



Utility Scale Solar Photovoltaic Development



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TOPIC

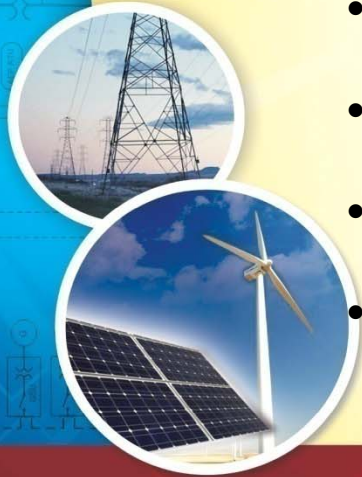
- Technical issues related to the development of utility scale solar PV
- From site due diligence to grid interconnection, design, all the way to shovel ready.

➤ Similarities and distinctions vis-à-vis wind energy systems



Overview

- Utility Scale Solar Projects
- Solar/Wind/Load Patterns
- Wind vs. Solar
 - Site Assessment, Soil Investigation,
 - Interconnection Process with ERCOT and SPP
 - Technical Information required in Applications
- Dynamic Models for transient stability
- Inverter Choices
- Fixed versus Tracking Installations
- Annual Energy Yields

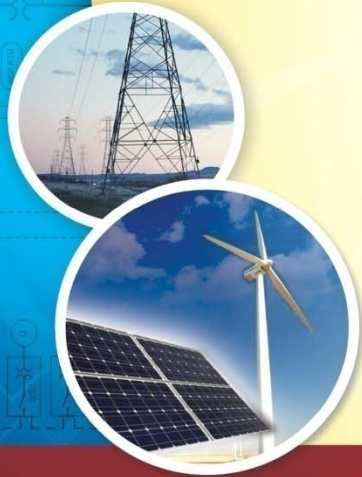


Utility Scale Solar Projects Rising

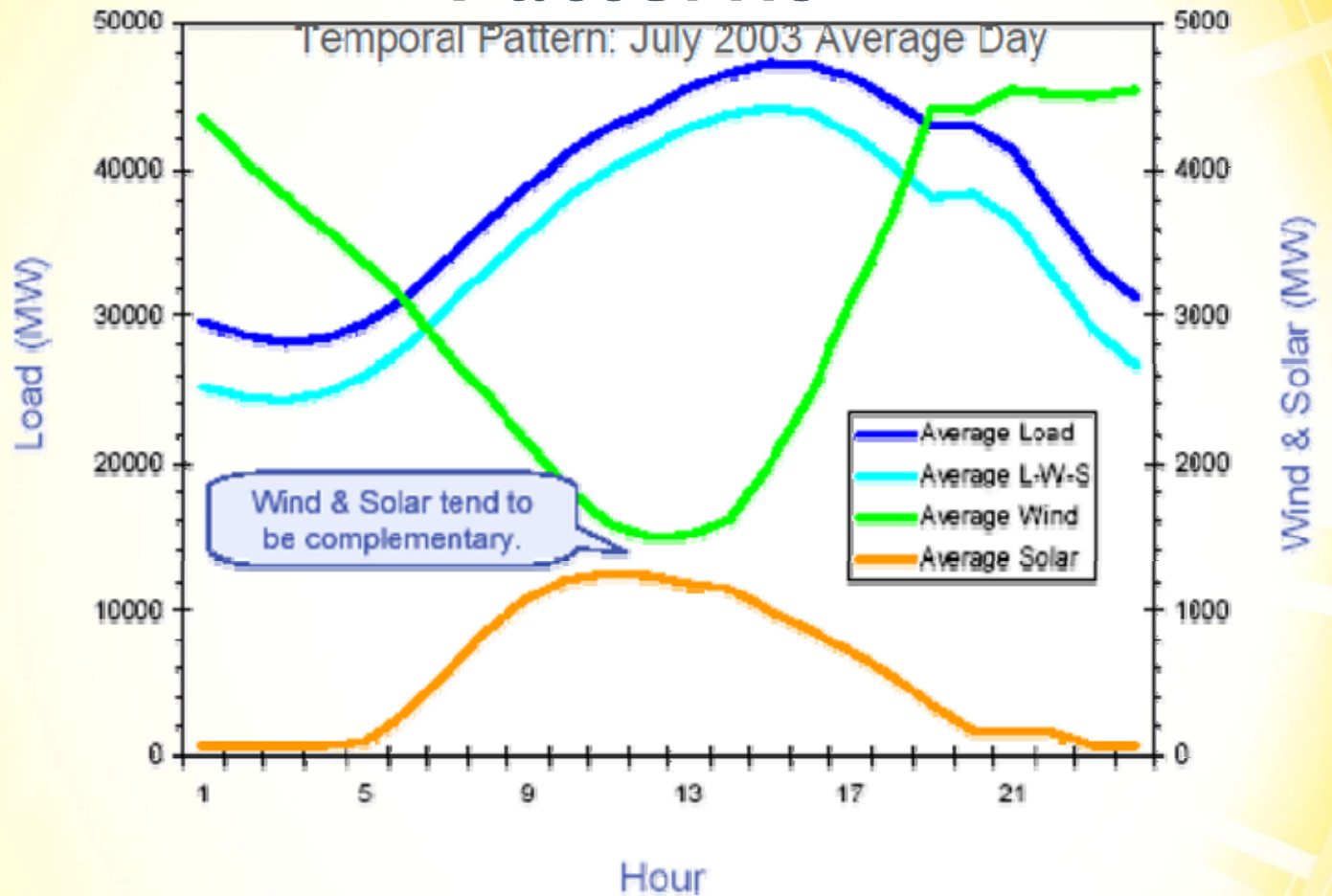
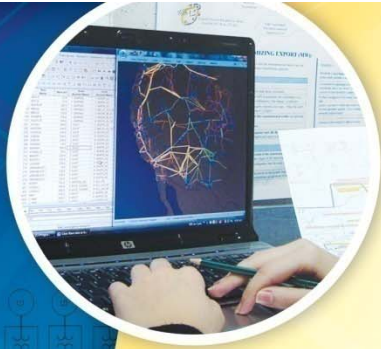
The past twelve months – more than 40 studies & rising.

- ✓ Technology and Price matured
- ✓ Rapid deployment
- ✓ Daytime peak power matches utility load profile
- ✓ Easier permitting

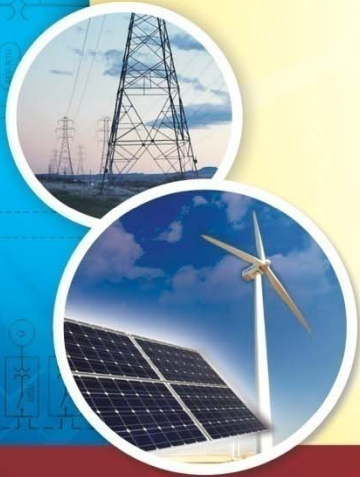
➤ Transmission congestion facing wind. Fill in the blanks with Solar?



