



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

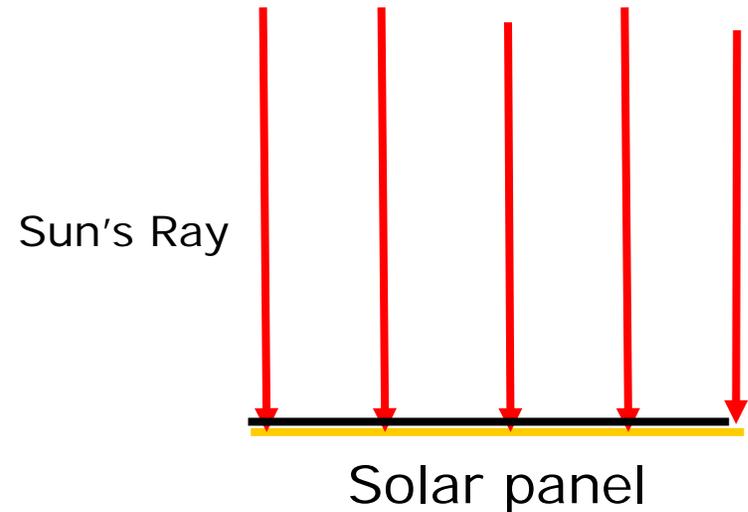
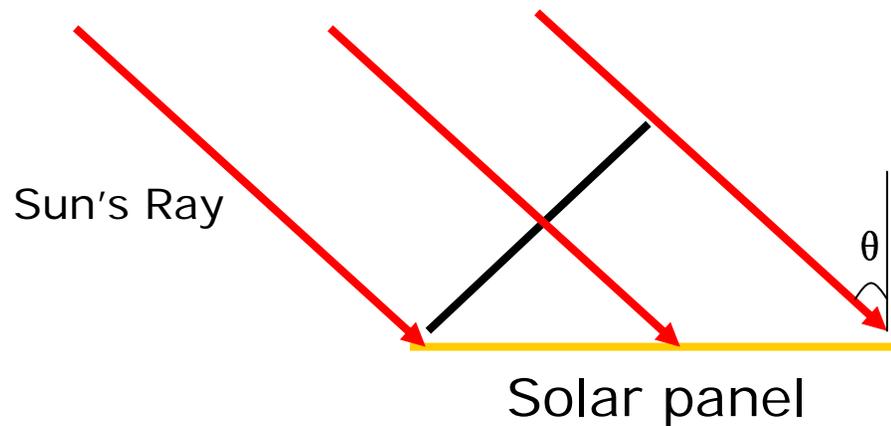
- ◆ Track the Sun



Maximizing irradiation intensity

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

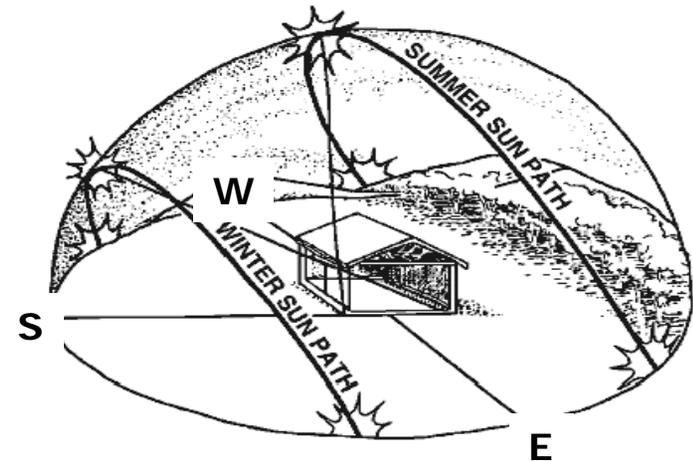
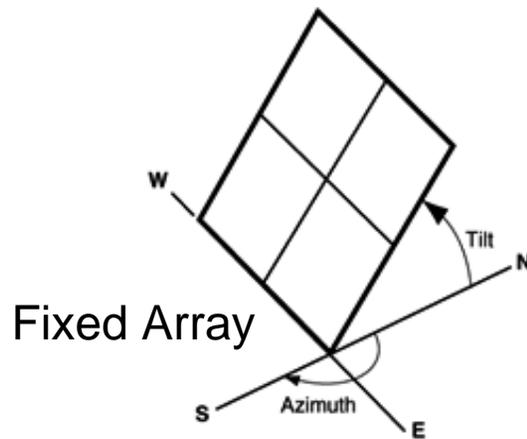
Intensity is largest when $\theta = 0$



