Todae Solar’s 1.22 MWp Rooftop Solar Photovoltaic Installation for Stockland Shellharbour, NSW.

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1.22 MWp Rooftop Solar Photovoltaic Installation

- The Project Highlights
- Design Requirements and Technical Details
- Innovation and Best Practice
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JJ Ferrandis – Head of Engineering – Todae Solar
## 1.22 MWp Rooftop Solar Photovoltaic Installation

### Modules
- **Canadian Solar CS6P-305 305 Watt Poly**

### # of Modules
- 3992

### Inverters
- **SMA STP25000-30**

### # of Inverters
- 43

### Inclination of panels
- 10° (panels landscape)

### Orientation of panels
- 13° East of North / 57° East of North

### Installation Time
- 11 weeks

### Estimated Annual Output
- 1,748,325 kWh/ year
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System #1
137.25 kWp

System #2
202.825 kWp

System #3
202.825 kWp

System #4
163.48 kWp

System #5
146.4 kWp

System #6
163.48 kWp

System #7
202.825 kWp

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Todae Solar in partnership with Canadian Solar was selected to design, supply, construct, commission and maintain this unique photovoltaic system on a Shopping Centre with a final power of 1,217.56 kWp utilising 3992 Canadian solar panels (305Wp) and 43 SMA STP25000 inverters.

The most unique and innovative features of the development are:

✔ Achieve the 1.2 MWp target using the area available

✔ Solar development with renovation / construction happening on the roof

✔ Shopping Centre surrounded by public areas and open 24 hours

✔ Inverter stations built and installed on the roof

✔ Tilt system and non-penetrating fixings

✔ Minimised losses from shading (existing elements and panel to panel)

✔ 7 connection points across the buildings

✔ Installation completed within Stockland record time requirements

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1.22 MWp Rooftop Solar Photovoltaic Installation

• The Project Highlights

• Design Requirements and Technical Details

• Innovation and Best Practice
The client wanted a system size of 1.2MW.

This was challenging as the solar plant had to be designed with-in restricted areas of available roof space, and areas of roof were being refurbished as the solar installation was taking place.
Timing

The installation needed to be built and commissioned within strict timeframes.
Stockland Shellharbour strictly required no interference with, or disruption to the vehicle and pedestrian traffic around the shopping centre (when accessing the rooftops, storage on site, craning equipment to the roof etc). This was challenging in a shopping centre with public access 24 hours a day, 7 days a week.
Consideration for shading losses

Shading analysis to obtain minimum distance between panels without compromising performance.
Consideration for shading losses
Self-consumption - Load Analysis (Generation to match consumption)

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Annual Utilization by Day

Solar Utilisation - Weekdays (kWh)

Imported Profile
Special mount

- Anodized Aluminium
- 10 degree tilt
- Non-penetrating fixings for Klip-Lok roof,
- Avoid dissimilar metal corrosion on the roof
- Mount is compatible with purlin distance of 1200 mm running both parallel and perpendicular to panels
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Special mount
The solar system had to be visually appealing, and have a low impact on the 'aesthetics' of the Shopping Centre as there are areas where the installation can be seen from car parks and other publicly accessible areas.
Compliant structural design

Mount to be structurally adequate and certified for being tilted at 10 degrees with dead load (including panels and other components) to be less than 15kg/m2 and uplift to be less than 2kPa.
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Panel Type

<table>
<thead>
<tr>
<th>System</th>
<th>Panels</th>
<th>Power (kWp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>450</td>
<td>137.25</td>
</tr>
<tr>
<td>#2</td>
<td>665</td>
<td>202.825</td>
</tr>
<tr>
<td>#3</td>
<td>665</td>
<td>202.825</td>
</tr>
<tr>
<td>#4</td>
<td>536</td>
<td>163.48</td>
</tr>
<tr>
<td>#5</td>
<td>480</td>
<td>146.4</td>
</tr>
<tr>
<td>#6</td>
<td>531</td>
<td>161.955</td>
</tr>
<tr>
<td>#7</td>
<td>665</td>
<td>202.825</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3992</td>
<td>1217.56</td>
</tr>
</tbody>
</table>