Solar, Wind and Load Patterns



Reference: PG&E



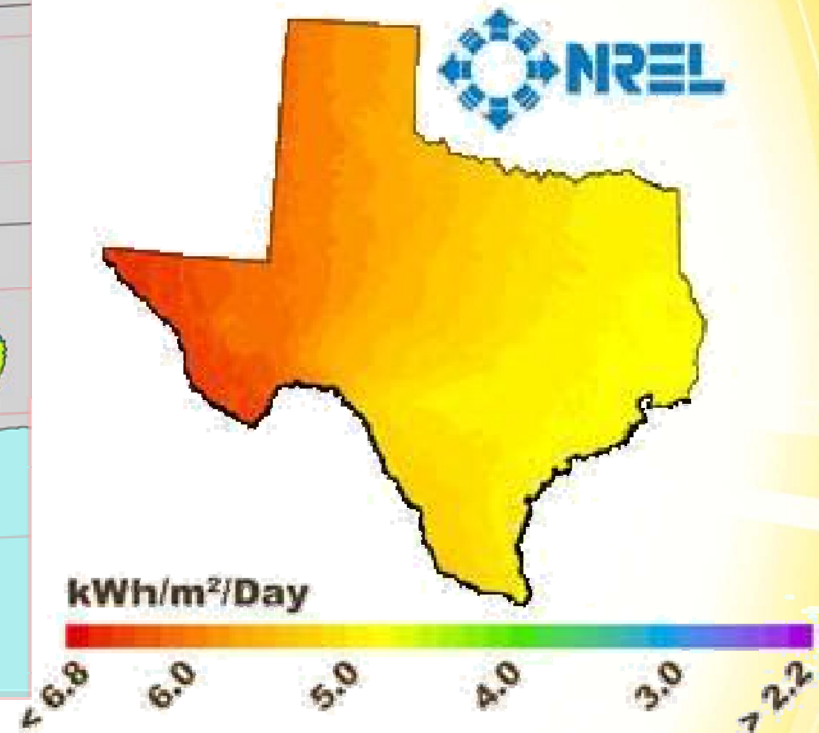
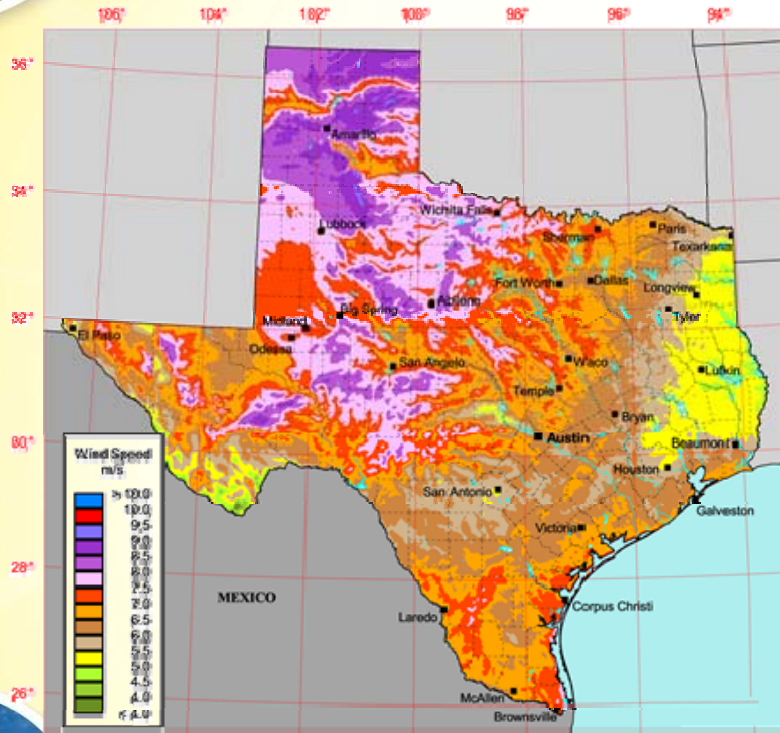
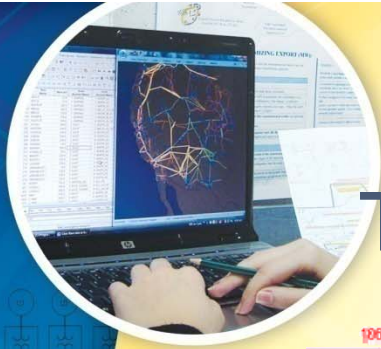
Solar vs. Wind Site Assessment

	SOLAR	WIND
Site Use	Packed: 40,000 panels /60 acres *	1 turbine /60 acres
Obstructions	Shading	Air flow
Topography	Flat preferred	Ridges
Transmission	Accessibility & Deliverability	Accessibility & Deliverability
Environmental	ESA, Waterways, Endangered Species	ESA, Waterways, Endangered Species, Bird and Bat
Soil Investigation	More extensive	Samples at each turbine location

**Each Panel is 280 W, 3.26 ft by 6.42 ft wide*

...Solar vs. Wind

The Resource in West Texas & Panhandle



..Solar vs. Wind Interconnection Process

The application process, and timelines are the same for both Wind and Solar.

