EU Jordan  Energy Networking Event in Energy within  JERA-Center
National Center for Research and Development NCRD

Recent Trends in PV Systems

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Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

1988: ZSW was established as a non-profit foundation under the civil code.

2012: About 220 employees work at 3 locations in the State of Baden-Württemberg (Turnover 2011: 40 m. EUR)

Goal of the foundation:
Industry-oriented research and technology transfer in the field of renewable energies
Stuttgart:
Photovoltaics (with Solab), Energy Policy and Energy Carriers

Solar Test Fields: Widderstall (D) and Girona (ES)

Ulm:
Electrochemical Energy Technologies Division with ZSW Laboratory for Battery Technologies (eLaB)
Department
Photovoltaics: Modules Systems Applications (MSA)

1. Photovoltaics test laboratory Solab
   • Quality, performance and reliability
   • Standardised and customer-specific tests

2. Outdoor test facilities
   • Performance and yield measurements
   • Acquisition of electr. and meteorolog. data

3. Testing methods
   • Accelerated ageing tests
   • New testing methods

4. Grid integration of PV plants
   • Grids and PV storage systems

5. Consulting
   • Manufacturers, investors, banks, project developers and carriers
Contents

- Actual state of PV
- Experience from Europe
- Means to reduce the noon peak
- PV systems with storage
- Problems in the field
- Recent trends in PV systems
- Need for long term outdoor characterization in all applying countries
Development of PV
Global relative Distribution of PV as of End 2012

- Germany 32%
- Italy 17%
- China 8%
- Japan 7%
- Czech Republic 2%
- Spain 4%
- France 4%
- Rest of Europe 9%
- Rest of Asia 2%
- Rest of World 6%
- North America 9%

Total 98.238 GWp

Source: ZSW
Development of PV

Cumulative Power [MWp]

- Rest of World
- Rest of Asia
- China
- Japan
- North America
- Spain
- France
- Czech Republic
- Italy
- Germany
Experience from Europe
Energy mix in Germany as of End 2012

- Lignite: 26%
- Nuclear: 16%
- Stone Coal: 19%
- Natural Gas: 11%
- Renewables: 22%
- Other: 6%

- PV: 4.6%
- Hydro: 3.3%
- Biomass: 6.6%
- Wind: 7.3%

Total: 617 TWh
Experience from Europe
RE Feed-In in Germany from 24.12. to 31.12.2011
Experience from Europe
RE Feed-In in Germany from 4.4. to 10.4.2011

![Graph showing RE Feed-In in Germany from 4.4. to 10.4.2011]
Experience from Europe

Evident need for a proper handling of the RE power peaks by suppliers of residual energy.
Experience from Europe

Evident need for a proper handling of the RE power peaks by suppliers of residual energy.

Possible solutions:
- Steeper ramps of conventional base load power plants
- Cutting off the peak
Reduction of the noon peak
Hard limitation by law to actual 70% of Pnom

Source: ZSW
Reduction of the noon peak
Use of a smaller inverter

Source: ZSW
Reduction of the noon peak
Different orientation (East + West instead of South)

Both alternatives with equal total PV power.

Source: ZSW
Reduction of the noon peak
Different orientation (East + West instead of South)

All alternatives with equal total PV power.

Source: ZSW
Reduction of the noon peak  
Different orientation (East + West instead of South)

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Tilt angle</th>
<th>Energy yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>30°</td>
<td>100%</td>
</tr>
<tr>
<td>East + West</td>
<td>30°</td>
<td>85%</td>
</tr>
<tr>
<td>East + West</td>
<td>45°</td>
<td>78%</td>
</tr>
<tr>
<td>East + West</td>
<td>60°</td>
<td>70%</td>
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</table>

Comparison of annual energy harvest (Amman)  
Source: ZSW
Reduction of the noon peak
Use of a PV storage system - schematic

Source: SMA
Reduction of the noon peak
Use of a PV storage system - real

Charging without delay
noon-peak still exists

Source: ZSW
Reduction of the noon peak
Use of a PV storage system - real

Charging without delay
noon-peak still exists

Charging with delay
noon-peak cut

Source: ZSW
Feed-in without self consumption over one year (15-min values)
Feed-in with self consumption and delayed battery charging over one year (15-min values)
Feed-in with self consumption, delayed batterie charging and a thermal buffer over one year (15-min values)
Problems in the Field
based on ZSW consultancy experience

Microcracks due to bad packaging
Problems in the Field based on ZSW consultancy experience

Microcracks due to bad packaging

Source: ZSW
Problems in the Field based on ZSW consultancy experience

Snail tracks

Source: ZSW
Problems in the Field
based on ZSW consultancy experience

85°C/85%RH Test with -1000V Bias

• Wide variation from very stable to highly PID susceptible
• Reproducibility of PID failure is quite o.k.

Potential Induced Degradation

Source: ZSW Solab
Problems in the Field based on ZSW consultancy experience

Module failure due to bad soldering

Source: ZSW
Problems in the Field
based on ZSW consultancy experience

Visible defects due to cleaning
Problems in the Field based on ZSW consultancy experience

Decreasing power in long-term operation?

Long term efficiency

<table>
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<tr>
<th>Operation time [years]</th>
<th>Normalized efficiency</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1.05</td>
</tr>
<tr>
<td>2</td>
<td>1.1</td>
</tr>
<tr>
<td>3</td>
<td>1.15</td>
</tr>
</tbody>
</table>

Source: ZSW Solab
Problems in the Field based on ZSW consultancy experience

- Microcracks
- Potential Induced Degradation
- Snail tracks
- Module failure due to bad soldering
- Defects due to cleaning
- Decreasing power in long-term operation
Recent trends in PV systems

• Extreme cost pressure in PV systems
• Module Bill of Materials is optimized economically
• Reduced cell thickness leads to microcracks
• New materials and material combinations – new risks
• Trend to higher voltages to save Balance of System cost
• During cleaning, if any, switch-off PV system highly recommended
• Only higher-efficient thin-film technologies will be part of the high cost pressure market
Need for long term outdoor characterization in all applying countries

- Nowadays 50% of the global PV Power is located in Germany and Italy
- Many of the above mentioned effects cannot be seen in actual standard lab tests but only in outdoor operation
- Climate in Central-Europe is not representative worldwide
- The higher the precision of measurements the earlier a trend can be detected
- Proposal of a network of high-precision test fields
Thank you for your attention!

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