36 MWp solar PV plant developed by Malpani Group in Rajasthan
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BRIDGE TO INDIA undertakes case studies to bring about a greater degree of trust and transparency in the market. We highlight key parameters, challenges as well as engineering and execution solutions associated with the projects. This case study is based on data provided by the developer and the project EPC contractor as well as a site visit by our team.

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Case study: 36 MWp solar PV plant developed by Malpani Group in Rajasthan

About the project

This is the first solar power plant developed by Giriraj Enterprises, a Malpani Group company. The EPC contractor was Sterling & Wilson for the project. The plant is located in the Jodhpur district of Rajasthan, an area that is among the highest solar radiation zones in India. The global horizontal irradiance (GHI) is 5.8 kWh/day. The project was commissioned in 22 weeks from the date of execution of the EPC contract on 21st March, 2013.

Project developer and owner

Malpani Group is a diversified Indian business group with interests in tobacco, real estate and power. The group turnover is around ₹ 8 bn ($ 132 m).

www.malpani.com

EPC contractor

STERLING AND WILSON

Sterling and Wilson Ltd. (SWL) is a Shapoorji Pallonji Group company. SWL, founded in 1927 as Wilson Electric, is one of the leading electro-mechanical engineering companies in India with a broad track record of providing turnkey solutions for HV and LV electrical systems, air-conditioning, diesel generating sets, structured data cabling and integrated building management systems.

SWL is now also a leading solar EPC company in India. As on May 2014, SWL has been involved in the execution of 163 MW of solar projects in India. SWL is currently working on 260 MW of solar projects under various stages of construction. This includes a 90 MW solar project in South Africa.

www.sterlingandwilson.com

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1 National Renewable Energy Laboratory (NREL)
Project Overview

- **Plant capacity**: 36.3 MWp/33 MW (AC)
- **Irradiance (GHI)**: 5.82 kWh/day
- **PV modules**:
  - 20.9 MWp - Canadian Solar (CS6P-245P)
  - 15.4 MWp - Jinko Solar (JKM245P, JKM250P)
- **Inverters**: 990 kVA SMA central inverter (Model - 900CP-XT)
- **Grid interconnection**: 33 kV
- **Distance to substation**: 7.5 km
- **Energy generation**: 58.67 million kWh (first year)
- **Capacity Utilization Factor**: 18.44%
- **CO₂ emission offset**: 48,000 tons CO₂/year
- **Commissioning date**: 21 March, 2013
- **Date of EPC contract**: 22 October, 2012
- **Construction time**: 108 days
- **Revenue model**: Sale of electricity to the grid at average pooled purchase cost (APPC, ₹ 2.75/kWh) + Renewable Energy Certificates (RECs)
- **Financing**: Debt equity ratio – 70:30
  
  Banker – Bank of Baroda

Project location and site parameters

The project is situated in Jodhpur district in western Rajasthan, approximately 50 km from the Thar desert. The climate is semi-arid with low rainfall (annual average is around 208 mm). Predominant soil type in the area is red desertic soil, which is loose, sandy to loamy in texture. Temperature highs range between 42 °C in summer and 26.3 °C in winter. Ground water quality is brackish to saline with electrical conductance ranging from 4,000 to 10,000 micro Siemens/cm at 25 °C.

The site was chosen for its high solar radiation. The location, however, also has high ambient temperature, dusty environment, loose soil and saline ground water – all issues that had to be factored in the design, engineering and construction of the plant.

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2 National Renewable Energy Laboratory (NREL)
3 Detailed project reports, Block – Phalodi under the Integrated Watershed Management Programme by Directorate of Watershed and Soil Conservation, Rajasthan
4 Brackish water - 0.05–3% dissolved salts
5 Saline water - 3-5% dissolved salts
6 District Groundwater Brochure - Jodhpur, Rajasthan by Central Ground Water Board, Govt. of India
Selection of EPC contractor

In October 2012, after an in-depth analysis of the capacities and proposals of various EPC providers, Giriraj Enterprises chose SWL as a turnkey EPC contractor to install and commission the solar plant. The motivation behind this choice was:

1. **Speed of execution**: Project timeline was of paramount importance for Giriraj Enterprises. The solar plant was to be commissioned within that financial year, i.e. before 31st March, 2013, to claim the accelerated depreciation tax benefit. SWL has a presence all over India and was able to mobilize manpower very quickly for the project.