Solar modules can generate more power when sunlight is perpendicular to the panel

Energy loss for fixed PV array

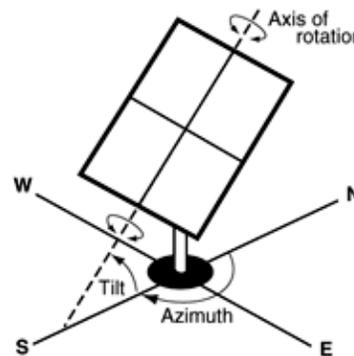
- ◆ Summer is a big loss for fix installation due to the longer day hours



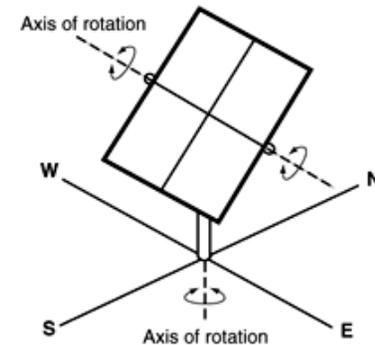
Latitude (degree)	10	15	20	25	30	35	40	45
Summer (hours)	12.71	13.02	13.34	13.70	14.08	14.52	15.02	15.62
Winter (hours)	11.54	11.24	10.92	10.58	10.21	9.80	9.33	8.76

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



One axis tracking PV array
with axis oriented south.



Two-axis tracking PV array

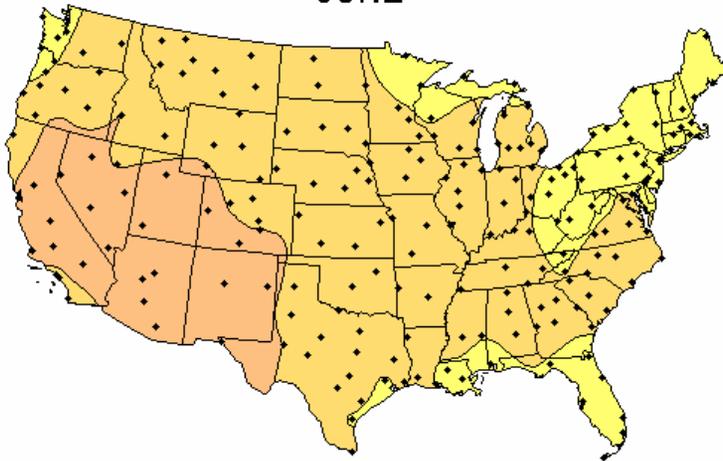
- ◆ Trackers increase energy output of PV systems
 - ◆ 10-17% for single axis
 - ◆ 30-42% for dual-axis trackers, respectively

Comparison of Solar radiation (US)

