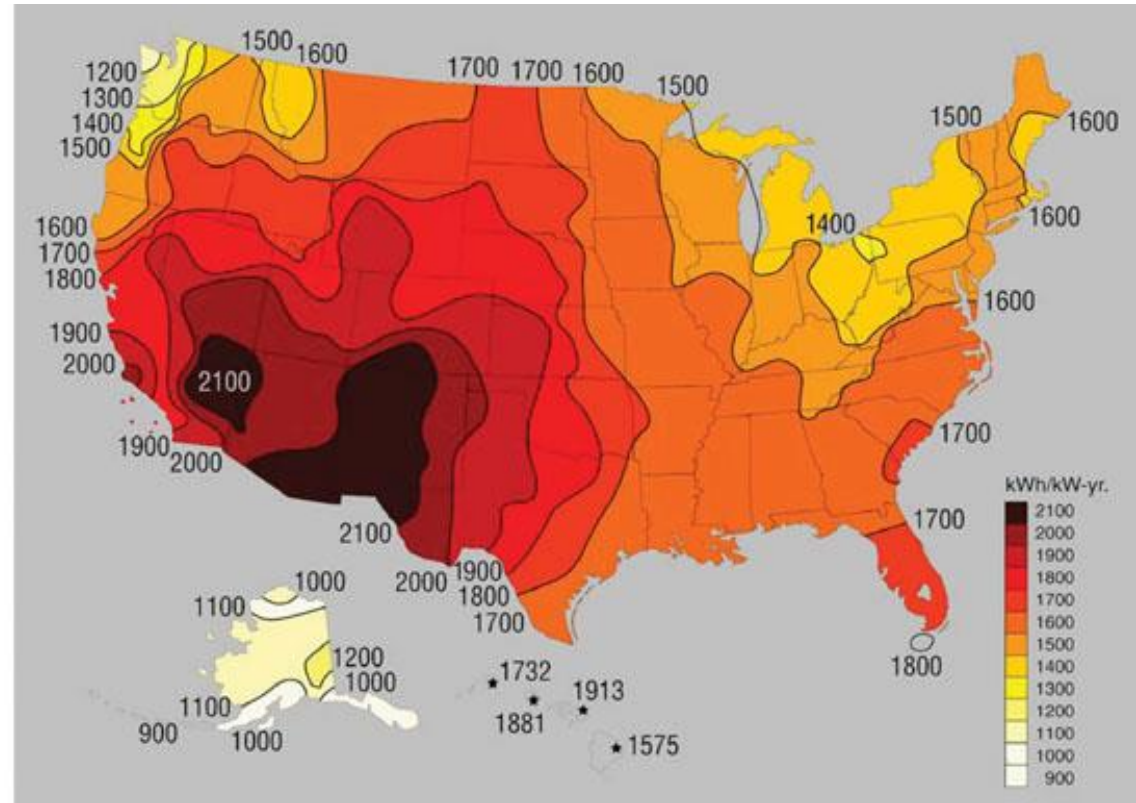
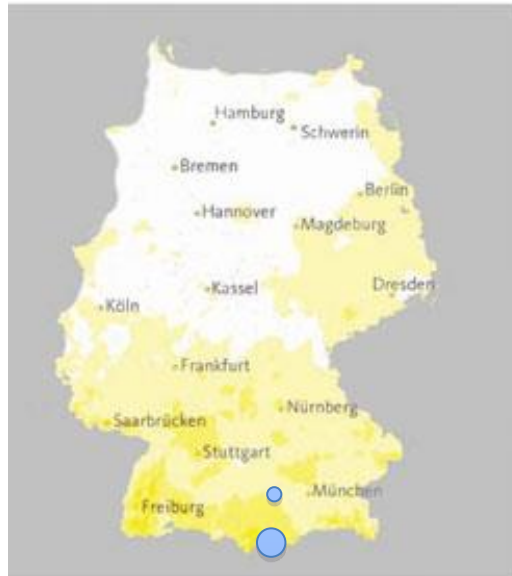
Legal notice: Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication.

Printed in December 2006

<http://sunbird.jrc.it/pvgis/countries/countries-europe.htm>

Source: PVGIS © European Communities, 2001-2007. Used with permission. Reference: Šuri M., Huld T.A., Dunlop E.D. Ossenbrink H.A., 2007. "Potential of solar electricity generation in the European Union member states and candidate countries." Solar Energy, 81, 1295-1305, <http://re.jrc.ec.europa.eu/pvgis/>.

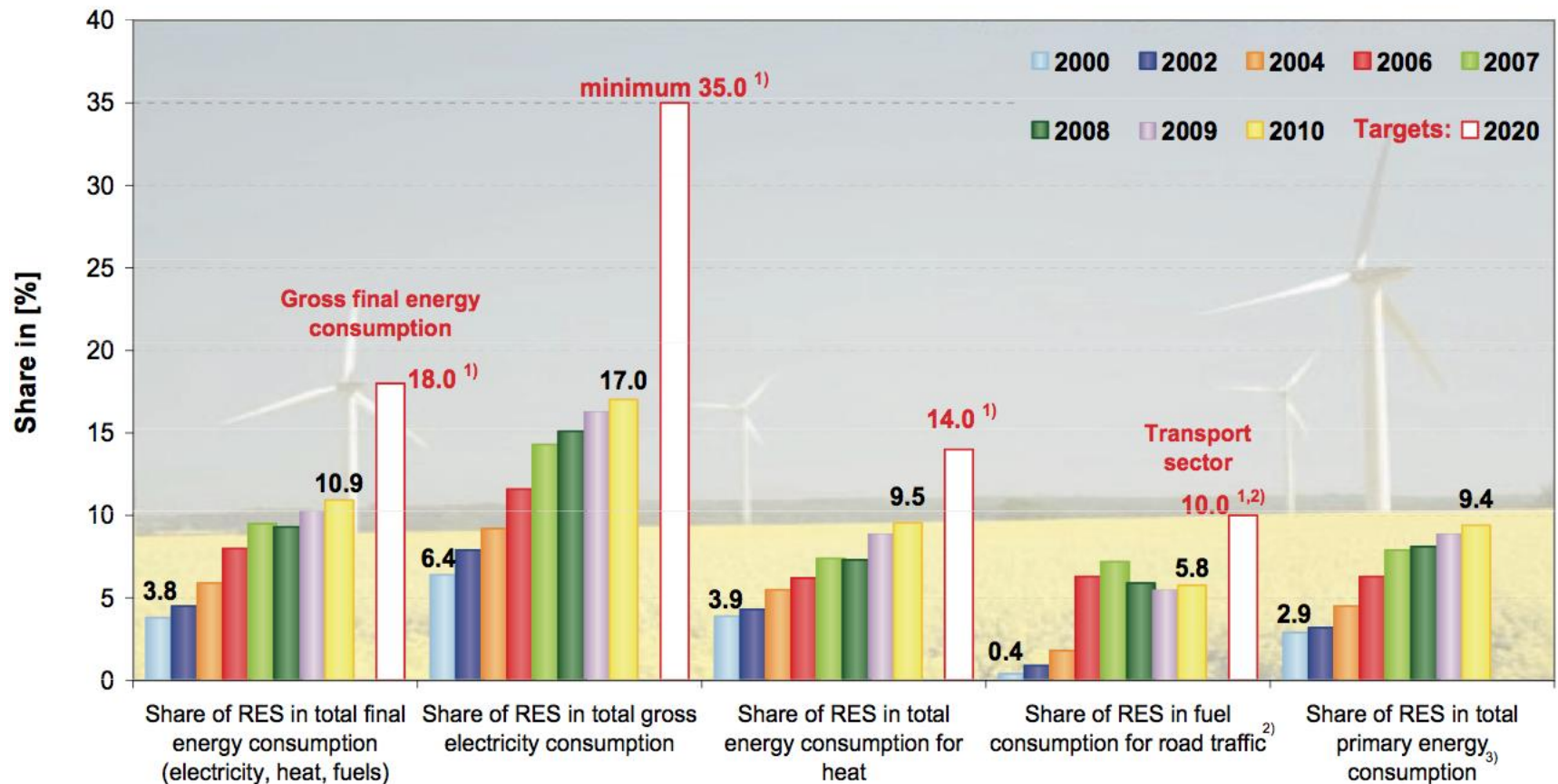
Germany & U.S. : A quick comparison



About half of all modules installed last year were installed in Germany...

