Distributed vs. Centralized Power Generation

Solar power can come from either distributed (PV) or centralized (CSP, PV) generation. Distributed generation takes the form of PV panels at distributed locations near load centers. Centralized plants are typically located at the point of best resource availability, and may be composed of PV or CSP technology. Currently there is a debate regarding which form of solar energy should be used to meet California Renewables Portfolio Standard requirements. Distributed PV and Centralized Power Generation each have their own strengths and weaknesses. In this section we discuss the merits and demerits of each, while keeping in mind that the topic is not yet settled and is open for debate.

Distributed PV has the promise of supplying power during peak demand time (around noon) and very close to the demand itself, thereby eliminating transmission loss. However, the intermittency of the panel output cannot be directly managed, and it is unclear how much distributed PV the electrical grid will be able to support.

On the other hand, Centralized Power Generation follows the current electrical power management model and may be located at regions where the resource is most available. But these stations require huge capital investments and may require new transmission lines to transfer power from the station to the load centers.

A. Grid Integration

1. Integration of Distributed PV into the Grid

The integration of distributed PV resources into the electrical power grid presents some difficulties for management and dispatch. PV panels introduce unmanaged two way current flows into the grid. Because insolation is variable, the intermittency of power available from the PV panels creates uncertainties in the management of the grid. This variation in production of electricity could lead to problems for the grid to supply continuous uninterrupted electricity.

California's rooftop capacity ranges from 8,000 MWac to 37,000 MWac (commercial)[1] to 60,000 MWac (incl. residential)[2]. It is expected by some that the current grid infrastructure could support mass amounts of PV at an affordable cost. Others, however, are concerned that variability might hinder PV's ability to meet peak demand. A Sacramento Municipal Utility District (SMUD) and National Renewable Energy Laboratory (NREL) study of 795 homes with tw0 kWac PV panels has shown that PV do not adversely affect voltage regulation, have high potential peak demand savings, and do not exceed the California Public Utility Commission's 15% rule[3]. Utilities are taking it slow and proceeding with a "look-and-see" approach[4]. {Problem of uncertain resource to be managed in grid, mitigation through averaging over large areas}

2. Transmission of Energy from Centralized Plants

Centralized plants are often located away from existing transmission lines. The construction of new transmission lines is one of the main challenges for large-scale centralized developments.

Transmission is currently the responsibility of each state and each state has its own energy pricing. Also sometimes the load center (demand) and the solar resource (large areas in desert) can be separated by state borders, which leads to the complication of which state has to build the line and which price has to be used to buy the energy. Also, building lines passing through tribal areas requires special permission from the tribes that could lead to further complication.

From the standpoint of Independent System Operators (ISOs), they do not want to invest billions in building a transmission lines for a project which may fail to take off leading to a vicious cycle where in the solar company finds it difficult to get financing without transmission lines and the ISOs are unwilling to commit to building transmission lines without assured financing for the companies. {Problem of intermittent resource, mitigation through communication, scheduling}

References

(1) Navigant, PV Grid Connected Market Potential under a Cost Breakthrough Scenario, prepared for The Energy Foundation, September 2004, p. 83. http://www.ef.org/documents/EF-Final-Final2.pdf
(2) California Rooftop Photovoltaic (PV) Resource Assessment and Growth Potential by County: http://www.energy.ca.gov/2007publications/CEC-500-2007-048/CEC-500-2007-048.PDF
(3)" Impact of SolarSmart Subdivision on SMUD's Distribution System" http://www1.eere.energy.gov/solar/pdfs/iprw2_mcnutt_impact_solarsmart.pdf
(4) Redefining PV Capacity, RICHARD PEREZ, ET AL, http://www.fortnightly.com/

Links for further reading

Additional links to be provided after the forum.

B. Power Density

Power density, the measure of how much solar power panels output, depends on variables such as size, facing (off-angle), cleanliness, availability of sunlight, latitude and longitude of site, elevation, array type (where the solar module is fixed or has a tracker), and hours of sunlight per day, which is a function of the time of year. Some example power densities are:

Distributed Photovoltaic (DPV) = 4.5–8 Acre/MWac (tracker C-Si on the higher side, fixed tilt thin-film on the lower side)
Concentrating Photovoltaic (CPV) = 7–8 Acre/MWac
Concentrating Solar Power (CSP) = 5–11 Acre/MWac (no storage on the lower side)[1]

1. Capacity Factors for CSP, CPV, DPV

The capacity factors are calculated by dividing total energy that a plant produces during a period of time and by the energy the plant would have produced at full capacity.

Capacity Factors for Various Systems[2]