Fixed array

Average Daily Solar Radiation Per Month

JUNE

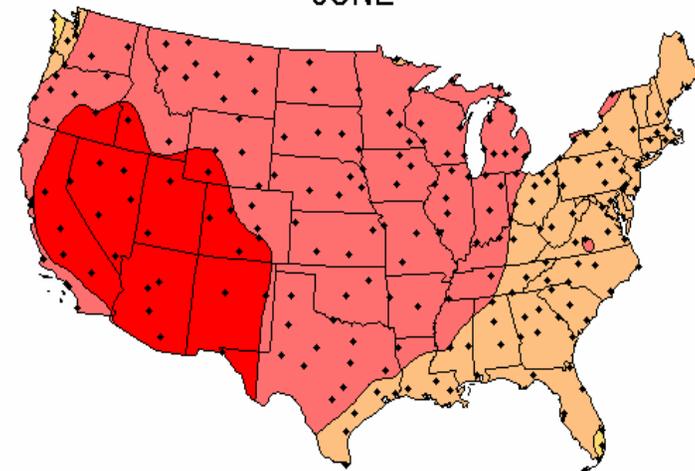


Flat Plate Tilted South at Latitude - 15 Degrees

Dual-axis tracker

Average Daily Solar Radiation Per Month

JUNE



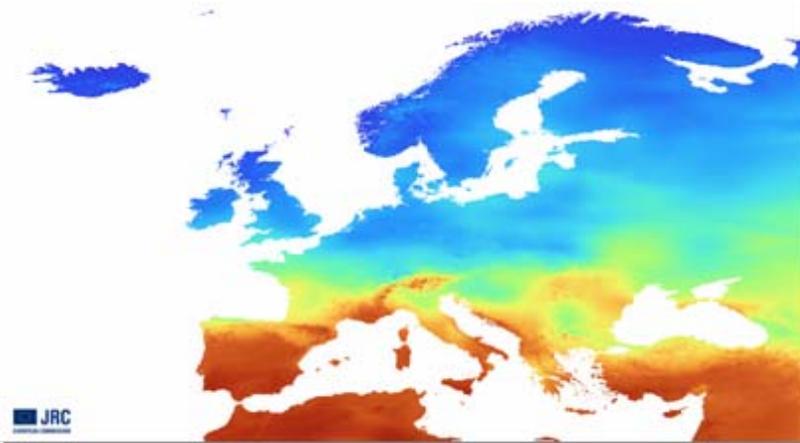
Two-Axis Tracking Flat Plate

kWh/m²/day

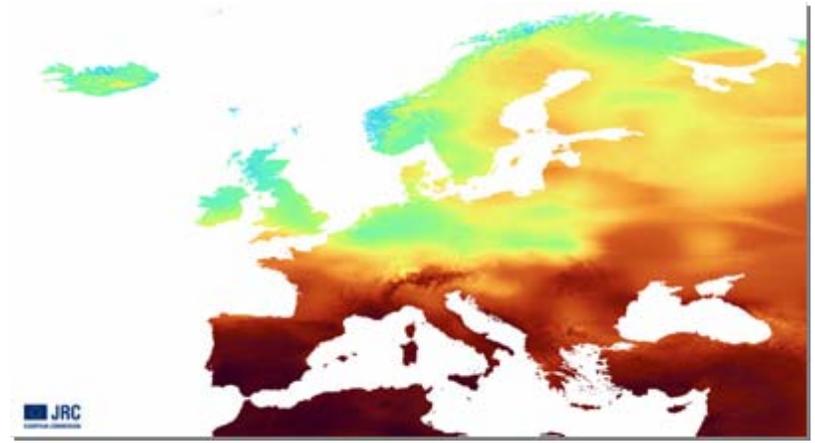


Comparison of Solar radiation (Europe)