2. **Experience**: At that point SWL had already been involved in commissioning 80 MW of solar PV projects in India. By May 2014 SWL had been involved in the successful completion of 163 MW solar projects in India.

3. **Liasoning support**: SWL agreed to provide complete liasoning support to Giriraj Enterprises for obtaining permissions and clearances including right-of-way (ROW) for setting up the 132 kV double circuit transmission line to the sub-station.

4. **Price**: SWL offered a competitive price per MWp, using quality components.

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The project timeline was of paramount importance. The solar plant was to be commissioned before 31st March, 2013, to claim the accelerated depreciation tax benefit.

**Monthly average GHI and temperature at the site**

- **GHI - NREL**
- **GHI - NASA**
- **Temperature (max)**

SWL offered complete liasoning support for obtaining permissions and clearances.
Challenges and solutions in project design and engineering

The project faced specific challenges related to the desert conditions at the site such as high temperature, sandy loose soil, sand storms, water quality and scarcity. SWL addressed these challenges with suitable design and engineering applications as well as selecting suitable components.

1. High temperature

   A. PV Module: SWL selected PV modules with a low temperature coefficient to optimise energy generation of the solar plant. SWL had conducted a comparative assessment of module parameters including temperature coefficient, comparative generation analysis and track record under similar operating conditions.

### PV module parameters

<table>
<thead>
<tr>
<th>Manufacture of PV modules</th>
<th>Canadian Solar</th>
<th>Jinko Solar</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV module –model</td>
<td>CS6P-245P</td>
<td>JKM250P</td>
</tr>
<tr>
<td></td>
<td>JKM245P</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical characteristics</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>STC* power rating</td>
<td>245W</td>
<td>250W</td>
</tr>
<tr>
<td></td>
<td>245W</td>
<td></td>
</tr>
<tr>
<td>NOCT** maximum power (Pmax)</td>
<td>178W</td>
<td>183Wp</td>
</tr>
<tr>
<td></td>
<td>179W</td>
<td></td>
</tr>
<tr>
<td>Peak efficiency</td>
<td>15.23%</td>
<td>15.27%</td>
</tr>
<tr>
<td></td>
<td>14.97%</td>
<td></td>
</tr>
<tr>
<td>Normal operating cell temperature (NOCT)</td>
<td>45±2°C</td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>- 40°C to 85°C</td>
<td></td>
</tr>
</tbody>
</table>

### Temperature coefficient

| Temp. coefficient of power | - 0.43%/°C | - 0.43%/°C |
|                           |           | - 0.43%/°C |
| Temp. coefficient of voltage | - 0.34%/°C | - 0.32%/°C |
|                            | - 0.32%/°C |             |
| Temp. coefficient of Isc   | 0.065%/°C  | 0.06%/°C    |
|                            | 0.06%/°C   |             |

### Warranty

| Power output warranty      | 25 year linear Power Warranty |             |

### Energy production

| Specific energy production kWh/kWp/year | 1510 | 1510 | 1510 |

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* STC 1000W/m²
** NOCT 800W/m²

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B. **Inverter**: SWL selected SMA's Sunny Central 900CP XT model inverters, which have an "OptiCool" cooling concept. OptiCool is an intelligent temperature management system that maintains internal temperature, maximizes yield and the inverter life. The inverter is designed to operate at ambient temperatures of up to 50 °C with maximum rated capacity.

2. **Sandy loose soil and sand storms**: The soil type of project area is loamy sandy with low soil bearing capacity (14 ton/square meter at 1.5 meter depth and 15 ton/square meter at 3 meter depth \(^7\)). Dust storms are common in the region during summer (average annual frequency is 10 per year in Phalodi \(^8\)). SWL opted for a composite piling type foundation for the project after assessment of geo-technical parameters of the site. In addition to providing adequate strength, SWL achieved high installation speed, less time for curing and low cost of installation. All relevant international quality codes \(^9\) and standards were followed during the design stage. Later, pull out tests were conducted to test the foundations. They showed that the foundation strength is up to 12.5 tonnes, making it extremely robust with the ability to withstand high wind speeds of up to 170 km/h.