Source: Cembalest, M. "Sue OPEC? Congress Should Sue Itself." *Forbes*, July 9, 2008. © Forbes.com LLC. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <http://ocw.mit.edu/help/faq-fair-use/>.

Renewable energy sources as a share of energy supply in Germany

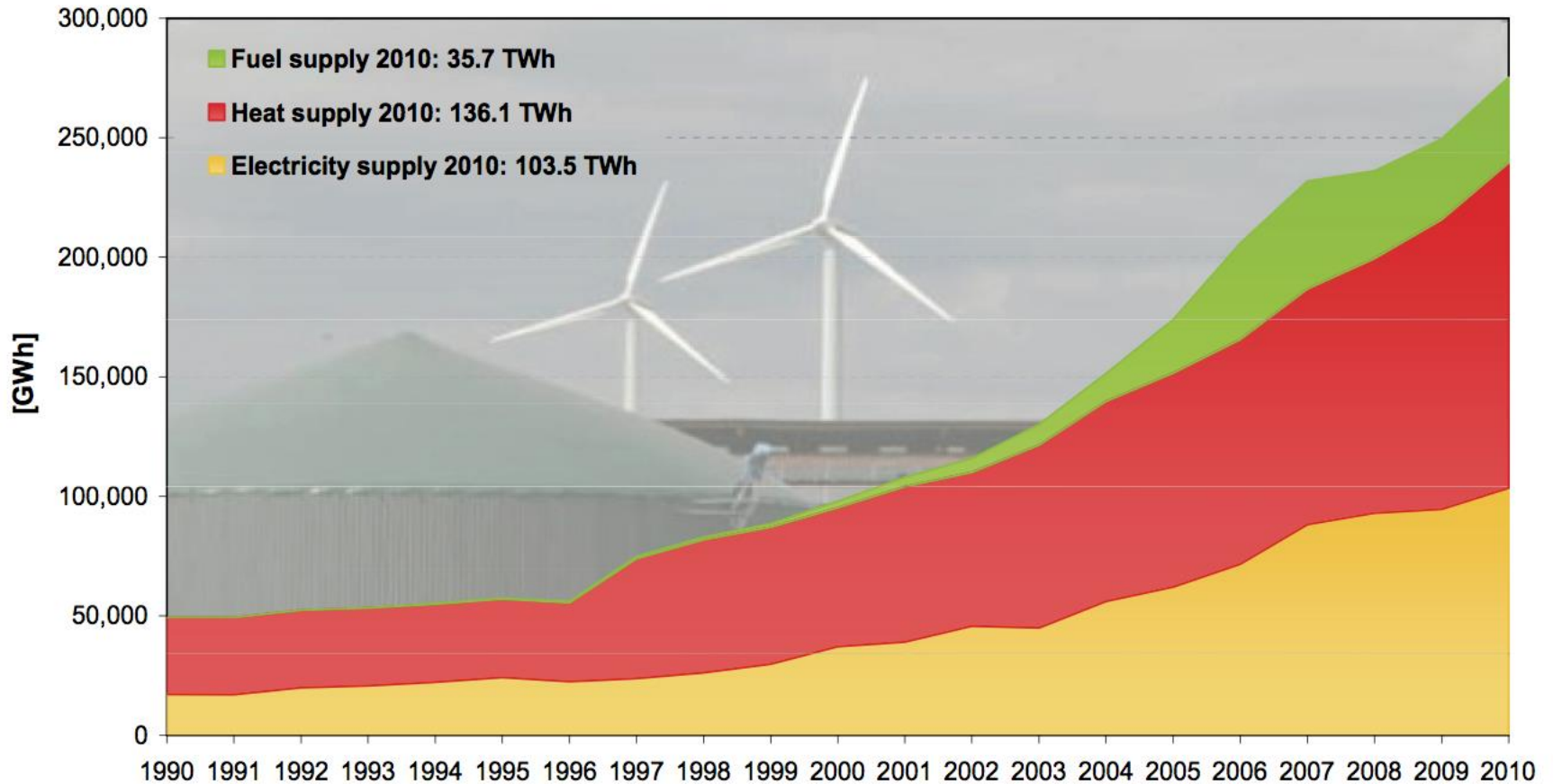


1) Sources: Targets of the German Government according to Energy Concept, Renewable Energy Sources Act (EEG); Renewable Energy Sources Heat Act (EEWärmeG), EU-Directive 2009/28/EC;
 2) Total consumption of engine fuels, excluding fuel in air traffic; 3) Calculated using efficiency method; Source: Working Group on Energy Balances e.V. (AGEB);
 RES: Renewable Energy Sources; Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); image: BMU / Brigitte Hiss; as at: July 2011; all figures provisional

Source: "Development of renewable energy sources in Germany 2011" (July 2012).

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Contribution of renewable energy sources to final energy supply in Germany



1 GWh = 1 Mill. kWh; 1 TWh = 1 Bill. kWh;

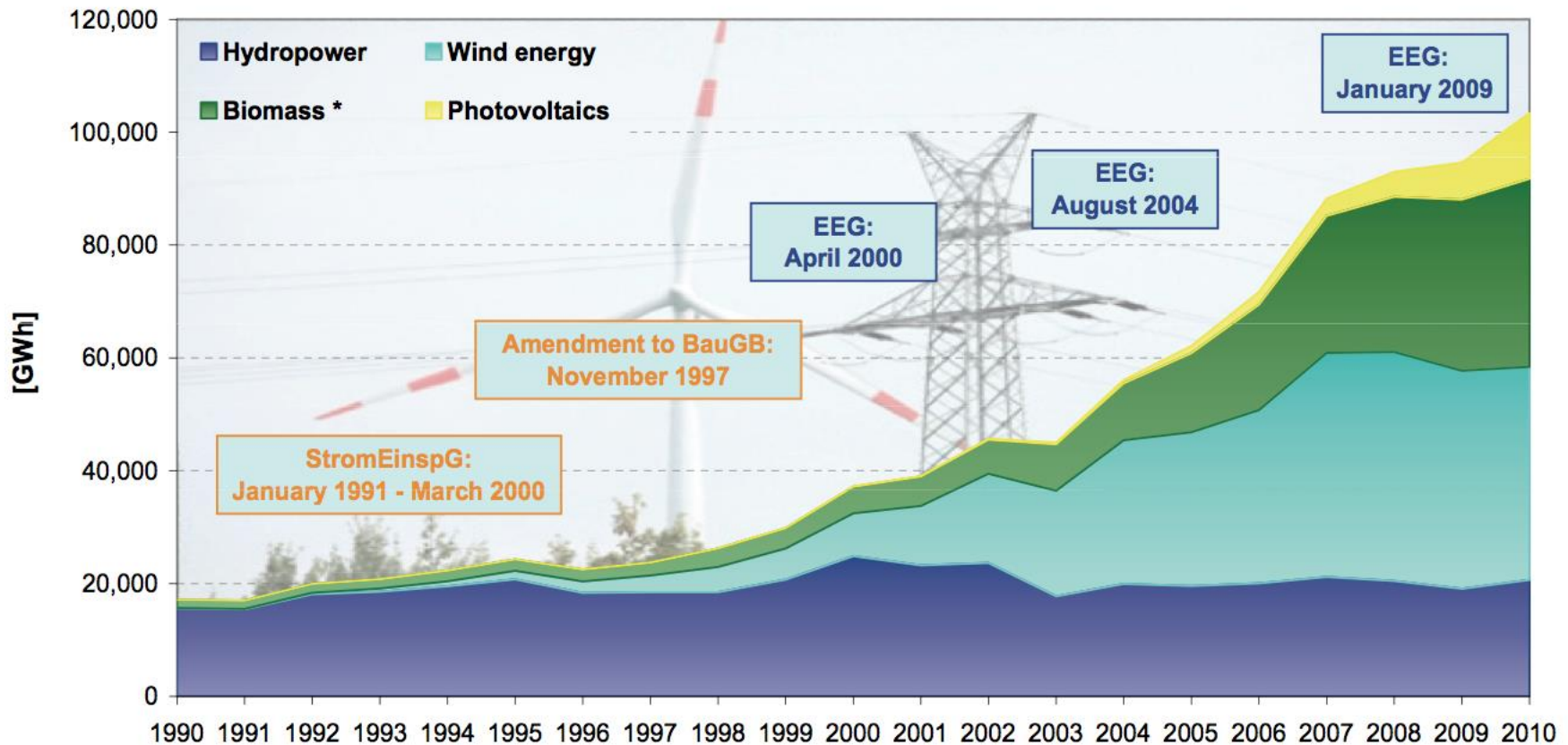
Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); image: BMU / Bernd Müller; as at: July 2011; all figures provisional

