Solar Dual Axis Tracker

Tracking the sun to generate more power

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How to reduce cost of PV power?

1) Reduce unit manufacturing cost
   - Use lower-cost materials: Thin film cell, UMG cell, concentration
   - Use less crystalline silicon: Thinner wafer
   - Increase solar cell efficiency: N-type cell

2) Increase system power production
   - Track the Sun
Maximizing irradiation intensity

- Intensity = constant $\times \cos \theta$

Intensity is largest when $\theta = 0$

Solar modules can generate more power when sunlight is perpendicular to the panel
Energy loss for fixed PV array

- Summer is a big loss for fix installation due to the longer day hours

<table>
<thead>
<tr>
<th>Latitude (degree)</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer (hours)</td>
<td>12.71</td>
<td>13.02</td>
<td>13.34</td>
<td>13.70</td>
<td>14.08</td>
<td>14.52</td>
<td>15.02</td>
<td>15.62</td>
</tr>
<tr>
<td>Winter (hours)</td>
<td>11.54</td>
<td>11.24</td>
<td>10.92</td>
<td>10.58</td>
<td>10.21</td>
<td>9.80</td>
<td>9.33</td>
<td>8.76</td>
</tr>
</tbody>
</table>
Solar trackers

- A solar tracker is a device for orienting PV panels toward the Sun throughout the day
- Product segmentation:
  - Single-axis tracker
  - Dual-axis tracker

- Trackers increase energy output of PV systems
  - 10-17% for single axis
  - 30-42% for dual-axis trackers, respectively
Comparison of Solar radiation (US)

Fixed array

Average Daily Solar Radiation Per Month

JUNE

Flat Plate Tilted South at Latitude - 16 Degrees

Dual-axis tracker

Average Daily Solar Radiation Per Month

JUNE

Two-Axis Tracking Flat Plate

Source: National Solar Radiation Data Base (NSRDB)
Comparison of Solar radiation (Europe)

Fixed array  

Dual-axis tracker
Tracker mkt share in large PV power plants

Tracking systems will be ~85% of commercial installations (>1 MW) in 2009 – 2012 (source: the report issued by PV Services Program and Energy Practice at Navigate Consulting)
Tracker Market Projection

Source: Prometheus Institute & Greentech Media, July 2008
D80 Tracker
D80 Tracker basic fact sheet (I)

- Module surface area: 85 m² (915 ft²)
- Module power: ~11 KWp
- Azimuthal rotation angle: 240° (-120° to +120°)
- Vertical inclination angle: 0 to 60°
- Tracker height: 4 m (13 ft)
D80 Tracker basic fact sheet (II)

- Azimuth rotation: Cogged crown wheel, driven by electric motor
- Vertical rotation: Liner actuator activated by motor
- Reinforced concrete foundation
- Power supply to motors: 380 to 480 V three phase, 50—60 Hz
Location: Delano, CA

Project: 2 D80 trackers
22 KWp
(with 200 W modules)

Simulated Production:
141 kWh/day
39% increase over fixed
(based on PVsys and PVWatts)

Actual production:
147 kWh/day
D80 Advantages: Robust design and fabrication

- Sturdy "V"-shaped metal structure
- Hot-dipped galvanized steel, resistant to corrosion
- Wind load of 137 km/h (90 mph)
- Compatible with all standard flat modules due to flexible mounting system
**D80 Advantages: PLC tracking Control**

- Tracks the sun precisely with Siemens Programmable Logic Controller (PLC), utilizing astronomical program
- Avoids “confusion” on cloudy days
- Allows interconnection between trackers for remote monitoring and controlling
D80 Advantages: Remote monitoring & control

- Remote monitoring of motor status, module orientation, and power output using internet or GSM SMS
- Automatic text message to warn operators
- Adjust tracker operation status
- Reduce maintenance cost
D80 Advantages: Night, weather positioning

- Automatic stow to horizontal position at night.
- Automatic stow to horizontal position at wind speeds greater than 70km/h (43 mph).
- Orient to the proper position depending on the weather conditions, after being connect to a meteorology station.
D80 Advantages: Rapid installation

- No ground penetration
- No excavation
- Pre-wired electrical assemblies
- Tracker mounts on foundation in minutes
- Easy array pre-assembly on the ground
- Team of 3 persons can install 4 trackers per day
D80 Advantages: Low maintenance

- 25+ year operation design
  --corrosion-resistant steel, weather-tight electrical cabinet, surge protection...