Electrical Data

<table>
<thead>
<tr>
<th>Specification</th>
<th>CS6X-305P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Maximum Power (Pmax)</td>
<td>305W</td>
</tr>
<tr>
<td>Optimum Operating Voltage (Vmp)</td>
<td>36.3V</td>
</tr>
<tr>
<td>Optimum Operating Current (Imp)</td>
<td>8.41A</td>
</tr>
<tr>
<td>Open Circuit Voltage (Voc)</td>
<td>44.8V</td>
</tr>
<tr>
<td>Short Circuit Current (Isc)</td>
<td>8.97A</td>
</tr>
<tr>
<td>Module Efficiency</td>
<td>15.90%</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40°C→+85°C</td>
</tr>
<tr>
<td>Maximum System Voltage</td>
<td>600V (UL)/1000V (UL)/1000V (IEC)</td>
</tr>
<tr>
<td>Maximum Series Fuse Rating</td>
<td>15A</td>
</tr>
<tr>
<td>UL Fire Classification</td>
<td>Class C</td>
</tr>
<tr>
<td>Power Tolerance</td>
<td>0→+5W</td>
</tr>
</tbody>
</table>

TEMPERATURE | CHARACTERISTICS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Coefficient (Pmax)</td>
<td>-0.43%/°C</td>
</tr>
<tr>
<td>Temperature Coefficient (Voc)</td>
<td>-0.34%/°C</td>
</tr>
<tr>
<td>Temperature Coefficient (Isc)</td>
<td>0.065%/°C</td>
</tr>
<tr>
<td>Normal Operating Cell Temperature</td>
<td>45±2°C</td>
</tr>
</tbody>
</table>
It was decided to use only the SMA STP25000 to make the installation consistent. 43 units in total were used.

This inverter has a good voltage window for large strings of Canadian Solar 305Watt. Using multiple inverters, with multiple maximum power point trackers (MPPTs) accommodated the different orientations of the panels.
Todae Solar managed to create a string and cable configuration to minimise the DC losses to 1.5%, well under the 3% maximum required in AS5033:2014.

The most critical runs were 230 metres (Array 3.A.1), 210 metres (Array 3.B.1) and 200 metres (Array 4.A.1). Todae Solar used 10mm² DC cable for these runs.
### AC Runs

Todae Solar installed the AC runs in an optimised way achieving great savings against the 1% maximum allowed voltage drop.

<table>
<thead>
<tr>
<th>System</th>
<th>No. Inverters</th>
<th>Current (A)</th>
<th>4C AC Cable (mm²)</th>
<th>Earth (mm²)</th>
<th>Distance (On Site)</th>
<th>Voltage Drop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>181</td>
<td>95</td>
<td>16</td>
<td>28</td>
<td>0.50%</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>254</td>
<td>185</td>
<td>35</td>
<td>45</td>
<td>0.58%</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>254</td>
<td>185</td>
<td>35</td>
<td>55</td>
<td>0.70%</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>217</td>
<td>150</td>
<td>25</td>
<td>50</td>
<td>0.68%</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>181</td>
<td>120</td>
<td>25</td>
<td>50</td>
<td>0.69%</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>217</td>
<td>150</td>
<td>25</td>
<td>44</td>
<td>0.68%</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>254</td>
<td>120</td>
<td>25</td>
<td>30</td>
<td>0.62%</td>
</tr>
</tbody>
</table>
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Specific meteorological data, expected generation output by system/inverter, performance guarantees

<table>
<thead>
<tr>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh/ m² / month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irradiance 198.4</td>
<td>154</td>
<td>148.8</td>
<td>114</td>
<td>86.8</td>
<td>69</td>
<td>80.6</td>
<td>111.6</td>
<td>141</td>
<td>170.5</td>
<td>174</td>
<td>198.4</td>
<td>1647.1</td>
</tr>
<tr>
<td>Average Daily Temperature °C 21.9</td>
<td>21.4</td>
<td>20.5</td>
<td>18.7</td>
<td>16.1</td>
<td>14.6</td>
<td>13.1</td>
<td>14.4</td>
<td>16.3</td>
<td>17.4</td>
<td>18.7</td>
<td>20.2</td>
<td>17.8</td>
</tr>
</tbody>
</table>

Performance guarantees were put in place in the contract for the next 5 years.