Source: "Development of renewable energy sources in Germany 2011" (July 2012).

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Contribution of renewable energy sources to electricity supply in Germany

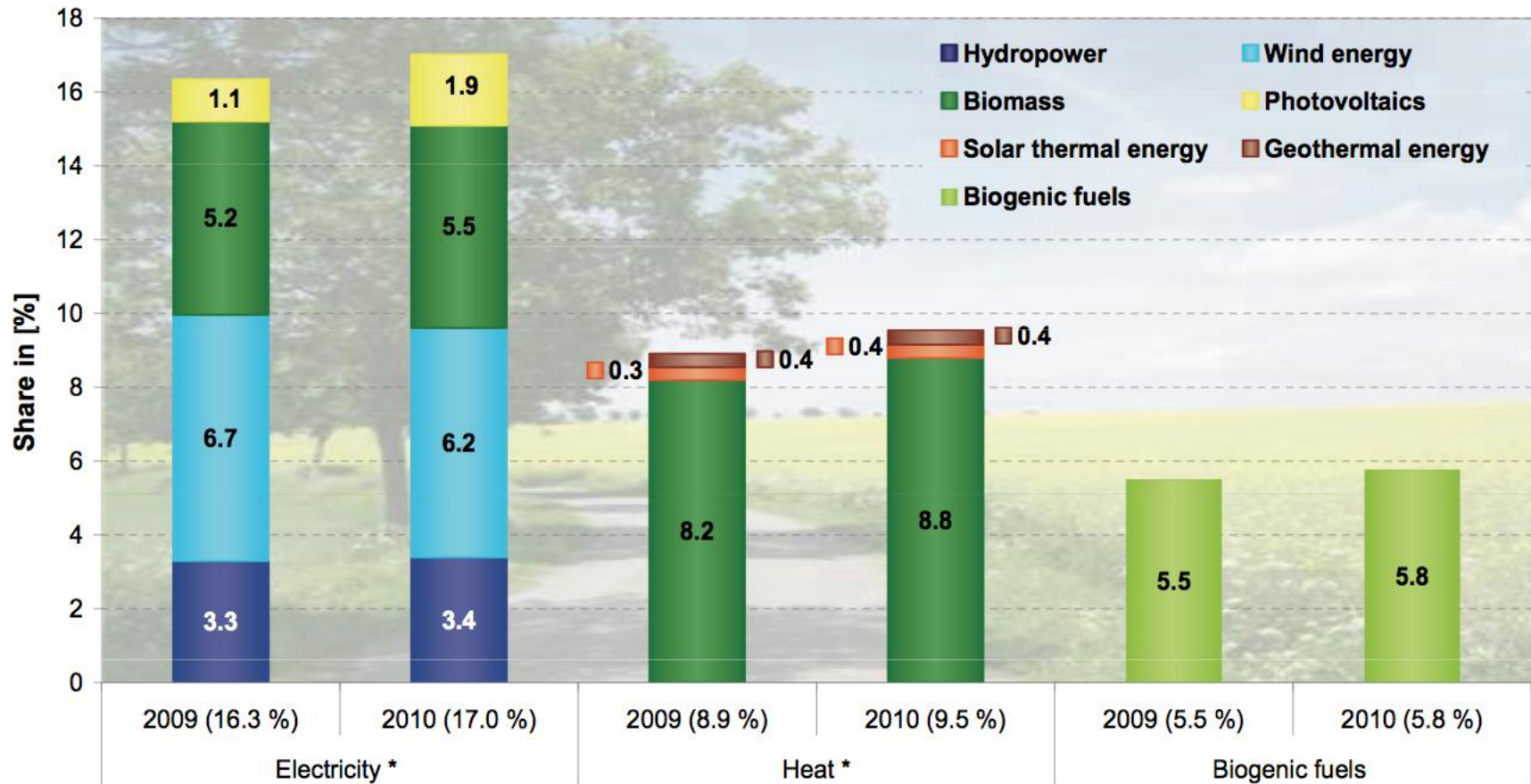


* Solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste; electricity from geothermal energy not presented due to negligible quantities produced; 1 GWh = 1 Mill. kWh;
 StromEinspG: Act on the Sale of Electricity to the Grid; BauGB: Construction Code; EEG: Renewable Energy 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

Source: "Development of renewable energy sources in Germany 2011" (July 2012).

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Share of renewable energy sources in total final energy consumption in Germany



