Mega Solar Power project in Japan based on silicon with very low carbon footprint from Norway

Elkem Solar & Mitsui & Co.Ltd.
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Summary Elkem Solar

- A New Solar Grade Silicon quality has been developed and industrialized by Elkem Solar
  - Equivalent performance as polysilicon at lower cost
    - Low Energy consumption
    - Reduced Energy Pay back Time
    - Less CO$_2$-emissions
- Significant In-house R&D effort since mid 70`s
- Currently production line in Norway has 7,000 MT/year capacity
  - Targeting cost leader position
- Future development target a simplified value chain and additional reduced cost
Elkem Solar Silicon®: Metallurgical purification of solar grade silicon

- Silicon production from quartz and coal in electric arc furnace (EAF)
- Pyro-metallurgical removal of boron
- Hydro-metallurgical removal of phosphorous and metals
- Direct solidification – ingot production
- Cutting and cleaning

- Significantly reduced power consumption compared to Siemens based polysilicon (up to 75% reduction)
- Tailor-made product for the solar industry
- Process based on Elkem’s core competencies in high temperature processes, process and equipment design and industrialization
Elkem Solar – Plant layout

1 Silicon
2 Pyro
3 Hydro
4 Solidification
5 Post Treatment
The PV value chain:

Si-metal → Solar Grade Silicon → Ingot/Block → Wafer → Cell → Module → Installation

Mega Solar Projects based on existing funds and/or creating new funds
**CO$_2$ emission and energy payback time for different types of solar grade silicon**

<table>
<thead>
<tr>
<th></th>
<th>Elkem Solar, Norway</th>
<th>Polysilicon Europe</th>
<th>Polysilicon China</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO$_2$ emission, kg CO2/kg Si</strong></td>
<td>10</td>
<td>40</td>
<td>150</td>
</tr>
<tr>
<td><strong>Energy payback time, Months</strong></td>
<td>1,3</td>
<td>4</td>
<td>7,2</td>
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</tbody>
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Difference due to variation in energy intensity of technology and energy mix at production site.

- SimaPro + Ecoinvent 2.2 used in Life Cycle Assessment calculations
- "Modified Siemens" is with TCS recycling
- "Modified Siemens – EU" = "Best case Siemens" - all electricity from Hydro Power, all heat from co-generation power plants

The Energy payback time of 1.3 Months is Calculated for a 7000 MT / yr Elkem Solar plant located in Norway where the product is used to produce modules with 14.3% efficiency, installed in an area with 1700 kWh/m$^2$/yr solar irradiation. 7000 MT of silicon is enough for an installed capacity of about 1.2 GW.
Road map of Norwegian Silicon to contribute to Japan’s energy mix toward less environmental load and cost competitive PV energy

Step-1
as CSR of Elkem
2011/2012

- Elkem Sunshine Friendship Project
  (Co-sponsored by Kyocera & Mitsui)
  - Donation of 15KW system made of ESS™ to Ishinomaki Commercial High School
    Cast by Silicon Plus in Yamagata
    Cell/Module/Sytem by Kyocera
  - Education Program
    - Silicon as versatile material by Elkem
    - Silicon PV and contribution to global warming
  - Exchange Program
    - 7 students and a teacher invited to Norway for 10 days (August 2012).
Road map of Norwegian Silicon to contribute to Japan’s energy mix toward less environmental load and cost competitive PV energy

Step-2
Roof Top demo plant (2012)

Elkem-Tobata Renewable Energy Co., Ltd.

- 155KW SYSTEM Made of ESS™
- Completion and grid connection December 2012
- Location: Kitakyushu, Fukuoka
- Business partner: Tobata-ko Unyu Co., Ltd.

Delegation from Fukuoka Association of Corporate Executives stopped by Elkem Solar, Kristiansand, Norway (Sep. 2012), during their fact finding tour to Scandinavia for clean energy and environment
Road map of Norwegian Silicon to contribute to Japan’s energy mix toward less environmental load and cost competitive PV energy

**Step-3**
Demonstration in Mega Solar (2013)

- Demonstration of ESS™ based panels in Mega-class project in Japan
  - 2 MWp project to be installed in 2013
  - Demonstration of ESS™ in Mega Solar outside Japan particularly in hot zone

Indian demo plant: 100 % ESS and 100 % Polysilicon reference. 1.4 % additional KWh production from ESS™ modules documented. In August.

Silicon Plus wafers, Q-Cells, Titan modules

ESS modules are producing significantly better when electricity generation is at the highest, due to better high solar irradiation/high temp. performance of ESS™
Similar trends for ESS vs Polysilicon seen in Ishinomaki

\textit{Ishinomaki production data January 2012}

ESS™ modules show similar trends like the other test sites. Increasingly better performance at high insolation relative to the Polysilicon reference modules.
Mitsui’s Portfolio of Independent Power Producers (IPP) Business

Target
Net Capacity: 12GW
RE Ratio: 10%
Mitsui’s Solar Projects ~some examples~

Mitsui HQ
- Operation: Mar. 2011～
- Capacity: 150kW

Juneda Solar (Catalonia, Spain)
- Operation: Sep. 2008～
- Capacity: 1.5MW

Tahara Solar & Wind Project
- Operation: Sep. 2013～
- Capacity: 50MW (Solar) + 6MW (Wind)

Tokyo International Airport Cargo Terminal
- Operation: Aug. 2010～
- Capacity: 2MW
Collaboration among Elkem, Kyocera and Mitsui

**ESS Producer**
- Cost Competitiveness
- Low Energy Consumption
- Low Carbon Footprint

**Project Owner and Developer**
- Eco Friendly Materials meets Mitsui’s Policy

**PV Module Producer**
- Experienced & Reliable PV Module Producer
- High Performance Module

Mitsui installs ESS based PV modules into a Mega Project in Japan