Technical information Wind Specific, yet general for Solar

Solar	Wind
General Forms	Wind Specific

Solar and Wind

Interconnection Process

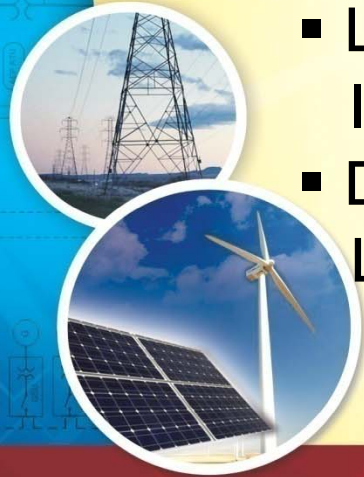
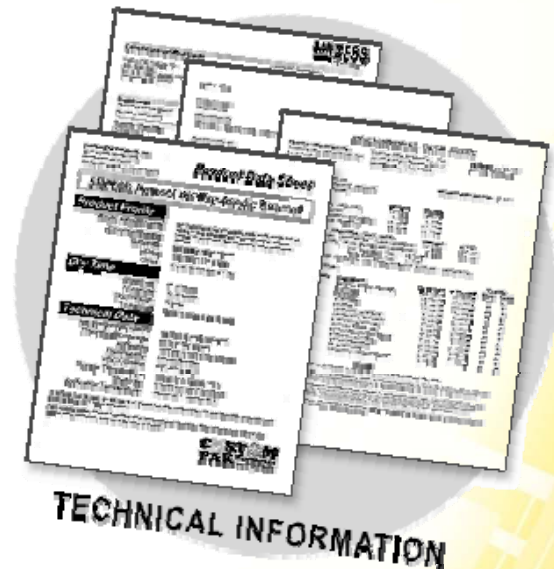
ERCOT vs. SPP

Although the process is the same for Solar & Wind, however ERCOT and SPP processes differ:

- SPP has a *Queue list*; whereas ERCOT has an *Interconnection list*
- Small Generation Interconnection Process:
 - Generators less than 10 MW for ERCOT
 - Generators less than 2 MW for SPP
- For large projects in ERCOT (>10 MW), and in SPP (>2 MW), this is usually a lengthy process
- Small projects in ERCOT go directly to the local utility and not through the LGIP

..Solar vs. Wind Technical Information Required in Applications-cont

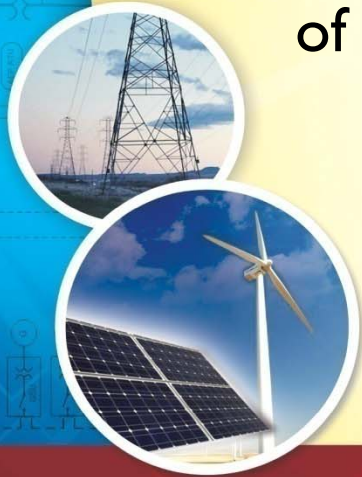
- Total Project Size
- Generator/Inverter Technical Information
- Proposed location of Interconnection Point
- Preliminary One-Line Diagram of Interconnection Facilities
- Layout map for project and Interconnection Point
- Demonstration of Site and Land Control



..Solar vs. Wind

Dynamic Models for the Transient Stability

- Readily Available for Wind from known manufacturers
- Must work with Inverter manufacturers and utilities to validate the need for and implementation of inverter models



Inverter Choices

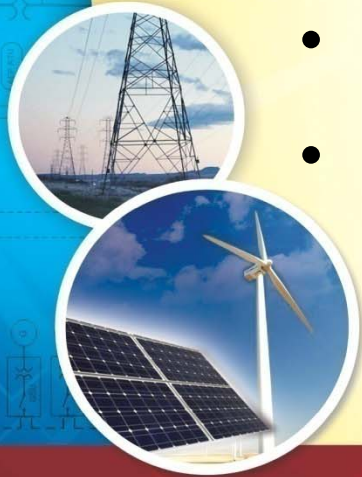
Most inverters available are and must be compliant with:

- IEEE STD 1547 (Recommended Practices for Interconnecting Distributed Resources)
- IEEE STD 929 (Recommended Practice for Utility Interface of PV Systems).
- IEEE 519 -1992
- UL Certified

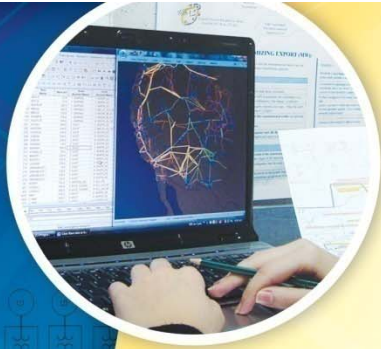


..Inverter Choices

- What requirements should the solar project inverters comply with?
 - Low voltage ride-through (LVRT)
 - Reactive power support
 - Over and under frequency ride-through
 - Voltage settings

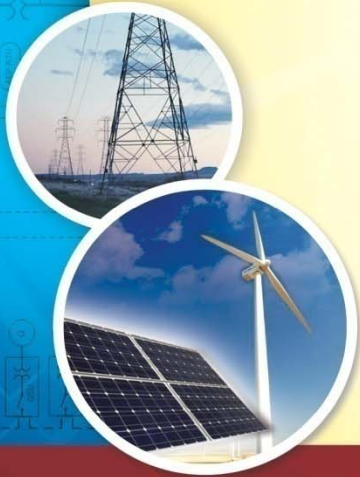


.. Inverter Choices ERCOT COMPLIANCE



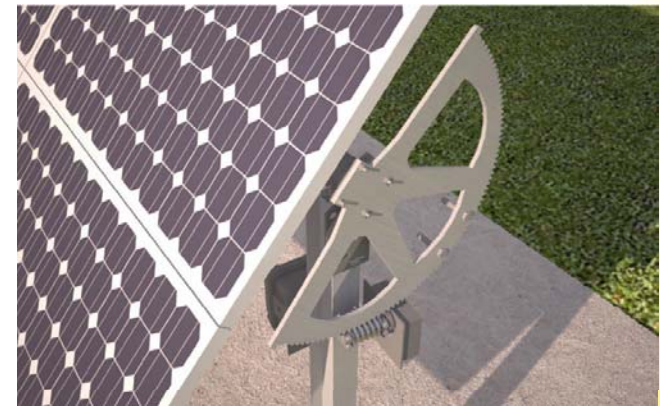
	ERCOT REQUIREMENTS		Example Inverter
Voltage Range (% V Nominal)	$110\% < V$	Generator Discretion	In Compliance
	$90\% \leq V \leq 110\%$	Continuous operation	In Compliance
	$0\% < V < 90\%$	0.15 sec to 1.75 sec	In Compliance
	$V=0$	0.15 sec (zero voltage ride through)	In Compliance
Frequency Range (Hz)	$f > 59.4$ Hz	Continuous operation	59.4 Hz < f ≤ 59.8 Hz trips in 5 minutes f > 59.8 in Compliance
	58.4 Hz < f ≤ 59.4 Hz	Not less than 9 minutes	Not in Compliance
	58.0 Hz < f ≤ 58.4 Hz	Not less than 30 seconds	In Compliance
	57.5 Hz < f ≤ 58.0 Hz	Not less than 2 seconds	In Compliance
	f ≤ 57.5 Hz	No time delay required	In Compliance

ERCOT Operating Guide does not address the removal of generating units for frequency deviations above 60 Hz. However it is realized that the generator operating restrictions below 60 Hz apply equally to the operation above 60 Hz.



Fixed vs. Tracking

- Fixed PV installations have a fixed tilt angle (usually set at latitude)
- Single axis trackers, track the sun east to west daily.