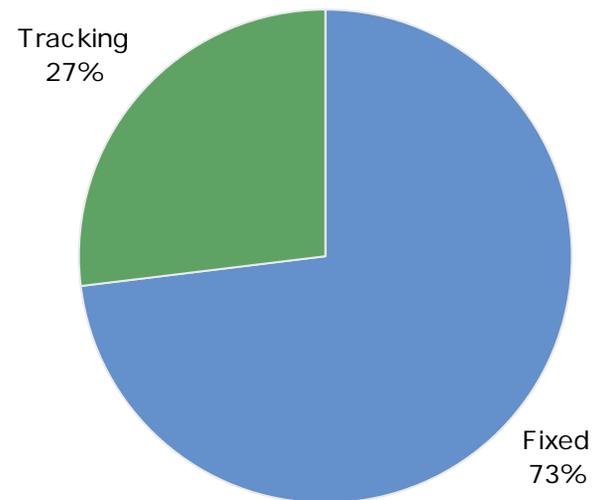
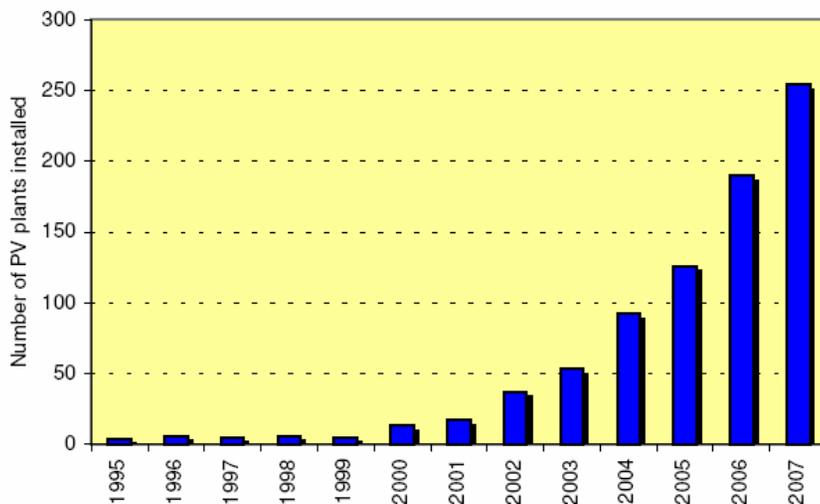
Fixed array



Dual-axis tracker



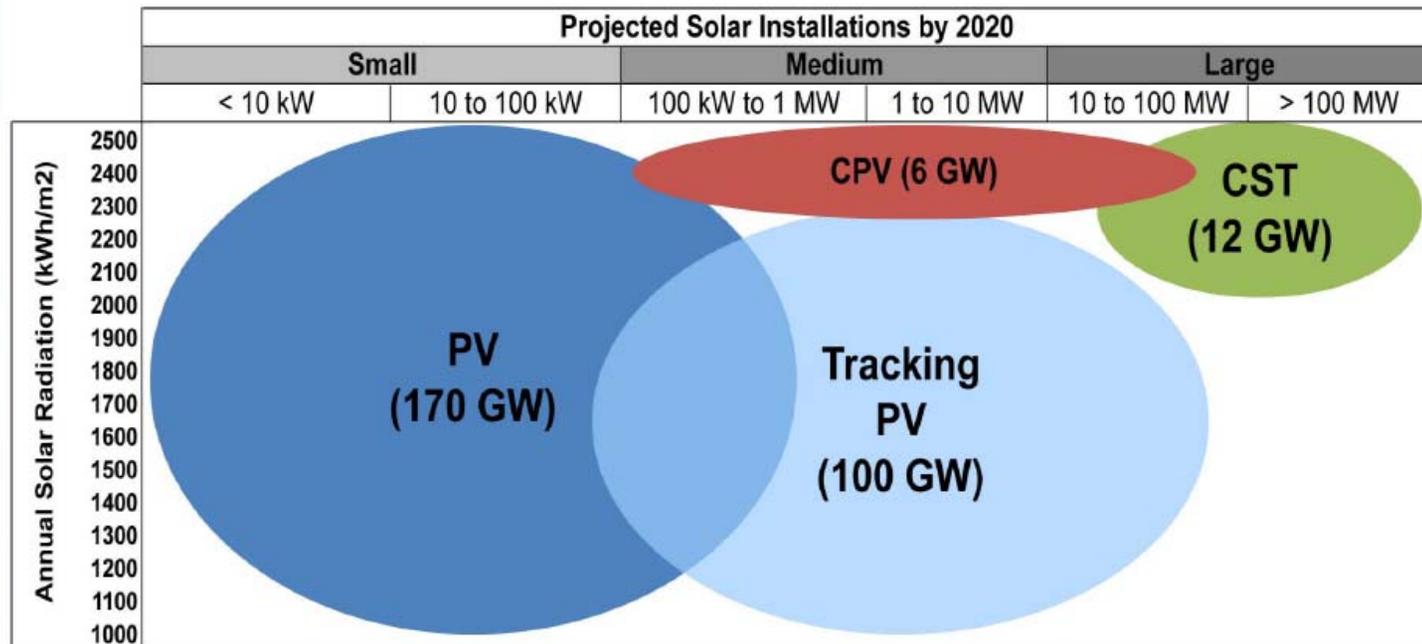
Tracker mkt share in large PV power plants