- Motors run infrequently

- Remote control saves site maintenance visits

- Low profile of operation parts
  --- easy to access

- Light weight electrical assemblies
  --- easy to replace

- Once per year preventive maintenance
D80 Advantages: Inverter flexibility

- Complete flexibility in inverter selection
- Allows for fully scalable systems
**D80 Advantage: Anti-Theft System**

- Passive security because of 4 meter high, horizontal position at night
- Automatic detection of panel disconnection
- Automatic text message warning
- Module security hardware can be used
D80 Advantage: Top Brand Parts

- High quality, globally-renowned parts
- UL listed electrical components
- 25+ year life span
- Key parts suppliers: Siemens, MGM, Schneider
D80 installation record

- Over 60 MW has been installed so far!

- The oldest system has been in the field for over 5 years.

- D80 trackers have been financed by major European banks.

Murillo el Fruto, Spain
Tracker Projects

Cintrunigo, Spain 1.4 MW

Almaraz, Spain 21 MW

California, USA 22 KW

California, USA 1 MW
D80 Tracker For 2008 Olympic Games

- Tracker installed in Beijing supporting **2008 Olympic Games**

near beach volleyball court
## D80 tracker vs. Conventional Single Axis Tracker (I)

<table>
<thead>
<tr>
<th></th>
<th>D80</th>
<th>Single Axis Tracker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power increase</td>
<td>Up to 40%</td>
<td>Up to 20%</td>
</tr>
<tr>
<td>Module density</td>
<td>7-9 acres/MW</td>
<td>5-8 acres/MW</td>
</tr>
<tr>
<td>Power density (in CA, USA)</td>
<td>50-70* kWh/m²/year</td>
<td>60 kWh/m²/year</td>
</tr>
<tr>
<td>Tracking method</td>
<td>PLC astronomical program</td>
<td>Active solar sensing</td>
</tr>
<tr>
<td>entire wind protection</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>

* 70 kWh/m²/yr is obtained with a novel tracker layout
## D80 tracker vs. Conventional Single Axis Tracker (II)

<table>
<thead>
<tr>
<th></th>
<th>D80</th>
<th>Single tracker array</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Requirement</td>
<td>Flexible</td>
<td>Flat, rectilinear shape</td>
</tr>
<tr>
<td>Land settling impact</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Ground Penetration</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>Azimuth Angle Range</td>
<td>+/- 120°</td>
<td>+/- 60°</td>
</tr>
<tr>
<td>Remote tracker operation</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>
Tracker Economics

- For a 1 MW project in California

<table>
<thead>
<tr>
<th></th>
<th>Turn-Key Cost ($/W)</th>
<th>Total Cost (Million $)</th>
<th>25 yr Power (MWh)</th>
<th>CSI Rebate (Million $)</th>
<th>PV Power Cost ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
<td>6.5</td>
<td>6.5</td>
<td>31240</td>
<td>2.4</td>
<td>0.13</td>
</tr>
<tr>
<td>Single</td>
<td>6.8</td>
<td>6.8</td>
<td>36551</td>
<td>2.8</td>
<td>0.11</td>
</tr>
<tr>
<td>Dual</td>
<td>7.0</td>
<td>7.0</td>
<td>42486</td>
<td>3.3</td>
<td>0.09</td>
</tr>
</tbody>
</table>

- Dual axis tracker projects offers the lowest $/kWh.
- Feed-in-tariff favors solar trackers.
D81 tracker: a significant upgrade

- Improved design for higher reliability
- Stronger wind load, 177 km/h (110 mph) for more challenging environment.
- Relocated, pre-wired electric box for faster installation
# D81 Marine & Desert Versions

<table>
<thead>
<tr>
<th></th>
<th>D81 Marine</th>
<th>D81 Desert</th>
<th>D81 Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy coating &amp; hot dipped galvanization</td>
<td>hot dipped galvanization</td>
<td>hot dipped galvanization</td>
<td></td>
</tr>
<tr>
<td>Corrosion-resistant cover on slewing bearing to protect from salty air</td>
<td>Corrosion-resistant cover on slewing bearing to protect from sand</td>
<td>no cover on bearing</td>
<td></td>
</tr>
<tr>
<td>Corrosion-resistant cover on motor to prevent from salty air</td>
<td>Corrosion-resistant on motor to protect from sand</td>
<td>no cover on motor</td>
<td></td>
</tr>
<tr>
<td>Air-tight electrical box</td>
<td>add tube outside cable for electrical safety and to protect from sand</td>
<td>add tube outside cable for electrical safety</td>
<td></td>
</tr>
<tr>
<td>Exposed cylinder</td>
<td>add tube for gas spring cylinder to protect from sand</td>
<td>exposed cylinder</td>
<td></td>
</tr>
</tbody>
</table>
Summary

- Dual axis tracker can increase power output up to 40% over fixed array.

- Solar trackers have been field-tested with more than 60 MW installed over 6+ years.

- D81 tracker is a significant improvement over D80, with a superb wind load and faster installation.

- Solar trackers can reduce $/kwh. It is an ideal tool to win project bidding!