Trends in large scale PV systems & concept of IEA PVPS Task8

Energy from the Desert

IEA PVPS Workshop at PVSEC-22
Hangzhou, China, 6 November 2012

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Trends in Large-Scale PV Systems
Applications for Photovoltaics

**Off-grid domestics**

![Off-grid domestics]( Courtesy RTS Corporation)

**Grid-connected distributed**

![Grid-connected distributed]( Courtesy Edisun Power)

**Off-grid non-domestic**

![Off-grid non-domestic]( Courtesy RTS Corporation)

**Grid-connected centralized**

![Grid-connected centralized]( photo Tecneira)

Source: IEA PVPS

Task8, IEA PVPS WS at PVSEC-22, Hangzhou, China, 6 November 2012
PV system deployment scenario

Stage 1: Stand-alone / central PS
- Local loads
- Village
- Primary transmission line
- Coal power on colliery
- Local loads
- Load center

Stage 2: Local Grid Formation
- Village
- Primary transmission line
- Superconducting long distance transmission line
- Electro-chemical plant
- Fuel cell

Stage 3: Network Integration
- Local loads
- Conventional power
- Load center

Stage 4: Global Network
- Wind, hydro etc.
- Conventional power

Source: IEA PVPS Task 8
Trends in Large Scale PV systems installation (until 2010)

Source: IEA PVPS Task 8
Trends in Large Scale PV systems installation (until 2010)

Source: IEA PVPS Task8
Trends in Large Scale PV systems installation

Large scale PV system installation in each year

Source: IEA PVPS Task8
Trends in Large Scale PV systems installation

[Chart: Annual & Cumulative Installation of large scale PV systems]

Source: IEA PVPS Task8
Large Scale PV systems in the world

Note: Power is specified in MWp if DC array power is known. If DC array power is unknown, the output power is specified. In some cases it is unclear if the power plant power is output or DC array power.
Agua Caliente Solar Project, AZ, USA

Courtesy of First Solar
Charanka Solar Park, Gujarat, India

http://www.gujaratsolarpark.com/
Golmud Solar Park, Qinghai, China
Some pipelines of VLS-PV in the world

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Inst. Power [MWp]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serbia (MoA)</td>
<td>(2013-2015)</td>
<td>1,000</td>
</tr>
<tr>
<td>Topez, CA, USA</td>
<td>2015</td>
<td>550</td>
</tr>
<tr>
<td>Region Antofagasta (PV cluster), Chile</td>
<td>2012-2015</td>
<td>506</td>
</tr>
<tr>
<td>OCI TX, USA</td>
<td>2013</td>
<td>400</td>
</tr>
<tr>
<td>NV, USA</td>
<td>(approval 2012)</td>
<td>350</td>
</tr>
<tr>
<td>Silver State, AZ, USA</td>
<td>(approval 2012)</td>
<td>350</td>
</tr>
<tr>
<td>Sonorvan, AZ, USA</td>
<td>2012/2013</td>
<td>300</td>
</tr>
<tr>
<td>Yunca, AZ, USA</td>
<td>2014</td>
<td>290</td>
</tr>
<tr>
<td>Extremadura, Spain</td>
<td>Up to 2015</td>
<td>250</td>
</tr>
<tr>
<td>Antelope Valley, LA, USa</td>
<td>2012</td>
<td>230</td>
</tr>
<tr>
<td>Moapa, NV, USA</td>
<td>(approval 2012)</td>
<td>200</td>
</tr>
<tr>
<td>Aqua Calienta, AZ, USA</td>
<td>2012</td>
<td>200</td>
</tr>
<tr>
<td>Neubrandenburg, Germany</td>
<td>2012</td>
<td>150</td>
</tr>
<tr>
<td>North Cape, South Africa</td>
<td>2012</td>
<td>150</td>
</tr>
<tr>
<td>Desert Harvest, USA</td>
<td>(approval 2012)</td>
<td>150</td>
</tr>
<tr>
<td>Copper mountain, CA, USA</td>
<td>2012</td>
<td>150</td>
</tr>
<tr>
<td>Vega, Italy</td>
<td>2012</td>
<td>123</td>
</tr>
</tbody>
</table>