..Fixed vs. Tracking

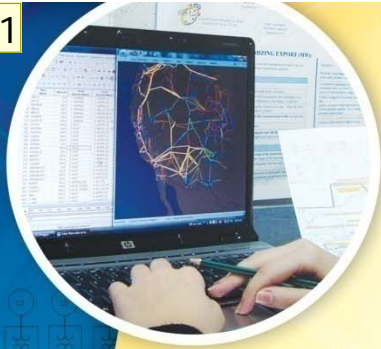
Fixed vs. Single Axis

- Land use:
 - 4-5 acres per MW for Fixed PV
 - 5-6 acres per MW for single axis.
- Some single axis tracking systems may yield 22-24% more energy than fixed PV.

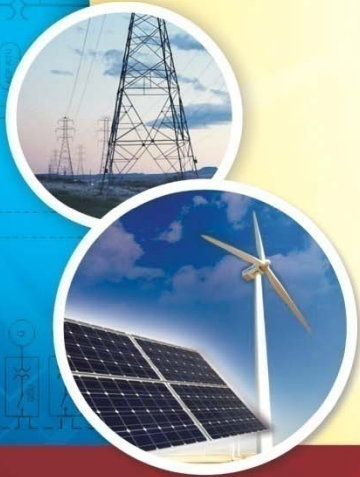
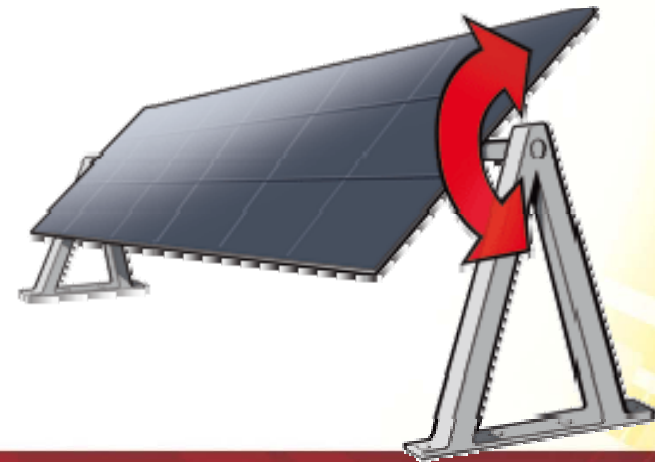
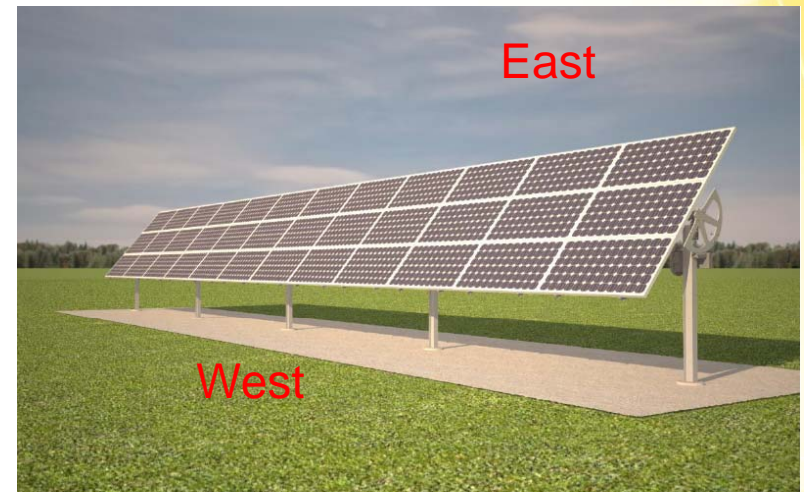
<i>10 MW DC system ->7.85 AC</i>	AC Energy*	Energy Value at 10 cents per/kwh	Capacity Factor
Fixed PV	13,595 MWh	\$1,359,551	20%
Single Axis Tracking	17,122 MWh	\$1,712,221	25%

*This analysis based on NREL PV Watt Version 2.0 software using the following assumptions: a) 10 MW DC system b).DC to AC derate factor of 0.784

