Lessons Learned from the Photovoltaic Market Development in Germany - with a Focus on the Rooftop Aspect

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Centre of Science and Environment (CSE)
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Headquarter of Fraunhofer ISE, Freiburg, Germany
Agenda

- Introduction
- German PV Market
- PV support schemes
- PV Rooftop
- Conclusions
Fraunhofer Institute for Solar Energy Systems ISE

- Applied research on Renewable Energies since 1981
- Largest Solar Research Institute in Europe
  1300 employees incl. 300 PhD and diploma students
- Director: Prof. Eicke R. Weber
- Part of the Fraunhofer Society with 67 institutes / 23000 employees, largest applied research network in Europe

- Energy Efficient Buildings
- Solar Thermal Technology
- Photovoltaics
- Renewable Power Supply
- Emission free mobility
- Further renewable energy technology
- Water desalination technologies

➔ Types of services: Energy concepts for cities, regions and countries, quality assurance services for PV and CSP plants (yield assessment, performance verification,…), measurement and certification, research and development on adapted technologies,…
# Key figures
## India and Germany

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>India</th>
<th>Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhabitants (2013)</td>
<td>Mio</td>
<td>1,252</td>
<td>81</td>
</tr>
<tr>
<td>Area</td>
<td>Thousand km²</td>
<td>3,287</td>
<td>357</td>
</tr>
<tr>
<td>Inhabitant density</td>
<td>Inhabitant/km²</td>
<td>376</td>
<td>227</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>$ per capita</td>
<td>1,500</td>
<td>41,000</td>
</tr>
<tr>
<td>Electricity demand</td>
<td>TWh</td>
<td>699</td>
<td>550</td>
</tr>
<tr>
<td>Electricity demand per cap</td>
<td>MWh per cap</td>
<td>656</td>
<td>6,780</td>
</tr>
<tr>
<td>RES power capacity</td>
<td>GW installed end 2013</td>
<td>27</td>
<td>78</td>
</tr>
<tr>
<td>RES on electricity demand</td>
<td>%</td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>Solar radiation</td>
<td>kWh per m² per year</td>
<td>1850 ± 20%</td>
<td>1200 ± 10%</td>
</tr>
</tbody>
</table>
Global annual PV installations 2000 - 2013

Source: EPIA

Installations 2013

- China: 11.3 GW
- Japan: 6.9 GW
- USA: 4.2 GW
- Germany: 3.3 GW

Europe

- China: 30,282 GW
- America: 29,865 GW
- APAC: 17,107 GW
- Europe: 37,007 GW

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German Photovoltaic Market
PV market development in Germany

**PV market data Germany 2014**
- Newly installed capacity: ca. 2,000 MWp
- Total installed capacity: 38,100 MWp
- Solar power produced*: 32,800 GWh
- Number of PV systems installed: 1.5 Mio
- PV electricity share generated: ca. 5%

*Source: BSW-Solar, BNetzA, EEX
Electricity generation from PV and Wind in Germany
Wind and solar power are ideal partners in the right mix

Monthly electricity generation from Wind and PV in 2014

Installed capacity end of 2014
PV: 38.1 GW
Wind: 35.7 GW
Annual generation:
PV: 32.8 TWh
Wind: 51.4 TWh

Electricity generation June 2013: Wind, PV and fossil/nuclear power stations > 100 MW

23.2 GW PV 17 Jun 2014
The PV support schemes
The German strategy to support PV market development
Instruments depend on the target group

Germany: EEG

Producer

Grid operator

Consumer

Feed-in tariffs
Quota

Quota
Certificates

Grants
Tax incentives

Utilities/ Grid
Two Ways of Connecting PV Systems to the Grid

On the consumer side of the meter: **Self-consumption first**, feed-in of not consumed solar electricity only

On the utility side of the meter: **100% feed-in**, every kWh is remunerated, attractive, as long as the feed-in tariff is higher than the consumer price of electricity
The Feed-in tariff (EEG) concept

**EEG-Principles**
- Utilities are obliged to connect all PV-systems with the grid
- Priority for feeding-in PV electricity
- Fixed feed-in tariff over 20 years
- Annual reduction of the tariff

**Graph:**
- FIT for residential PV systems and electricity rate in Germany
- Target: PV shall become cost-competitive

**Overview:**
- **Government:** Regulation of grid access and feed-in tariffs
- **Utility:**
  - Conventional + RES electricity
  - Payments for conventional electricity
  - + Feed-in tariff extra charge
- **RES electricity producer**
- **Electricity consumer**