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1,743,954</td>
</tr>
<tr>
<td>2017</td>
<td>1,735,234</td>
</tr>
<tr>
<td>2018</td>
<td>1,726,558</td>
</tr>
<tr>
<td>2019</td>
<td>1,717,925</td>
</tr>
<tr>
<td>2020</td>
<td>1,709,336</td>
</tr>
<tr>
<td>2021</td>
<td>1,700,789</td>
</tr>
<tr>
<td>2022</td>
<td>1,692,285</td>
</tr>
<tr>
<td>2023</td>
<td>1,683,824</td>
</tr>
<tr>
<td>2024</td>
<td>1,675,405</td>
</tr>
<tr>
<td>2025</td>
<td>1,667,028</td>
</tr>
<tr>
<td>2026</td>
<td>1,658,692</td>
</tr>
<tr>
<td>2027</td>
<td>1,650,399</td>
</tr>
<tr>
<td>2028</td>
<td>1,642,147</td>
</tr>
<tr>
<td>2029</td>
<td>1,633,936</td>
</tr>
<tr>
<td>2030</td>
<td>1,625,767</td>
</tr>
<tr>
<td>2031</td>
<td>1,617,638</td>
</tr>
<tr>
<td>2032</td>
<td>1,609,550</td>
</tr>
<tr>
<td>2033</td>
<td>1,601,502</td>
</tr>
</tbody>
</table>
Business Case

- Important reduction on costs of electricity.
- Positive cumulative cash flow in just a few years.
- Up to 15% reduction in electricity purchased from the retailer.
- 42,000 metric tons of carbon dioxide equivalent emissions will have been avoided (Over the lifetime of the system)
- Reduced consumption of grid sourced power has the potential to reduce the fixed monthly demand charges from Stockland Shellharbour’s electricity retailer.
- Solar Installation registered as an Accredited Power Station with the Clean Energy Regulator.
Monitoring and Weather Stations

Monitoring requirements:

- Independent monitoring (total energy per hours, days, months, years...) for every system
- Monitoring of Inverters and values (power, energy, alarms, faults, DC values, AC Values...)
- For each MPPTs (Voltage, Current, Power)
- Alarms
- Performance, Energy and Yield analysis and reports
- Generation (Energy) at the Point of Connection via Electrical Meter

Two Weather Monitoring Stations were installed at agreed locations to measure the following parameters:

- Global horizontal irradiance
- Irradiance on collector plane
- Ambient temperature
- Module cell temperature
- Wind speed
- Wind direction
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Monitoring and Weather Stations

This is a comprehensive monitoring system collecting data from 43 inverters across 7 PV systems, 7 electricity meters and 2 weather stations. The Sunny Portal system is robust, clear and easy to analyse. This is vital for preventive and corrective maintenance, and analysis reports required by the client.
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Monitoring and Weather Stations

Daily Yield of Inverters

Bar chart showing the daily yield of inverters from 8/17/2015 to 8/23/2015. The chart compares the yield of inverters with different specifications (e.g., Inv. 3.1 STP25 - 106, Inv. 3.2 STP25 - 194, etc.).
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Monitoring and Weather Stations

Daily Yield of Systems

Graph showing daily yield of systems from March 22, 2016, to March 28, 2016.
Monitoring and Weather Stations

Hourly Yield of Systems and Irradiance

from 4/6/2016

- Insolation [kW/m^2] Sensorbox 733
- Specific yield of PV system [kWh/kWp] Shellharbour 1
- Specific yield of PV system [kWh/kWp] Shellharbour 2
- Specific yield of PV system [kWh/kWp] Shellharbour 3
- Specific yield of PV system [kWh/kWp] Shellharbour 7
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Monitoring and Weather Stations

Electrical Meter Monitoring

from 4/5/2016

- Power grid feed-in [kW] Cluster Controller 150
- Power [kW] Shellharbour 5
- Analogue current input 2 [A] Cluster Controller 150
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Monitoring and Weather Stations

Wind Speed

(from 8/24/2015)

- Wind speed [m/s] Sensorbox 733
- WindVel km/h [km/h] Sensorbox 733
Monitoring and Weather Stations

Irradiance

from 8/22/2015

[W/m^2] Mean values

Insolation [kW/m^2] Sensorbox 733
Monitoring and Weather Stations

Module Temperature

from 8/24/2015

- Ambient temperature [°C] Sensorbox 733
- Module temperature [°C] Sensorbox 733
Other Design and Project Requirements

- **Maintenance (preventive and corrective)**
  - Maintenance by Todae Solar for five years, coupled with system performance warranties and detailed energy generation and maintenance reports

- **LGC Claims and Administration**
  - Todae Solar is responsible for the application and administration of LGCs.

