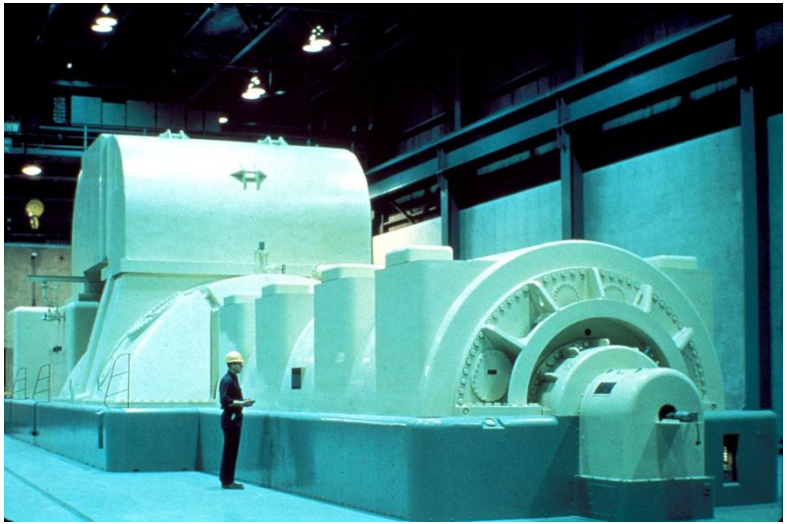
The Grid: Integration of Renewable Energy

Solar Photovoltaic Energy
March 16, 2011

Variable Asynchronous Generation

Technology Change in the Utility Industry



Spinning Iron - Rules and expectations formed around conventional generators

How do we set expectations/requirements for new technologies

Solar PV Grid Integration

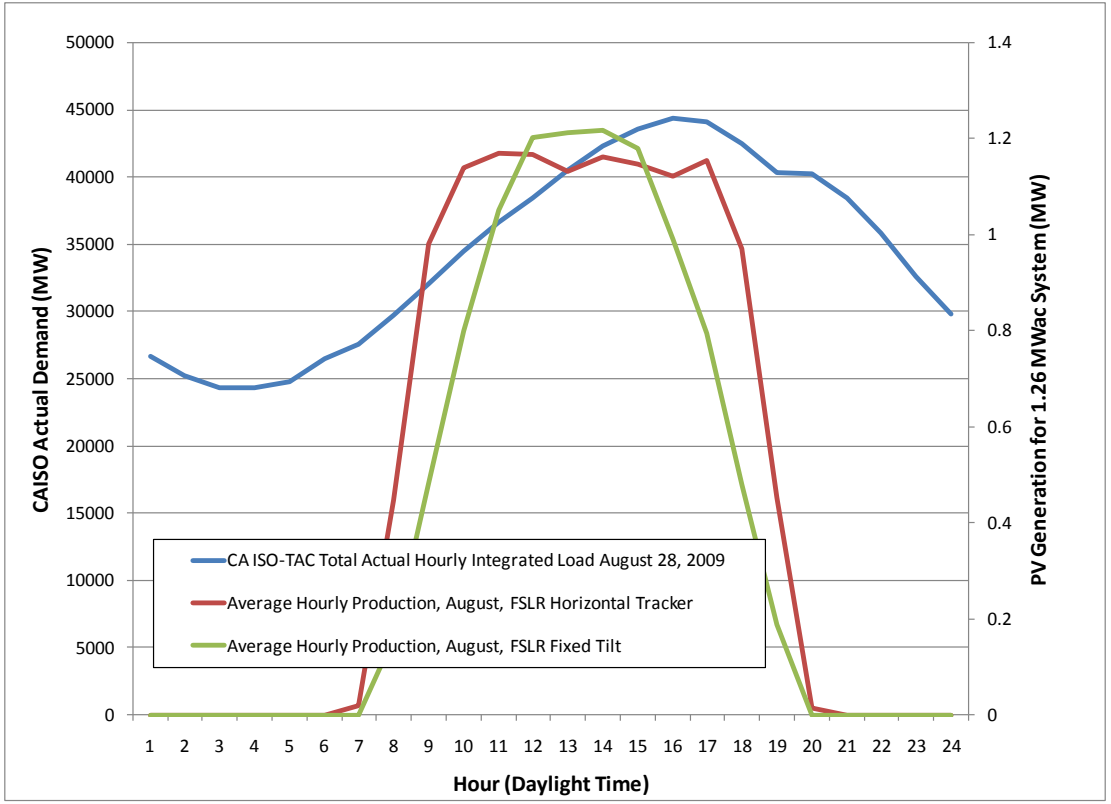
Modular design from rooftop system to utility-scale power plant

- Distributed Generation
  - Rooftop or small ground mounted systems
  - Either on the customer side of the meter to offset retail purchases or on the utility side selling into a FIT
  - Increased inverter functionality supporting the grid allow for higher penetrations
  - Germany – 17,000 MW of PV installed in 840,000 sites