Source: 2007 annual report from www.pvresources.com

✓ 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



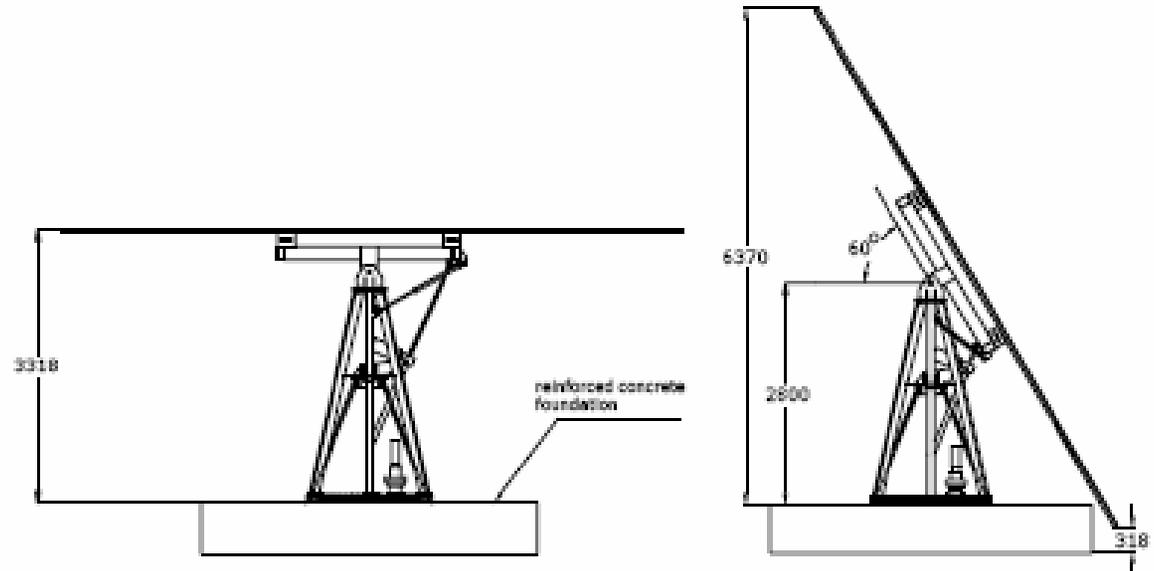
Source: Prometheus Institute & Greentech Media, July 2008

D80 Tracker



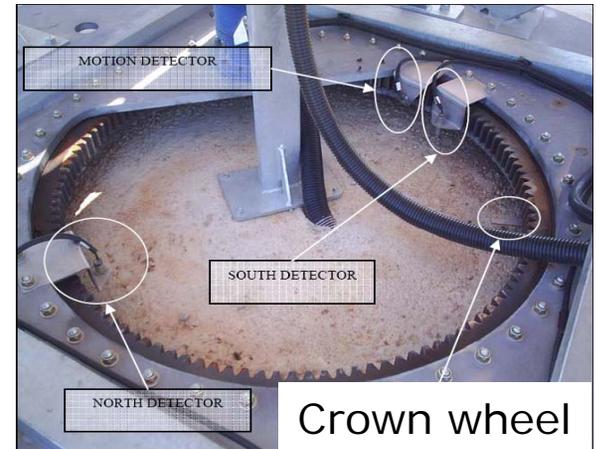
D80 Tracker basic fact sheet (I)

- ◆ 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)