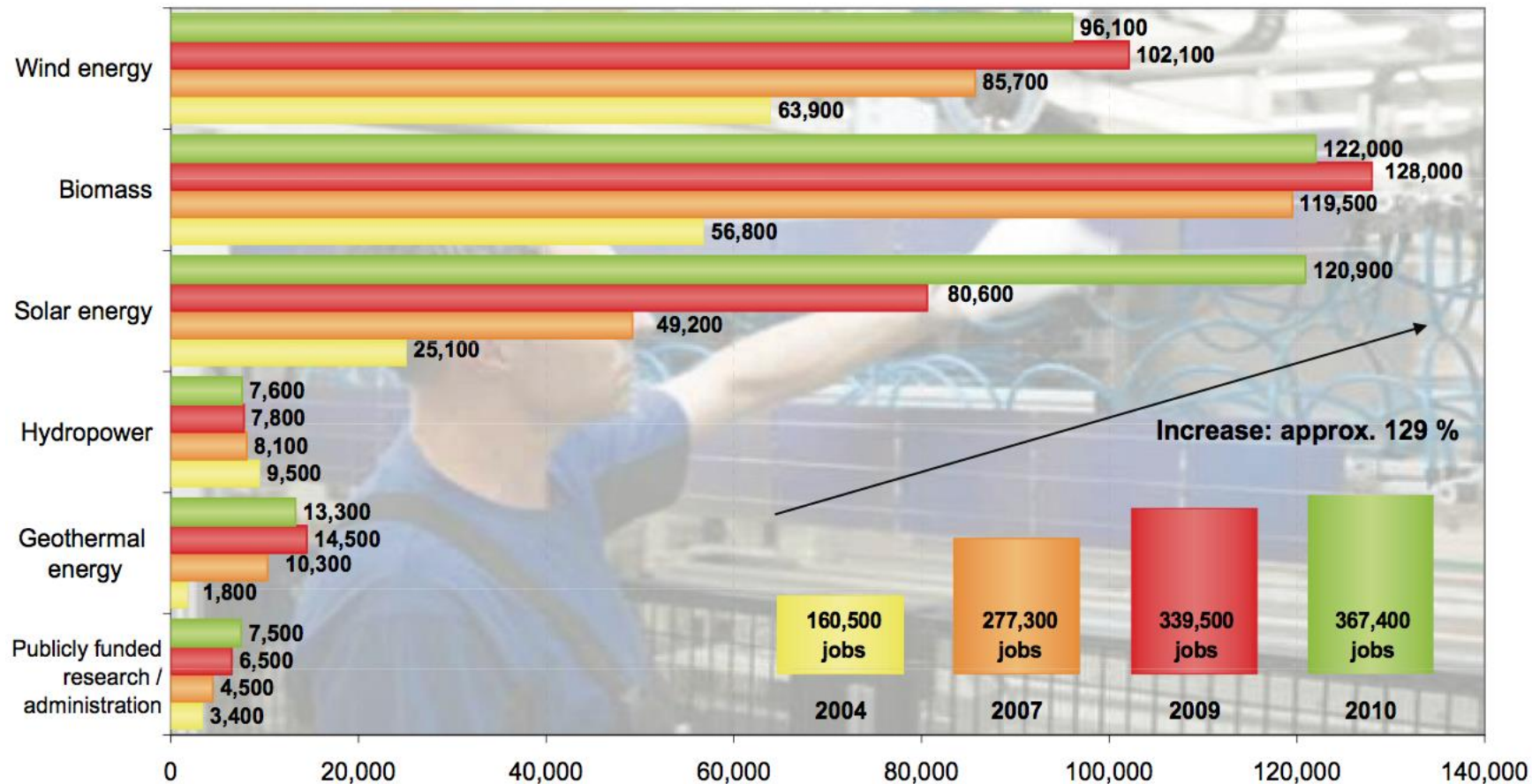
* Solid and liquid biomass, biogas, sewage and landfill gas, biogenic share of waste; electricity from geothermal energy not presented due to negligible quantities produced; deviations in the totals are due to rounding; Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat);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

Source: "Development of renewable energy sources in Germany 2011" (July 2012).

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Jobs in the renewable energy sources sector in Germany



Figures for 2009 and 2010 are provisional estimate; deviations in totals are due to rounding;

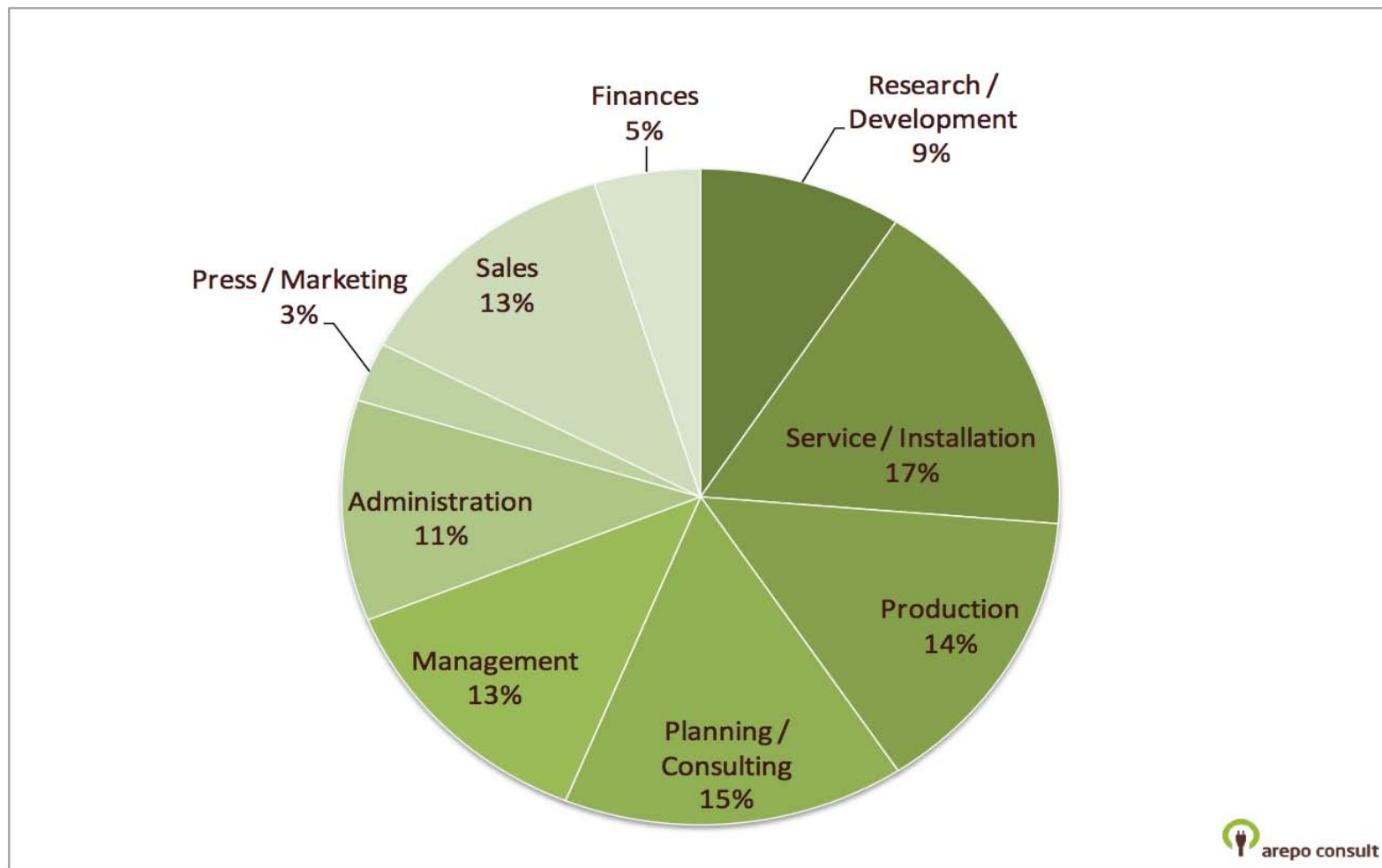
Source: O'Sullivan/Edler/van Mark/Nieder/Lehr: "Bruttobeschäftigung durch erneuerbare Energien im Jahr 2010 – eine erste Abschätzung", as at: March 2011; interim report of research project „Kurz- und langfristige Auswirkungen des Ausbaus erneuerbarer Energien auf den deutschen Arbeitsmarkt“; image: BMU / Christoph Busse / transit

Source: "Development of renewable energy sources in Germany 2011" (July 2012).