- **Testing at Completion**
  - Testing at Completion included: Mechanical (Roof Inspection, Inspection of Installed Equipment...) / Electrical (Wiring Inspection and Insulation, Voc and Isc testing...)

- **Acceptance Tests**
  - Insulation resistance, Functional and operational checks on energised control equipment and circuits, Earth resistance measurement, Solar Isolation Device Test, Integrated tests to demonstrate operation of the automatic connection and disconnection of the Solar PV Systems to/from the main electricity network and as per the authority requirements, Inspection and testing of communication systems and display

- **Documentation prior and post-installation**
1.22 MWp Rooftop Solar Photovoltaic Installation

• The Project Highlights

• Design Requirements and Technical Details

• Innovation and Best Practice
The Todae Solar Engineering department initially created an accurate 3D design of the building and surroundings adding the 3992 panels and the mounting.

This is an innovative approach during the design process that allows better visualization and checking of the system design early in the process.
Due to the tight deadline Todae Solar implemented solutions to speed up the installation time as much as possible.

For example, rooftop enclosures for DC isolators and fuses were prewired and labelled before being delivered on site.

DC isolators for the inverter stations were pre-built in an enclosure, pre-wired and delivered on site so the installation team had to simply fix on the wall and connect.
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Longer solar panel leads allowing strings to be connected between rows
SMA inverters allowed flexible electrical design around the challenging physical panel layout design. Electrical string configurations to match panel layouts on challenging roofs areas.
Outdoor Inverter Stations were designed, built and certified by Todae Solar considering:

- Loads
- Limited Space
- No fixings on the roofs
- Locations
- Corrosion
- Areas of exclusion (some walls from tenants couldn’t be used)
- Impacts on cable losses
- Proximity to Point of Connection
- Timing/Deadline
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Inverter Stations

<table>
<thead>
<tr>
<th>Inverter Station</th>
<th>Systems</th>
<th>No. of Inverters</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>5</td>
<td>On roof</td>
</tr>
<tr>
<td>B</td>
<td>2, 3</td>
<td>14</td>
<td>On roof</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>7</td>
<td>On roof</td>
</tr>
<tr>
<td>D</td>
<td>4, 5</td>
<td>11</td>
<td>Concrete Wall (Public space)</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>6</td>
<td>Concrete Wall (Restrictive area)</td>
</tr>
</tbody>
</table>
Exceptional Signage and Detailed Labelling for preventive and corrective maintenance

All signage on switches, isolators and within distribution boards and switchboards have to be in accordance with AS 4777 and AS/NZS 5033 and Service and Installation Rules of New South Wales.

As there are 7 systems installed at one Shopping Centre premises, labelling clearly and accurately reflects which devices control which equipment.
Techniques to minimise corrosion

Panels and Inverters certified for installation in close proximity to ocean

Mount and Fixing Components in Anodized Aluminium

Spray Galvanized paint on grounding lugs

Hot Dipped Galvanized Cable Tray

Elements for Inverter Structure HDG
1.22 MWp Rooftop Solar Photovoltaic Installation

Roof penetrations (none in this project)
Natural ventilation of panels (20mm gaps, tilt)

Following the guidelines from the solar panel manufacturer a 20 mm gap was left. The inclination of panels at 10 degrees contributes to better performance and less losses due to natural ventilation.
To simplify the installation while achieving best practice, the AC and DC cable trunking was carefully selected to improve the visuals, quality and performance of the system while ensuring mechanical protection.
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JJ Ferrandis – Head of Engineering – Todae Solar
Stockland Shellharbour are installing Australia’s largest single-rooftop solar system.
As a high quality example of commercial solar this system:

- Proves solar is a **valuable financial investment** and business asset to the client
- **Robust Performance Guarantee** to confirm the quality of the installation and generation
- **Weather Stations** as a method of **overseeing the performance** of the power station for the future years
- **Self-Consumption and Distributed Generation** a reality for large plants from the technical, legal and financial perspectives
- **WHS incident free** installation
- Performing above expectation
- An **example of best practice** in solar PV installations
- Installation & Design (Nomination for CEC Awards / Stockland Green Globe Awards / NSW Green Awards)
- Exceed client expectations
- Large Photovoltaic Power Stations **integrated in Public Spaces**
THANKS FOR YOUR ATTENTION!