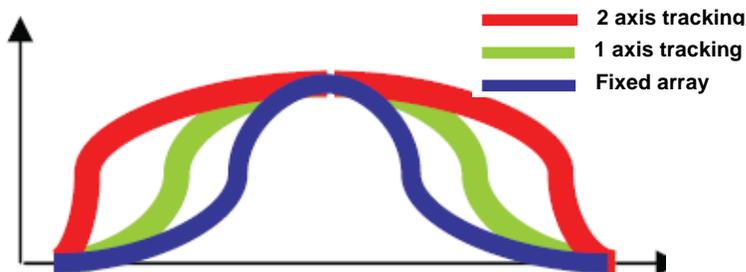
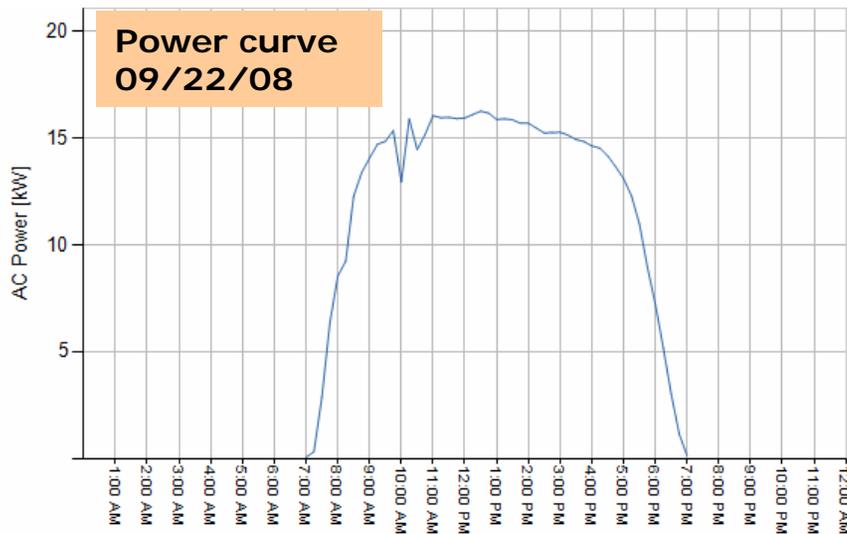


D80 Tracker basic fact sheet (II)

- ◆ 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



D80 Benefit: Production Increase to 40%



Location: Delano, CA

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

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

Actual production:
147 kWh/day

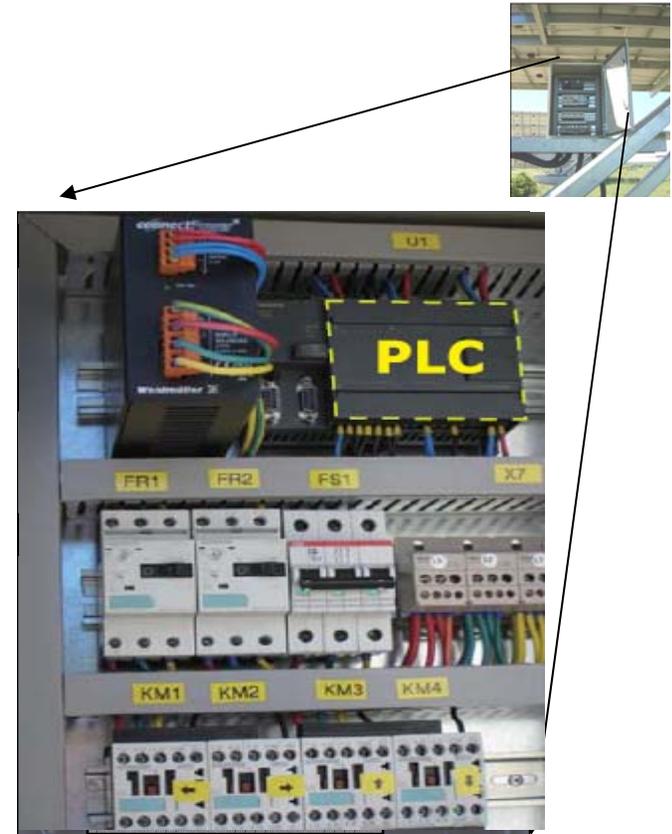
D80 Advantages: Robust design and fabrication