- Utility-Scale Solar Power Plants
  - Connected directly to the utility high voltage grid
  - Utility Scale
    - 80 MW_{ac} plant in operation at Sarnia, ONT
    - 290 MW_{ac} plant under construction in AZ
    - 550 MW_{ac} plants in advanced development in CA
  - Advanced controls to support electric grid stability and operability

Typical Solar Energy Production and System Demand

Average August PV Supply and CAISO Peak Demand



*CAISO Hourly Demand from CAISO OASIS Data Service for August 28, 2009 (third highest demand day for CAISO for 2009)

Renewables Integration – Short Term Variability

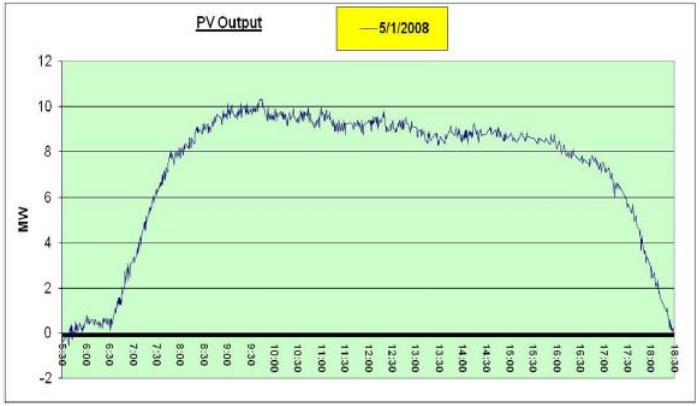


Figure 2.11: PV plant output on a sunny day (Sampling time 10 seconds)

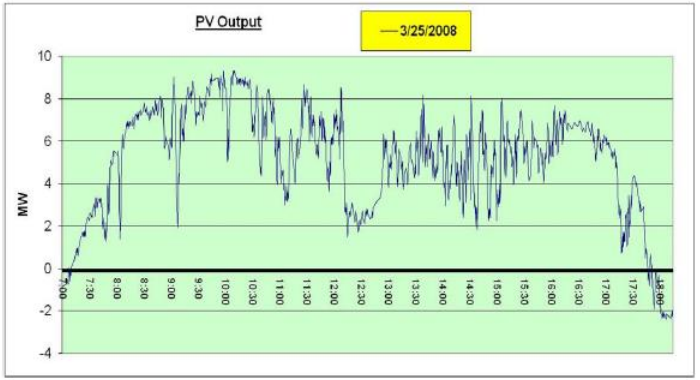
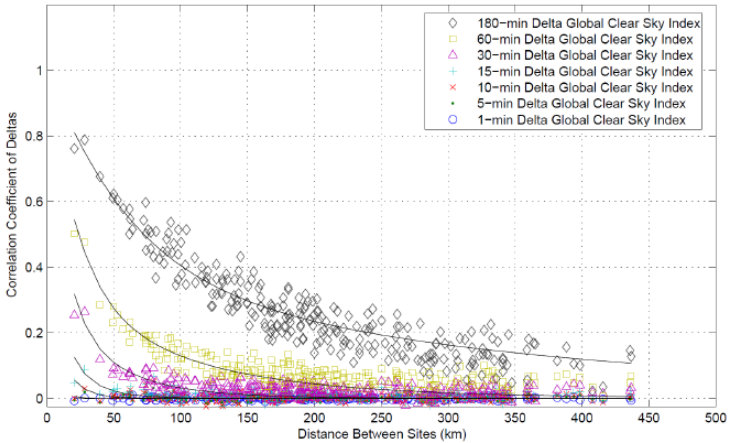


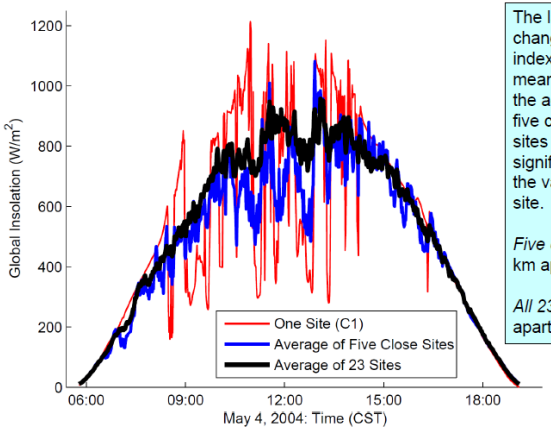
Figure 2.12: PV Plant output on a partly-cloudy day (Sampling time 10 seconds)

NERC – Accommodating High Levels of Variable Generation – April 2009

Spatial Diversity & Short Term Variability



Short time scale changes in insolation are uncorrelated between sites



The lack of correlation in changes in the clear sky index over short time scales means that the variability of the aggregated data from the five closest sites and all 23 sites in the SGP network is significantly smoother than the variability of an individual site.

Five closest sites: 50 – 170 km apart

All 23 sites: 20 – 440 km apart

Aggregate variability at multiple sites is significantly smoother than individual sites

LBNL - Implications of Wide-Area Geographic Diversity for Short-Term Variability of Solar Power, September 2010