Source: LS-PV consulting
### Pipelines in Japan

<table>
<thead>
<tr>
<th>Location</th>
<th>[MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setouchi, Okayama</td>
<td>218</td>
</tr>
<tr>
<td>Tomatoh, Tomakomai, Hokkaido</td>
<td>100</td>
</tr>
<tr>
<td>Minamisoma, Fukushima</td>
<td>100</td>
</tr>
<tr>
<td>Hiyoshibanu, Oita, Oita</td>
<td>73</td>
</tr>
<tr>
<td>Nanatsujima, Kagosima</td>
<td>73</td>
</tr>
<tr>
<td>Niimi, Okayama</td>
<td>73</td>
</tr>
<tr>
<td>Tahara, Aichi</td>
<td>73</td>
</tr>
<tr>
<td>Yonago, Tottori</td>
<td>73</td>
</tr>
<tr>
<td>Kisosaki, Kuwana, Mie</td>
<td>73</td>
</tr>
<tr>
<td>Awaji, Hyogo</td>
<td>73</td>
</tr>
<tr>
<td>Iwanuma, Miyagi</td>
<td>73</td>
</tr>
<tr>
<td>Shiranuka, Hikkaido</td>
<td>73</td>
</tr>
<tr>
<td>Aozaki, Oita, Oita</td>
<td>73</td>
</tr>
<tr>
<td>Tomakomai, Hokkaido</td>
<td>73</td>
</tr>
<tr>
<td>Miyama, Fukuoka</td>
<td>73</td>
</tr>
<tr>
<td>Mie</td>
<td>73</td>
</tr>
<tr>
<td>Shiranuka, Hikkaido</td>
<td>73</td>
</tr>
</tbody>
</table>

218 large scale PV systems (>1MW), e.g. 733MW in total, are certified under the Japanese FIT. (as of 30 Sep. 2012)
Setouchi, Okayama

- Capacity: 250 MW
- Area: 400 ha
- Starting construction: Apr. 2013

(Source: http://www.city.setouchi.lg.jp/kinkai/)
### Hiyoshibaru, Oita

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>81.5 MW</td>
</tr>
<tr>
<td>Electricity generation</td>
<td>87 GWh/y</td>
</tr>
<tr>
<td>Area</td>
<td>105 ha</td>
</tr>
<tr>
<td>Starting construction</td>
<td>Nov. 2012</td>
</tr>
<tr>
<td>Starting Operation</td>
<td>Mar. 2014</td>
</tr>
<tr>
<td>Company</td>
<td>Marubeni</td>
</tr>
</tbody>
</table>

http://www.itmedia.co.jp/smartjapan/articles/1210/23/news026.html)
Nanatsujima, Kagoshima

Capacity: 70 MW  
Electricity generation: 79 GWh/y  
Area: 127 ha  
Starting construction: Sep. 2012  
Starting Operation: Autumn 2013  
Companies: Kyocera, IHI, Mizuho CB, etc.

(Source: http://www.kyocera.co.jp/news/2012/0704_kgos.html)
Several initiatives in the MED region

Source: IEA PVPS Task8 (provided from Mr. Roberto Vigotti)
Asia Solar Energy Initiative

- Launched in May 2010
- 3,000 MW in 3 yrs.
- Regional task force has been established.
IEA PVPS Task8: Energy from the Desert

Study on Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems
IEA PVPS Task8

- To examine and evaluate the feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems, which have a capacity ranging from over multi-MW to GW

- To accelerate and implement real VLS-PV projects
  - Performing active dissemination and communication with stakeholder
  - Developing recommendations of how to overcome hurdles/ barriers, from viewpoints of technical and non-technical
Task8 participating countries

- Japan (OA)
- Canada
- China
- France
- Germany
- Israel
- Italy
- Korea
- the Netherlands
- Spain (observer)
- Mongolia (observer)
Type of deserts
Solar resource of world six deserts

**Negev** 2.3
**Thar** 18
**Sahara** 626
**Gobi** 64
**Sonora** 7.4
**Great Sandy** 34

<table>
<thead>
<tr>
<th>Desert</th>
<th>NDVIymax</th>
<th>Times of World Energy Demand in 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negev</td>
<td>0.55</td>
<td>Low availability</td>
</tr>
<tr>
<td>Thar</td>
<td>0.45</td>
<td>Low availability</td>
</tr>
<tr>
<td>Sahara</td>
<td>0.35</td>
<td>Low availability</td>
</tr>
<tr>
<td>Gobi</td>
<td>0.25</td>
<td>Low availability</td>
</tr>
<tr>
<td>Sonora</td>
<td>0.15</td>
<td>Low availability</td>
</tr>
<tr>
<td>Great Sandy</td>
<td>n.a.</td>
<td>High availability</td>
</tr>
</tbody>
</table>