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Job offers by field of business activity in the renewable energy job market in 2009

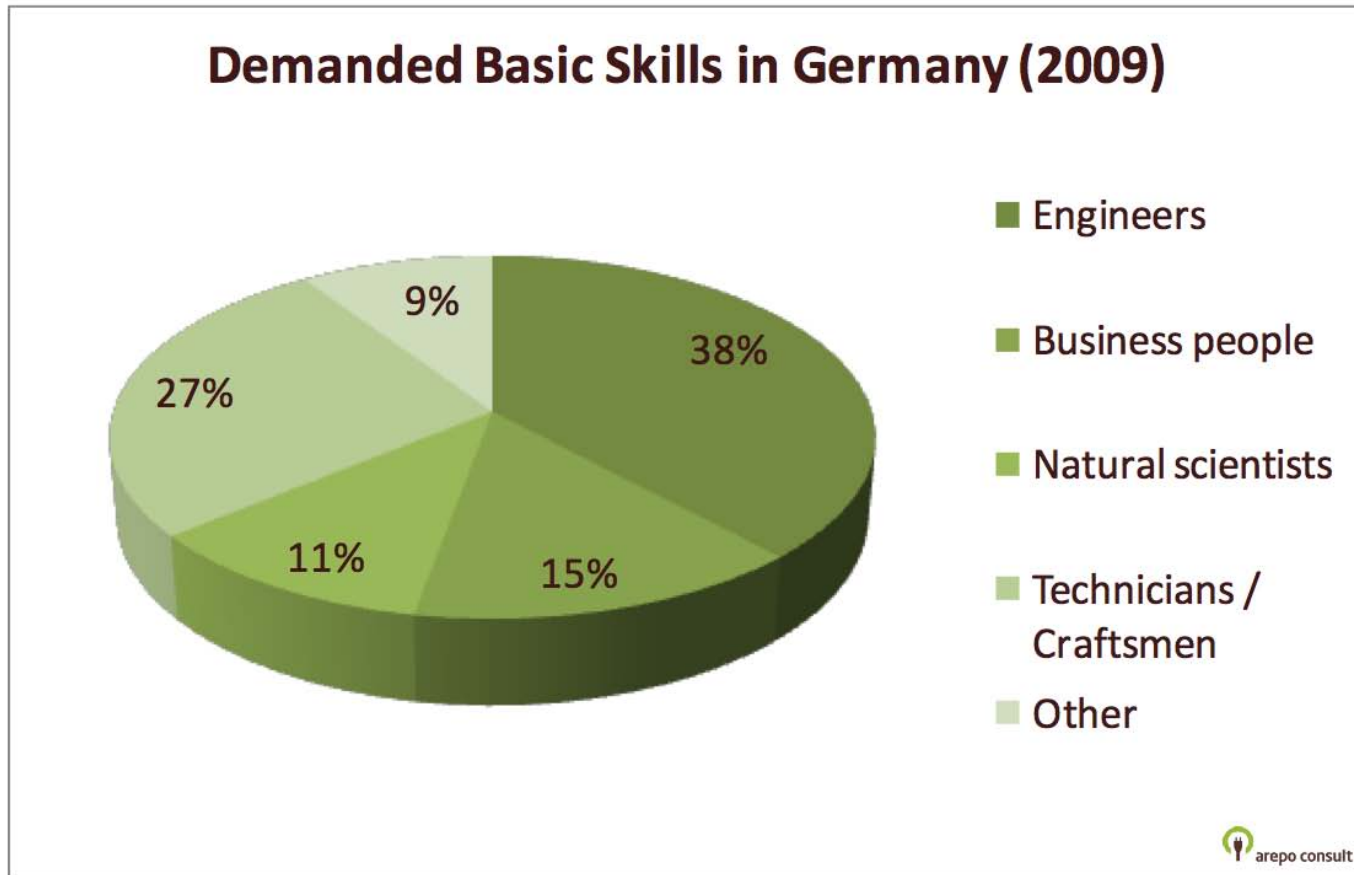


Own translated diagram based on: Wissenschaftsladen Bonn et al. 2009, p.4

Source: http://www.schoolofpublicpolicy.sk.ca/_documents/_outreach_event_announcements/Woerlen_PresentationSlides.pdf

Courtesy of Dr. Christine Woerlen, arepo consult. Used with permission.

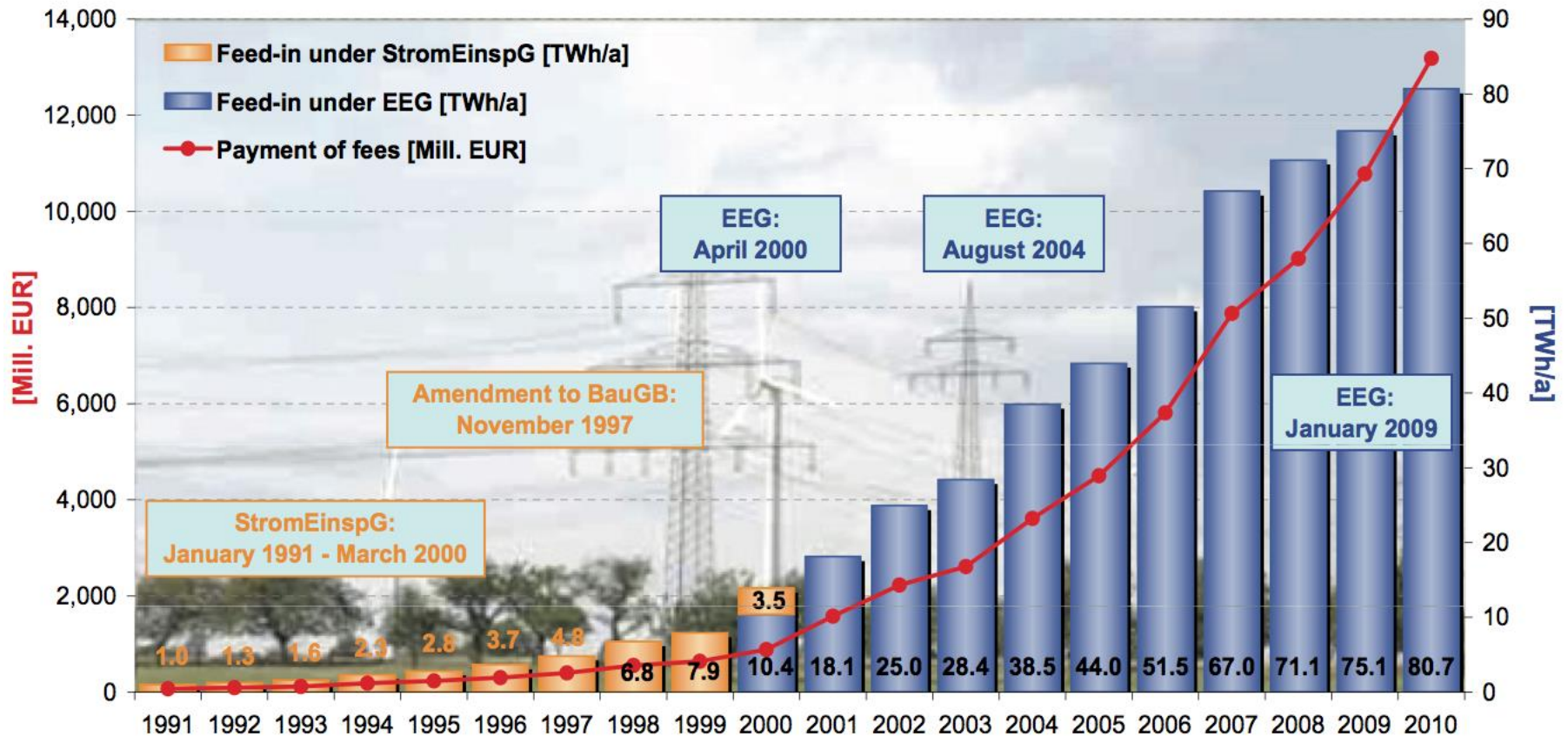
Job offers in the German renewable energy job market by basic skills required



Source: http://www.schoolofpublicpolicy.sk.ca/_documents/_outreach_event_announcements/Woerlen_PresentationSlides.pdf

Own translated diagram based on: Wissenschaftsladen Bonn et al. 2009, p.4
Courtesy of Dr. Christine Woerlen, arepo consult. Used with permission.