**Flowchart:**
- Feed-in tariff
- Renewable electricity
- FIT electricity rate (+3%/a)
- Target: PV shall become cost-competitive
# History of feed-in tariff for solar electricity

FIT in ct/kWh is paid for 20 years at the same level than the beginning

## FIT PV

<table>
<thead>
<tr>
<th>Category</th>
<th>Jan 2006</th>
<th>April 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooftop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 10 kW</td>
<td>51.80</td>
<td>13.28</td>
</tr>
<tr>
<td>&lt; 30 kW*</td>
<td>51.80</td>
<td>12.60</td>
</tr>
<tr>
<td>&lt; 100 kW</td>
<td>49.28</td>
<td>11.23</td>
</tr>
<tr>
<td>&lt; 1000 kW</td>
<td>48.74</td>
<td>9.19</td>
</tr>
<tr>
<td>&lt; 10 MW</td>
<td>48.74</td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>40.60</td>
<td></td>
</tr>
</tbody>
</table>

* From April 2012: 10/40 kW instead 30 kW-threshold

## Reduction

- **1/2006 – 4/2014:** 74% - 81%
- **4 – 10/2012:** 1%/Mon
- **11/2012 – 1/2013:** 2.5%/Mon
- **2 – 4/2014:** 1.0%/Mon

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Photovoltaic market segments in Germany

- **Ground mounted**
  - **Size**: ca. 26%
  - **Installation effort**: Share of segment on total installation until mid 2013

- **Roof top**
  - **Residential homes 1-10 kWp**: ca. 12%
  - **Multi family homes, commercial + public buildings, farms 10-100 kWp**: ca. 42%
  - **Large commercial plants > 100 kWp**: ca. 20%

- **BIPV**
  - ca. 2%

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Price reduction for PV systems < 10 kWp

PV electricity is becoming competitive step by step

Average final customer price for residential PV roof top systems up to 10 kW ready installed without VAT

Quelle: BSW-Solar, Photovoltaik Preismonitor, 2/2014
2013: Solar power more affordable than household electricity

Generating cost for solar power

Household electricity price (Unit price)

Real PV price development

Solar electricity is less than half of electricity price from the grid

Sources: Federal Environment Ministry (2010 Pilot Study), BSW-Solar (PV-Roadmap)
PV Rooftop
Motivation for Rooftop PV systems

- **Market pull:** Accelerate PV market deployment by an additional market segment
  - Home owners/businesses can become investors in the electricity sector
  - Rooftop market is not only profit driven, owners/businesses do have additional motivation to invest (comfort, security of supply, image, …)
  - Innovative solutions (e.g. PV + batteries) can be easier and faster developed and implemented on a small scale in a non-profit environment

- **Installation area:** roof areas are needed for PV installations to achieve 100 GW
  - There is not enough land area available to install 100 GW on the ground

- **Democratization of electricity sector:** Consumer can become electricity producer
  - Increased awareness/support for sustainable energy supply policy
  - Increased awareness of efficient use of electricity
  - Improved access to a stable electricity supply

- **Decentralization of electricity generation:** Generation close to consumption reduces electricity transport (however: the grid is still necessary if the sun is not shining)
  - Less electricity grid extension needed (which could be a bottleneck)
  - Enable more flexible solutions

- **Enable smaller companies and more local jobs** by installation of smaller systems
Small, medium and large rooftop installations
Investment environment for PV rooftop systems

On attractiveness, regulation, prices, expected solar yield, certification, permissions,...

Awareness
Transparency

Attractiveness of investment

Stable support policy: Feed-in tariff,... Adaption on market development, limit electricity price increase,...

PV system financing

Interest rates, bankability (securities for loans),...

High solar yield, monitoring, maintenance, long life time,...

Operation of PV system

Clear regulation, permissions, processing time, cost sharing for installation costs, feed-in payments,

Grid connection feed-in remuneration

Physical installation

Permissions, roof stability, quality of installation (trained installer), ...

PV market and companies

PV technology, products

Durability, security, quality, certification, ...

Rooftop owner & Investor

Clear, stable, long-term oriented policy framework: regulation, support policy, targets,...
Conclusions

- Photovoltaic installations in Germany 2014
  newly installed: ca. 2 GW
  total installed: 38.1 GW

- The feed-in tariff (FIT) is proven a very powerful instrument to develop the PV market, however, to limit the market dynamic is a challenge

- PV rooftop systems played an important role in the German PV market development

- PV rooftop systems are needed to achieve the PV target of India

- The entire investment environment for rooftop PV systems must be provided for a successful market deployment
Thank you very much for your attention!

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