**752 PWh: 5.3 times of world energy demand in 2009**
8MW large Scale PV system in Dunghuang, China

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Investment (Million Yuan)</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV module</td>
<td>236.8</td>
<td>73.43</td>
</tr>
<tr>
<td>Inverter</td>
<td>34.2</td>
<td>10.61</td>
</tr>
<tr>
<td>Transformer</td>
<td>3.52</td>
<td>1.09</td>
</tr>
<tr>
<td>Test &amp; Monitoring</td>
<td>2.5</td>
<td>0.78</td>
</tr>
<tr>
<td>Civil Construction</td>
<td>15.56</td>
<td>4.83</td>
</tr>
<tr>
<td>Transportation and Installation</td>
<td>7.35</td>
<td>2.34</td>
</tr>
<tr>
<td>Feasibility Study and Preliminary Investment</td>
<td>7.0</td>
<td>2.17</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>15.36</td>
<td>4.65</td>
</tr>
<tr>
<td>Total HaveHV-G1</td>
<td>322.47</td>
<td>100</td>
</tr>
</tbody>
</table>
Generation cost of VLS-PV system

Based on technical cost analysis
Interest rate: 3%/year (100% debt)
Depreciation: 30 years

Based on financial model
80% Debt (Interest rate: 3%/year), 20% Equity (IRR 15%)
Reserve, Insurance, Security, etc.
Energy from the Desert

Feasibility of Very Large Scale Photovoltaic Power Generation (VLS-PV) Systems: Published in 2003

Practical Proposals for Very Large Scale Photovoltaic Systems: Published in 2007

Very Large Scale Photovoltaic Systems, Socio-Economic, Financial, Technical and Environmental Aspects: Published in September 2009

Task8, IEA PVPS WS at PVSEC-22, Hangzhou, China, 6 November 2012
4th edition: to be published soon

‘Energy from the Desert’

Very Large Scale PV Power- state of the art and into the future

1. Introduction
2. PV and Other Renewable Energy Issues
3. Global Potential of Solar Energy
4. Overview of large scale solar power generation
5. Environmental aspects of VLS-PV
6. Technical Engineering Guideline for VLS-PV
7. Financial Guideline for VLS-PV
8. Grid matching issues
9. VLS-PV Intermittence and Stationary Storage for VLS-PV
10. PV and Wind based Renewable Power Methane
11. VLS-PV Case Studies
12. Expected Role of International Cooperation
13. Possible contribution of VLS-PV to sustainability
15. Conclusions
Socio-Economic and Environmental Benefits

- Providing for security of energy supply and fair access to energy in local
- Sustainable local market for PV industry including services
- Technology transfer from developed countries to developing countries
- Saving fossil fuel consumption and mitigating GHG emissions
- Decreasing ecological footprint
Engineering and Financial Approach

- Knowledge on soil science and meteorology
- Experiences on issues of safe, secure, trouble-free operation, maintenance and reliable services
- Adaptation to requirements of the credit and investment, technical and legal due diligences
- Support of government and/or developing bodies toward removing barriers
Technical Potential

- Adapting tracking and concentrating technology, depending upon the site
- Predicting intermittence and energy storage: onsite storage & storage on grid
- Hybridization between VLS-PV and other renewable energy technologies
- Sophisticated hybrid concepts, such as renewable power hydrogen, methane, etc.
- World-wide grid of HVDC
Projection for the Future

- PV to be a main energy source in the global energy mix
- Achievement of IEA perspectives as a minimum level
  - PV Roadmap
  - Energy Technology Perspectives
  - Solar Energy Perspectives
- Innovative change: require certain lead time
- Delay in actions: cause serious problems
- Immediate actions for sustainable perspectives
Necessity of International Collaboration

- Requirement of increasing investment
- Innovative financial approaches and active international collaboration
- Creation of new joint initiatives at regional and global level
- Transferring knowledge and experiences
- Clear political commitment and stable regulatory framework
Road to Very Large Scale PV

- **MW-scale PV system**: already ‘proven’
- **100MW PV system**: now realizing!
- **GW-scale PV plant**: within a decade!

**Very Large Scale PV (VLS-PV):**
- Promising option for mass-deployment of PV system
- Basic load of production capacity for PV industry
- New ‘conventional’ power plant in remote and desert region, supplying solar electricity

GW-scale to ‘TW electricity’
Key issues

- Involvement of and strong initiatives by stakeholders
- Clarification of technical/non-technical barriers
- Providing suggestions of ‘how to overcome’ such barriers
- Understanding differences between developed and developing countries
- Creating opportunities of providing information & outcomes, and productive communication for filling gaps
Next steps: our focuses

- Requirements for VLS-PV from the utility points of view
- Suggestion and recommendations of how to overcome technical and non-technical barriers
- Learning-based implementing strategy for policy maker and entrepreneurs
Thank you for your attention!