Feed-in and payment under the Electricity Feed Act (StromEinspG) and the Renewable Energy Sources Act (EEG) in Germany



StromEinspG: Act on the Sale of Electricity to the Grid; BauGB: Construction Code; EEG: Renewable Energy Sources Act; 1 TWh = 1 Bill. kWh; Source: BMU-KI III 1 according to Working Group on Renewable Energy-Statistics (AGEE-Stat); Year 2010: provisional estimate (IfnE); image: BMU / Bernd Müller; as at: July 2011; all figures provisional

Source: "Development of renewable energy sources in Germany 2011" (July 2012).

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PV Installations Worldwide: Annual

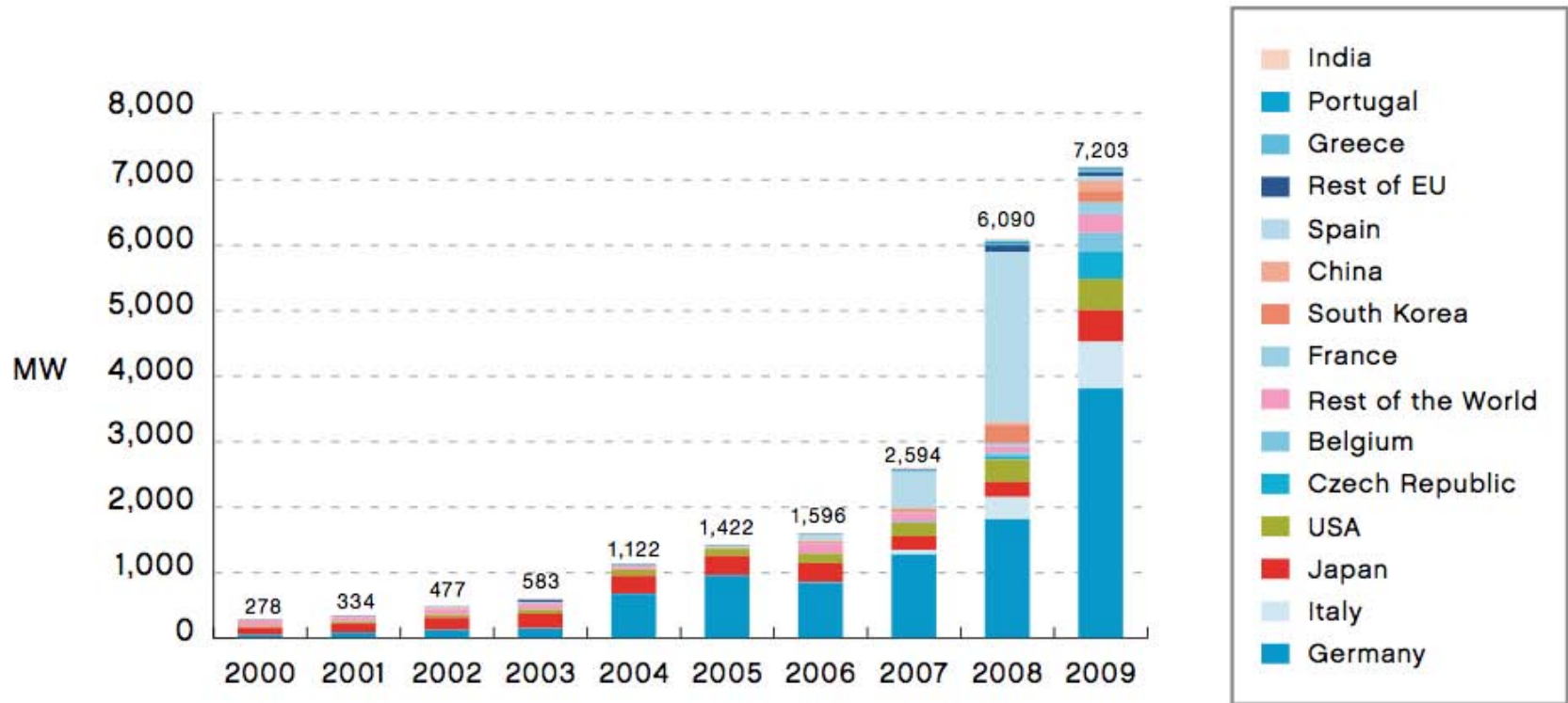
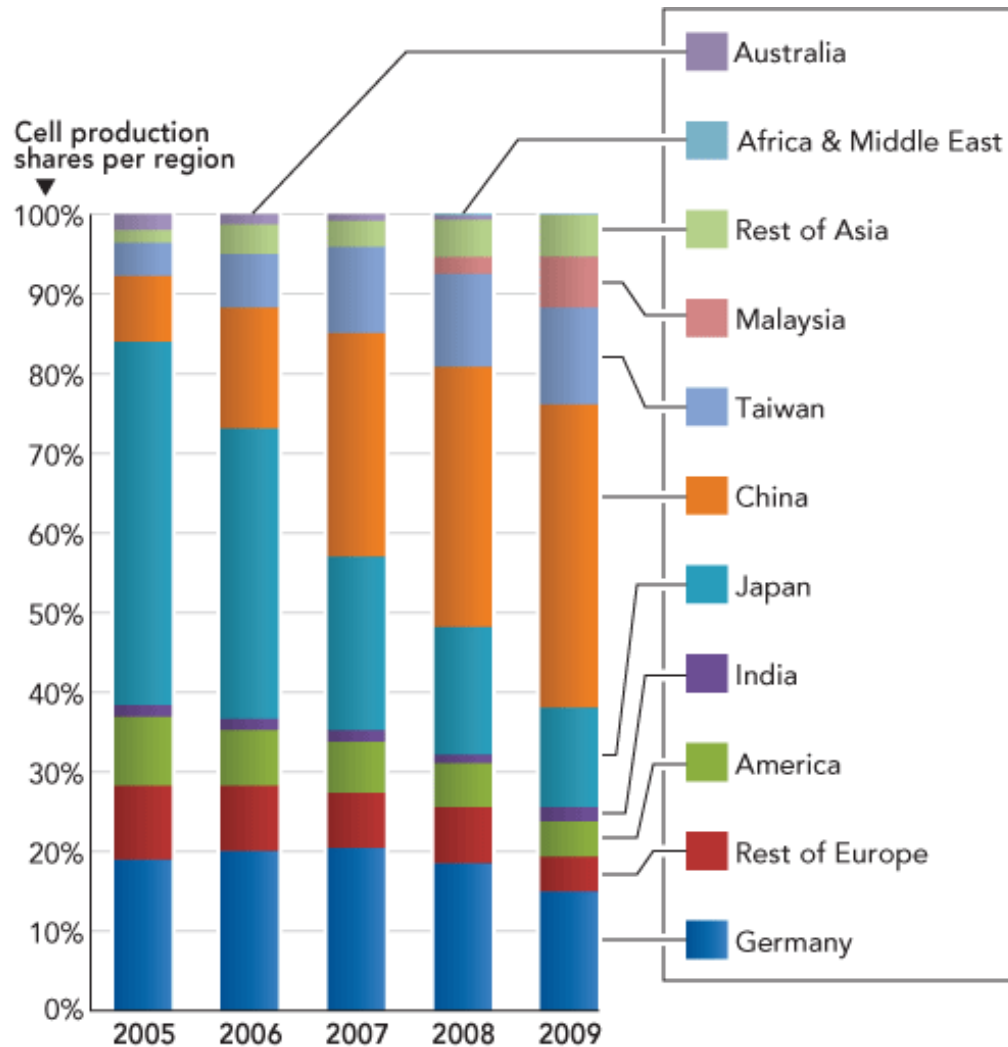


Figure 2 - Evolution of the World annual PV market 2000-2009

Source: "Global Market Outlook for Photovoltaics Until 2014." May 2010 update. EPIA. ([PDF](#))

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PV Manufacturing Worldwide: Annual



Singer, P. "Inside Taiwan's PV manufacturing push."
PV World, October 28, 2010. Accessed Oct. 17, 2013.