Fixed vs. Tracking Single Axis Trackers



- Horizontal axle:
 - East to west daily tracking.
 - Panels face east or west through the day
 - Some horizontal axis tracker have “backtracking” capabilities to minimize shadowing during early morning and late afternoon allowing a closer layout.
 - Networking capabilities for remote monitoring and programming



Fixed vs. Tracking Dual Axis Trackers



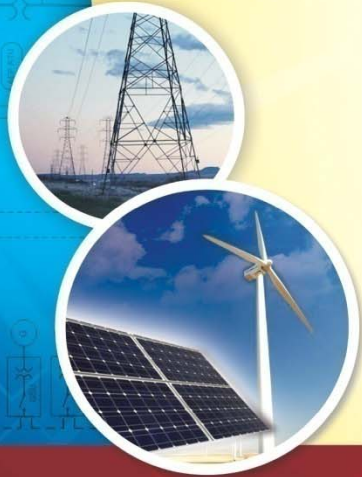
- Dual tracking:
 - Daily tracking (vertical rotation)
 - Seasonal tracking (Azimuth rotation)
- Approximately 32% increase energy output versus fixed PV.

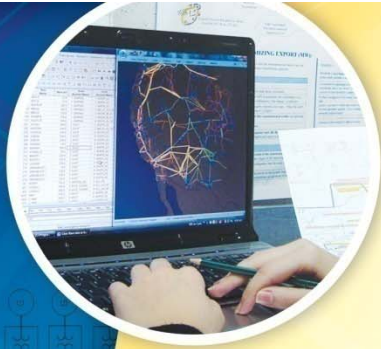


Annual Energy Yield

The energy yield depends on the following:

- DC Project Size
- Location of site
 - Longitude
 - Latitude
- Fixed or tracking technology
 - Azimuth: angle measured clockwise from true North.
 - Tilt Angle: angle from the horizontal axis.





QUESTIONS



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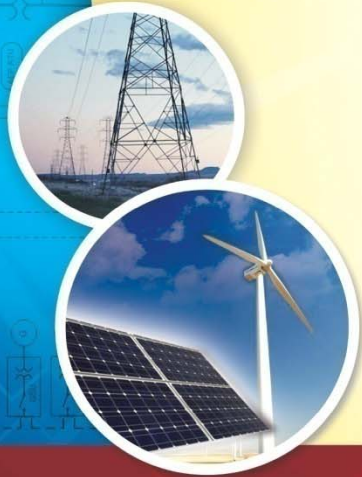
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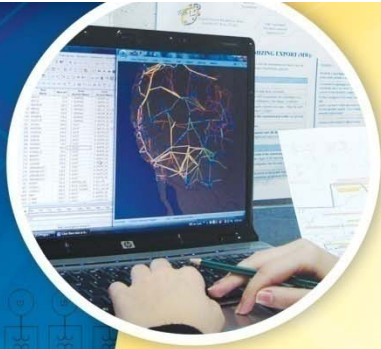
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PSEG Solar Source Projects totaling 29.2 MW to be completed by end of 2010.

Solar at New Jersey

(September 23, 2009 – Newark, NJ) - PSEG Solar Source today completed the acquisition from juwi solar Inc., of two utility-scale solar projects to be located in **Florida** and **Ohio**

Abengoa Solar to build the first Solar Thermal installation integrated with a Coal Plant owned by Xcel Energy

Denver, August 27, 2009 – Abengoa Solar has been selected by Xcel Energy, Colorado's largest electric utility, to build a demonstration parabolic concentrating solar power (CSP) plant near **Grand Junction, Colorado.**

New York Times

Gemini Solar to Build Big in Austin

Gemini Solar Development scored its first deal this week, and it's for one of the largest solar photovoltaic plants in the country — a **30-megawatt plant in Austin, Texas**, that's expected to go online by the end of 2010. The unanimous approval of the project by the Austin City Council serves as a clear sign that Gemini's future is a bright one.