3. **Saline groundwater**: The ground water at the project site is saline. The pH of surface water is 7.67 \(^10\). This could corrode the metal structures of the project. In general, hot dip galvanisation is done with 70 micron thickness to avoid any corrosive impact of water. SWL used hot dip galvanised structures with 80 micron thickness, to ensure sufficient protection for a longer life.

4. **Water scarcity**: In addition to poor water quality, availability of water is a major issue at the project site. The project is estimated to require around 7.08 million litres of water per year \(^11\), for cleaning of modules (2 litres per module, 2 times in a month). SWL installed five rainwater harvesting tanks with cumulative capacity of 6 million litres per year to collect rain water for cleaning the modules.

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\(^7\) Source - SWL  
\(^8\) Research Article on Satellite Viewed Duststorms – An Overview, R.K. Giri, Pooja Rani, Satish Prakash and Jagadish Singh  
\(^10\) Test results of surface water  
\(^11\) Source - SWL
Challenges and solutions in project execution

As per the EPC contract terms, the project was to be setup within five and a half months from the date of signature of the contract. This short timeframe created its own challenges, which SWL was able to overcome successfully. The plant was commissioned 4 days in advance of the scheduled commissioning date.

1. **Supply of materials**: SWL tapped into its network of trusted, reliable suppliers to ensure timely delivery of all materials and components. This was well synchronized with the site construction work so that each stage could be executed on-time.

2. **Pre-engineered structures**: SWL used pre-engineered structures as far as possible for the project. SWL included pre-cast foundations for transformers and inverters. This reduced on-site construction work and accelerated the entire process. The level of standardisation also ensured higher execution quality.

3. **Plant construction**: SWL adopted a construction process in which the entire plant was segregated into different blocks. Specialised teams were formed to complete different construction tasks associated with each block.

Project implementation timeline

“This was our first solar project. The plant was commissioned within time and is performing well. Based on this experience, we have decided to invest into further solar plants and continue our relationship with SWL.”

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**Quality codes followed for electrical design and installation of the project:**

1. Transformer: IS-2026 and IEC-60076
2. Cables:
   A. PVC insulated cable: IS-1554, IEC-60227
   B. XLPE insulated cables: IS-7098, IEC-60502
3. Ring Main Unit (RMU): IS-12729, IEC-62271
4. Earthing: IS-3043, IEC-600364
5. Lightning Protection: IS-2309

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Challenges and solutions in O&M

1. **O&M contract**: SWL is providing comprehensive O&M services to Giriraj Enterprises under a six year O&M contract. As the first solar plant for Giriraj Enterprises, there was a need for an experienced partner to help manage the plant as well as provide quality O&M services to ensure high and stable power generation. It was also important to ensure a high level of maintenance in order to meet all the performance warrantee conditions.

2. **O&M of solar plant**: The plant has various O&M challenges due to water scarcity, dust storms and local political issues. SWL has been able to address these and has been maintaining a high level of plant performance.
   
   A. **Water**: SWL has installed five rain water harvesting tanks. During the collection process, soil and sand particles get mixed with rain water and therefore a water treatment system has been installed at the site which provides soft water for module cleaning operations. The water harvesting system has reduced dependence on external water sources (such as bore wells, ponds and canal water) as well as O&M costs.

   B. **Dust storms**: Sand/dust storms are common during the summer season. During this period modules and inverters are checked frequently to prevent or quickly detect any potential damage.

   C. **Local political issues**: The area is prone to agitations by small farmer groups. SWL is managing this issue as and when it arises through intermediation and discussions. In order to reduce the number of agitations to a minimum, SWL is employing capable local staff at the plant as contractors, suppliers or in plant maintenance roles in an effort to make the local population stakeholders in the plant.

Water treatment system
Plant performance

1. **Plant performance monitoring**: SWL has set up a remote monitoring facility to provide real-time performance data to Giriraj Enterprises and SWL’s O&M team. This allows Giriraj Enterprises and SWL to address any issues at the plant immediately thereby maximizing plant uptime.

2. **Plant performance**: The current performance of the plant exceeds the predicted performance level. The plant performance ratio (PR) was expected to be 76%. The PR achieved by the plant over twelve months operation is more than 79%.

![Plant monitoring system](image1)

![Plant monitoring system](image2)