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Energy in Germany – Legal Issues, Facts and Opinions

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German Solar Feed-in Tariff Reduction Mid-2010

After much political debate, the German Bundestag (Parliament) on 6 May 2010 decided on a mid-year reduction of the solar feed-in tariffs. However, the Bundesrat (Federal Council) invoked the Mediation Committee (Vermittlungsausschuss) procedure to reduce the cuts. On 5 July 2010, the Mediation Committee agreed on a two-step reduction, with reductions becoming effective 1 July and 1 October 2010.

The German Bundestag on 8 July 2010 agreed with the proposed changes. The Bundesrat also decided not to object on 9 July 2010. The German solar feed-in tariffs pursuant to the German Renewable Energy Sources Act (EEG) will therefore be adjusted downwards as of 1 July and 1 October 2010.

Based on the Bundestag's decisions of 8 July 2010, the following key changes will take place:

- Installations attached to or on top of buildings: minus 13% for installations starting operation for the first time after 30 June 2010, minus a further 3% for installations starting operation for the first time after 30 September 2010
- Other installations (in particular freestanding facilities): minus 12% for installations starting operation for the first time after 30 June 2010, minus a further 3% for installations starting operation for the first time after 30 September 2010

http://www.germanenergyblog.de/?page_id=2740

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Type and Wait to Search

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Reduction Mid-2010](#)

[Decision 6 May 2010](#)

[Proposal 3 March 2010](#)

[Proposal 9 February 2010](#)

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United States

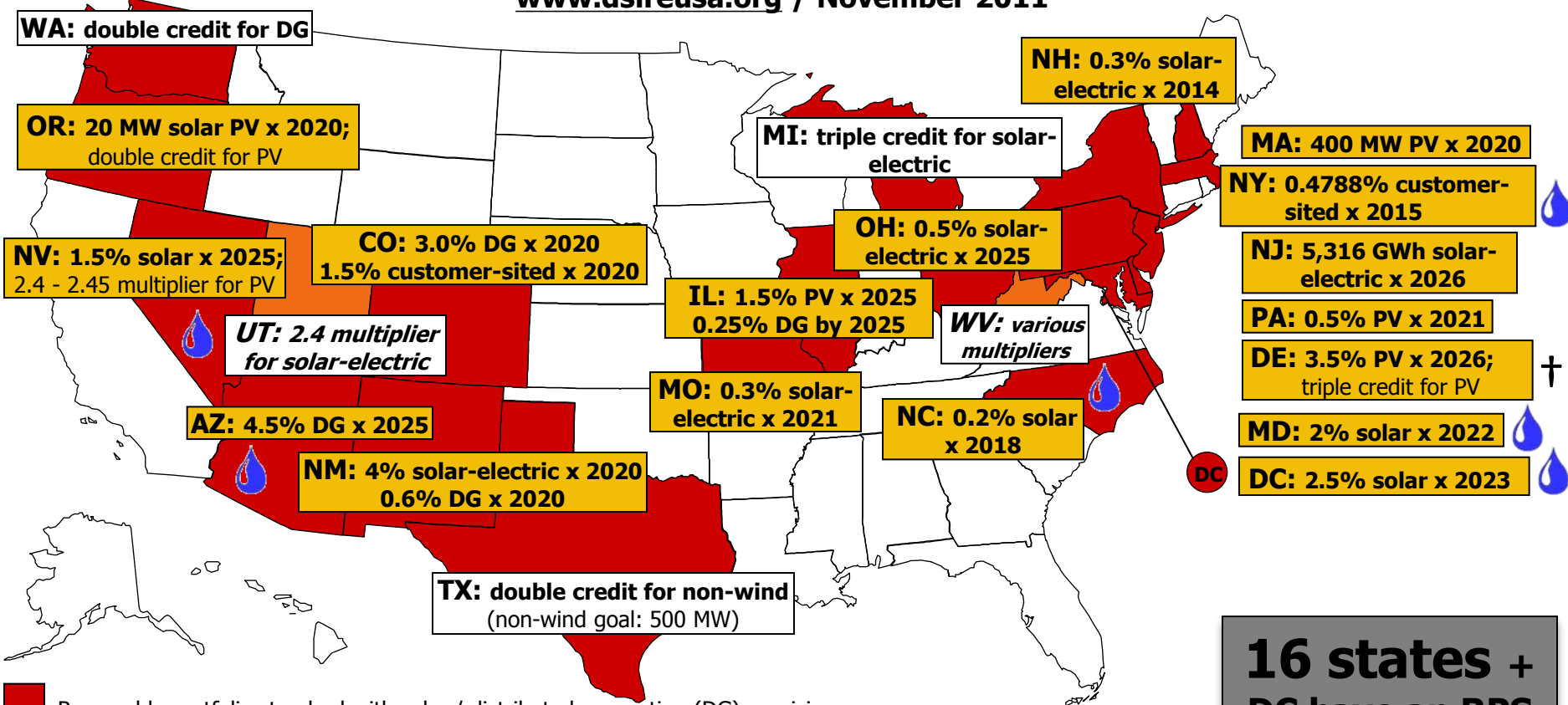
Summary Maps

- (Historical) lack of federal leadership led to fractionalized energy policy.
 - Huge state-to-state variation.
 - Website compiling all state-specific information:
<http://www.dsireusa.org/>

-  3rd-Party Solar PPA Policies
-  Grant Programs for Renewables
-  Interconnection Standards
-  Loan Programs for Renewables
-  Net Metering Policies
-  PACE Financing Policies
-  Property Tax Incentives for Renewables
-  Public Benefits Funds for Renewables
-  Rebate Programs for Renewables
-  RPS Policies
-  RPS Policies with Solar/DG Provisions
-  Sales Tax Incentives for Renewables
-  Tax Credits for Renewables

RPS Policies with Solar/DG Provisions

www.dsireusa.org / November 2011



■ Renewable portfolio standard with solar / distributed generation (DG) provision