- ◆ 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



Control Cabinet

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

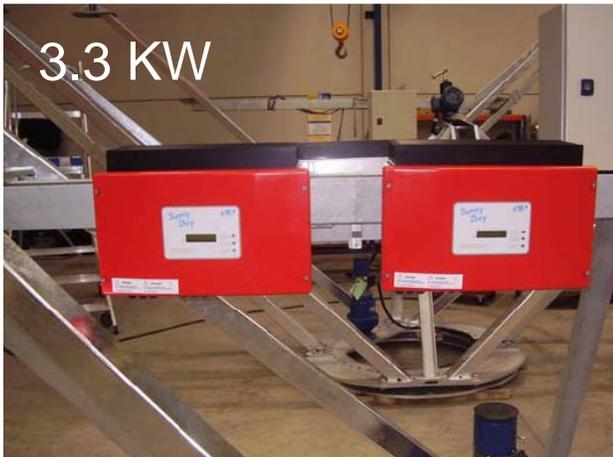


D80 Advantages: Low maintenance

- ◆ 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



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)

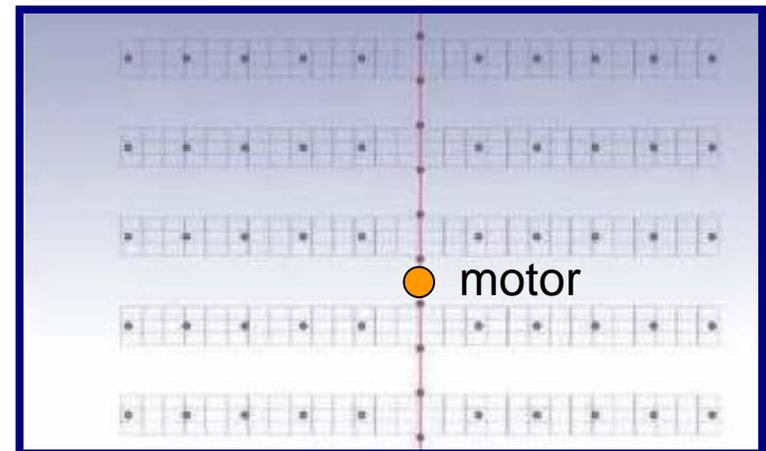
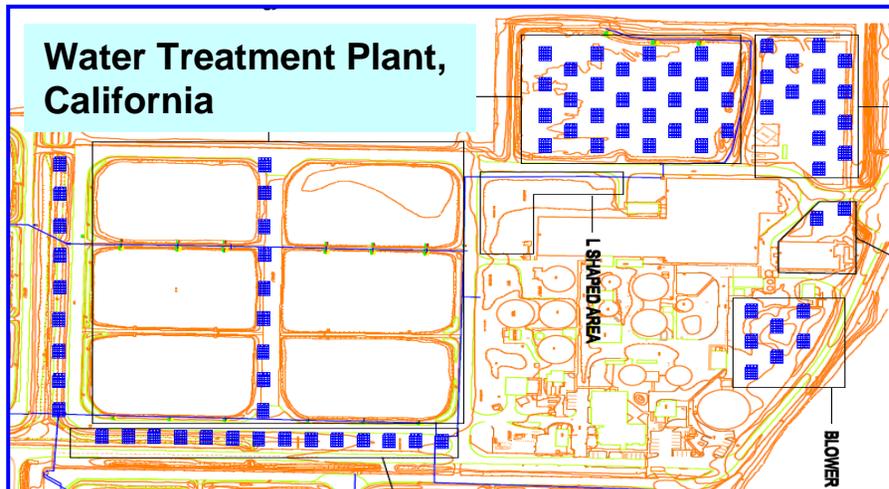
	D80	Single Axis Tracker
Power increase	Up to 40%	Up to 20%
Module density	7-9 acres/MW	5-8 acres/MW
Power density (in CA, USA)	50-70* kWh/m ² /year	60 kWh/m ² /year
Tracking method	PLC astronomical program	Active solar sensing
entire wind protection	yes	no



* 70 kWh/m²/yr is obtained with a novel tracker layout

D80 tracker vs. Conventional Single Axis Tracker (II)

	D80	Single tracker array
Land Requirement	Flexible	Flat, rectilinear shape
Land settling impact	no	yes
Ground Penetration	no	yes
Azimuth Angle Range	+/- 120°	+/- 60°
Remote tracker operation	yes	no