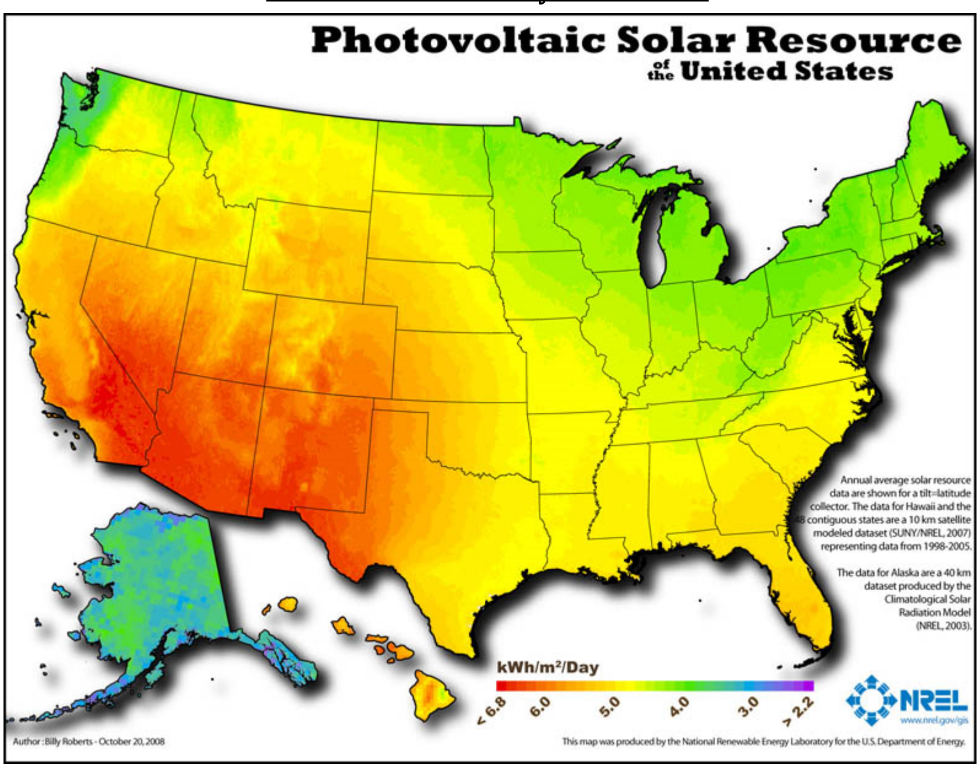
System	Capacity Factor (Phoenix)
Horizontal PV	15.7%
10% Tilt PV	17.1%
25% tilt PV	18.2%
1-axis PV	22.2%
2-axis PV	25.5%
CSP (trough w/o storage)	28.0%

Capacity Factors for Various CSP Systems[3]

Plant Name	Location	First Year of Operation	Net Output (MW_e)	Solar Field Outlet (°C)	Solar Field Area (m^2)	Solar Turbine Effic. (%)	Power Cycle	Dispatchability Provided By
Nevada Solar One	Boulder City, NV	2007*	64	390	357,200	37.6	100 bar, reheat	None
APS Saguaro	Tucson, AZ	2006	1	300	10,340	20.7	ORC	None
SEGS IX	Harper Lake, CA	1991	80	390	483,960	37.6	100 bar, reheat	HTF heater
SEGS VIII	Harper Lake, CA	1990	80	390	464,340	37.6	100 bar, reheat	HTF heater
SEGS VI	Kramer Junction, CA	1989	30	390	188,000	37.5	100 bar, reheat	Gas boiler
SEGS VII	Kramer Junction, CA	1989	30	390	194,280	37.5	100 bar, reheat	Gas boiler
SEGS V	Kramer Junction, CA	1988	30	349	250,500	30.6	40 bar, steam	Gas boiler
SEGS III	Kramer Junction, CA	1987	30	349	230,300	30.6	40 bar, steam	Gas boiler
SEGS IV	Kramer Junction, CA	1987	30	349	230,300	30.6	40 bar, steam	Gas boiler
SEGS II	Daggett, CA	1986	30	316	190,338	29.4	40 bar, steam	Gas boiler
SEGS I	Daggett, CA	1985	13.8	307	82,960	31.5	40 bar, steam	3-hrs TES

2. Variability of Insolation

Insolation Variability in the U.S.[4]



Ivanpah Insolation (NASA Surface Meteorology and Solar Energy)

Parameters for Solar Cooking:

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m^2/day)

Lat 33 Lon -115	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year Average	3.17	4.00	5.35	6.57	7.37	7.65	7.04	6.14	5.48	4.38	3.49	2.93

Parameter Definition

Parameters for Sizing and Pointing of Solar Panels and for Solar Thermal Applications:

Monthly Averaged Clear Sky Insolation Clearness Index (0 to 1.0)

Lat 33 Lon -115	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year Average	0.69	0.71	0.71	0.70	0.69	0.68	0.67	0.63	0.65	0.65	0.68	0.69

Parameter Definition

Los Angeles Insolation (NASA Surface Meteorology and Solar Energy)

Parameters for Solar Cooking:

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m^2/day)

Lat 34 Lon -119	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year Average	2.97	3.74	5.18	6.70	7.53	7.88	7.58	6.90	5.79	4.48	3.41	2.76

Parameter Definition

Parameters for Sizing and Pointing of Solar Panels and for Solar Thermal Applications:

Monthly Averaged Clear Sky Insolation Clearness Index (0 to 1.0)

Lat 34 Lon -119	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
22-year Average	0.73	0.75	0.76	0.76	0.75	0.73	0.70	0.69	0.70	0.70	0.71	0.71

Parameter Definition

References

(1) SolarByTheWatt.com, SPG Solar, Solo Power Inc, and NextLight Energy Renewable Power, LLC.
(2) Dr. Craig Turchi , NREL Solar Concentrating Research Group.
(3) NREL: TroughNet - U.S. Parabolic Trough Power Plant Data." National Renewable Energy Laboratory (NREL) Home Page. Web. 18 Mar. 2010: http://www.nrel.gov/csp/troughnet/power_plant_data.html
(4) "NREL: Dynamic Maps, GIS Data, and Analysis Tools - Solar Maps." National Renewable Energy Laboratory (NREL) Home Page. Web. 18 Mar. 2010: http://www.nrel.gov/gis/solar.html

Links for further reading

Additional links to be provided after the forum.