■ Renewable portfolio goal with solar / DG provision

💧 Solar water heating counts toward solar / DG provision

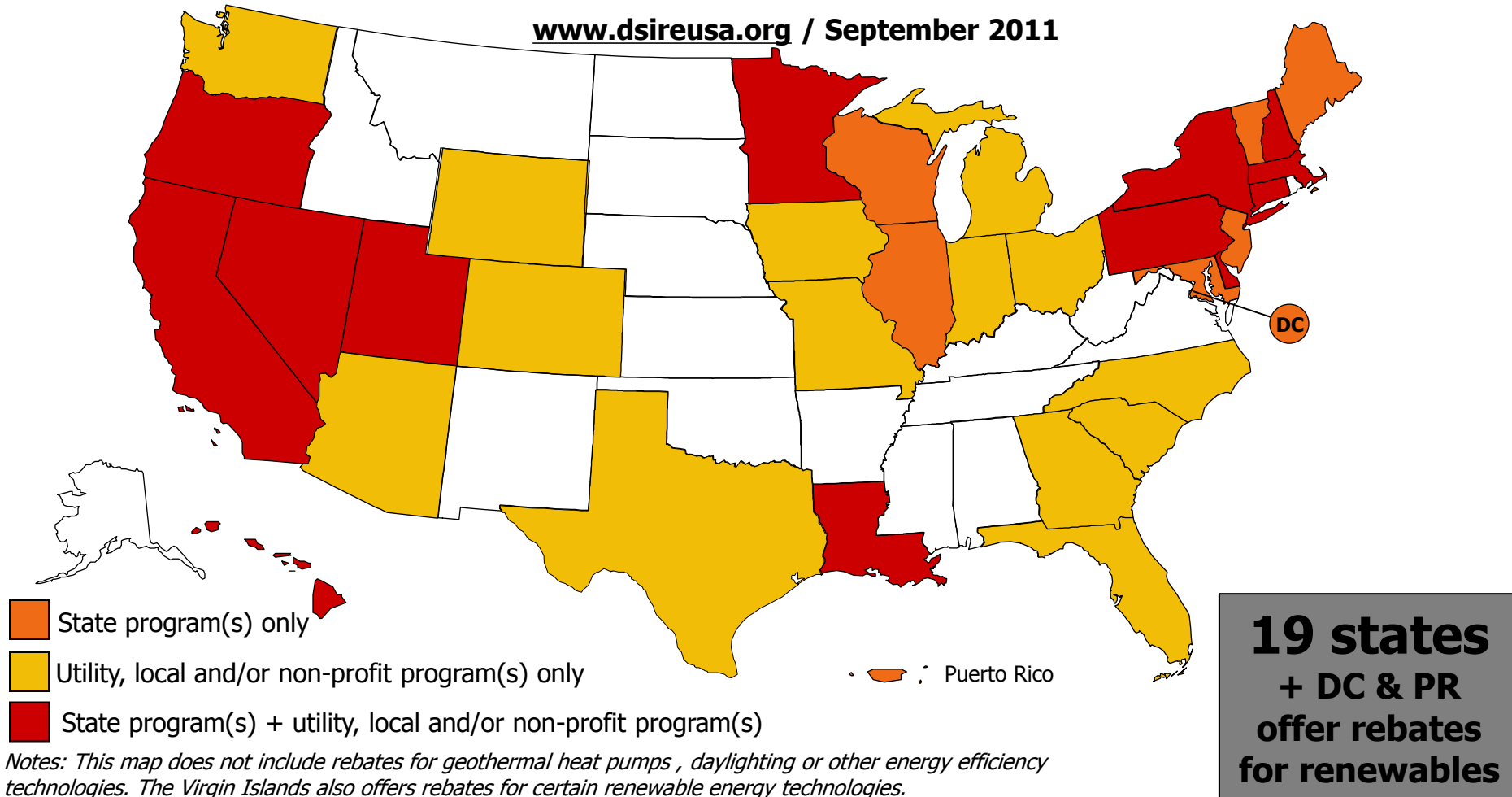
† Delaware allows certain fuel cell systems to qualify for the PV carve-out

16 states + DC have an RPS with solar/DG provisions

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Rebate Programs for Renewables

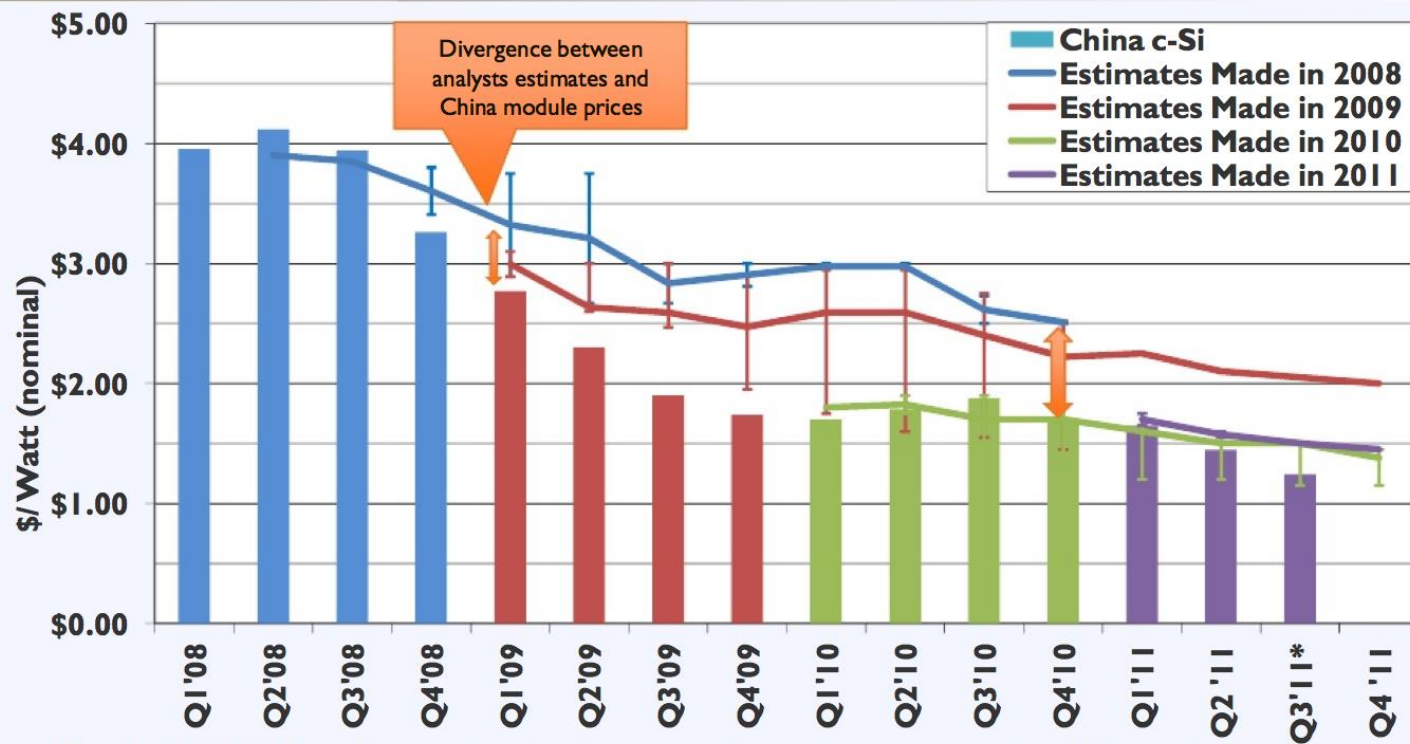
www.dsireusa.org / September 2011



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Rapid Price Decline

Actual Module ASP vs. Analyst Estimates



- In Q1 2009, independent industry analysts were expecting PV module prices to remain strong and above \$2/W into 2011
- Chinese made PV modules are now selling as low as \$1.15/W

*Q3 '11 through 9/16/11

Sources : For 2007-2011 Actual Module Selling Price: Q1'07 to Q2'09: Barclays Capital (12/14/09) and Stifel Nicolaus (5/5/11), Q3'09 onward: UBS Securities, LLC(2/12/10, 4/23/10, 7/29/10, 10/29/2010,1/24/11, 6/3/11, 8/17/11, 9/16/11). For Analyst Estimates 2008-10: analyst reports, Barclays (5/1/09,11/15/10); Deutsche Bank (5/27/08, 1/23/09, 5/6/10, 1/5/11); Lazard (11/4/08, 4/2/09); Stifel Nicolaus (10/6/09, 4/8/10); UBS(8/22/10, 3/8/11)

Wesoff, Eric. "Solar Module Pricing vs. Analyst Estimates." *Greentech Solar*, Nov. 21, 2011.

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