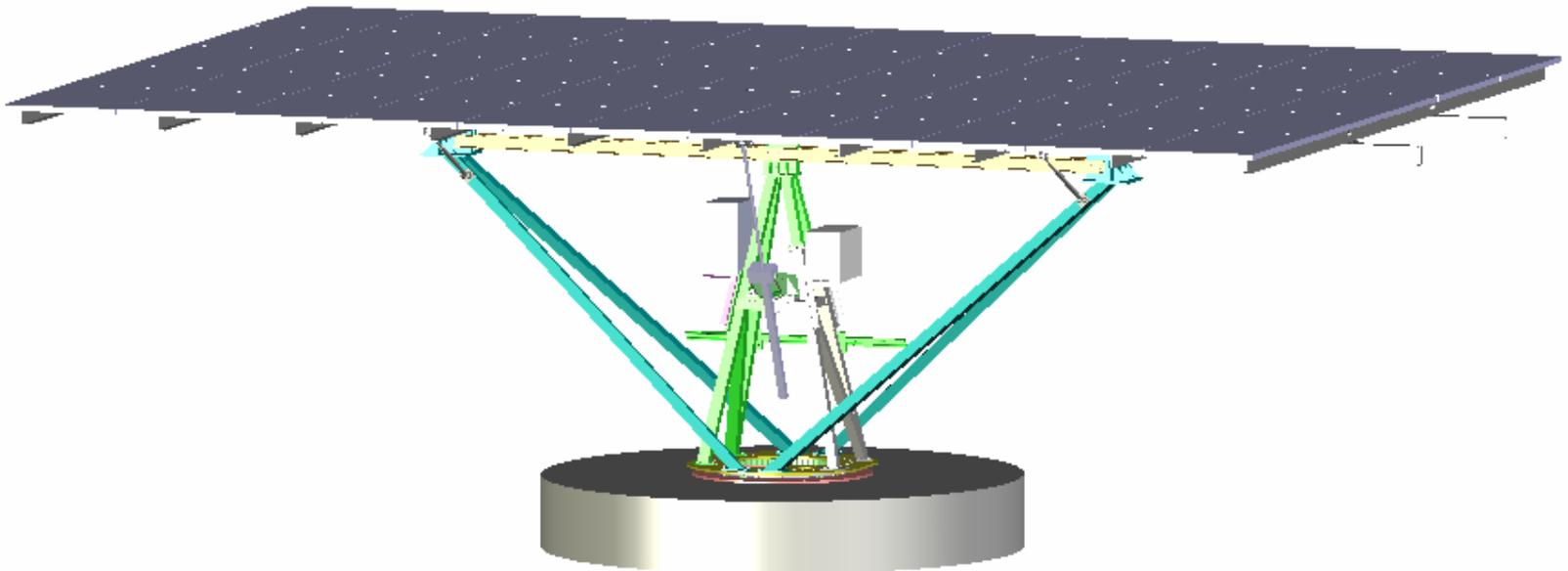
Tracker Economics

- ◆ For a 1 MW project in California

	Turn-Key Cost (\$/W)	Total Cost (Million \$)	25 yr Power (MWh)	CSI Rebate (Million \$)	PV Power Cost (\$/kWh)
Fixed	6.5	6.5	31240	2.4	0.13
Single	6.8	6.8	36551	2.8	0.11
Dual	7.0	7.0	42486	3.3	0.09

- 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

D81 Marine	D81 Desert	D81 Standard
epoxy coating & hot dipped galvanization	hot dipped galvanization	hot dipped galvanization
Corrosion-resistant cover on slewing bearing to protect from salty air	Corrosion-resistant cover on slewing bearing to protect from sand	no cover on bearing
Corrosion-resistant cover on motor to prevent from salty air	Corrosion-resistant on motor to protect from sand	no cover on motor
Air-tight electrical box	add tube outside cable for electrical safety and to protect from sand	add tube outside cable for electrical safety
exposed cylinder	add tube for gas spring cylinder to protect from sand	exposed cylinder

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!



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