INTEGRATING PV INTO UTILITY PLANNING AND OPERATION TOOLS
Project Focuses

- CSI Project
  > Address cost-effective strategies and solutions for integrating large amounts of PV into distribution systems by integrating PV modeling into utility planning and operation tools

- Complimentary CEC project
  > Validate ability of satellite-derived solar data to forecast PV fleet output in partnership with the CAISO, and to integrate the methodologies into the CAISO planning process.
Tasks

- Produce, Validate, and Extend SolarAnywhere Data
- Validate SolarAnywhere FleetView Methodology
- Integrate SolarAnywhere FleetView into Utility Software Tools
Produce, Validate, and Extend SolarAnywhere Data

- Extend SA Enhanced Resolution (1 km, ½ hour)
- Produce SA High Resolution (1 km, 1 minute)
- Validate SA Enhanced Resolution (CSI and SMUD PV output data)
- Validate SA High Resolution (California ISO and SMUD irradiance data)
SolarAnywhere

Web-accessible solar irradiance data & analytical tools

Irradiance data
- Satellite-derived time-series data
- Historical values from 1998 through latest hour
- Forecasts up to 7-days in advance

Analytical tools
- PV system modeling (FleetView)
- Benchmark to site data (DataCheck)
- PV fleet variability
Produce, Validate, and Extend SolarAnywhere Data

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Publicly Accessible Solar Data (SolarAnywhere.com)
Produce, Validate, and Extend SolarAnywhere Data

- Extend SA Enhanced Resolution (1 km, ½ hour)
- **Produce SA High Resolution (1 km, 1 minute)**
- Validate SA Enhanced Resolution (CSI and SMUD PV output data)
- Validate SA High Resolution (California ISO and SMUD irradiance data)
Three SolarAnywhere Resolutions

**Standard Resolution**
10 km, 1 hour

**Enhanced Resolution**
1 km, ½ hour

**High Resolution**
1 km, 1 minute

Example: San Francisco, CA
Produce, Validate, and Extend SolarAnywhere Data

- Extend SA Enhanced Resolution (1 km, ½ hour)
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UCSD Validation of SolarAnywhere Enhanced Resolution Data

Calibrated SolarAnywhere performance, with 30-min time step, versus CSI measured output (averaged over two 15-min time steps), for 86 PV sites in 2009 in San Diego, CA

Source: Jan Kleissl, UCSD
Produce, Validate, and Extend SolarAnywhere Data

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- Produce SA High Resolution (1 km, 1 minute)
- Validate SA Enhanced Resolution (CSI and SMUD PV output data)
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2.4. Validate 1 km, 1 Minute Irradiance Data

July 4, 2011, CAISO Site A

![Graph showing clear sky and ground measurements with high resolution data from July 4, 2011, at CAISO Site A. The graph plots irradiance data from 4:00 to 20:00 with clear sky, ground, and high resolution data lines.](image-url)
Example Using SMUD’s Solar Data Network on Highly Variable Day (Nov. 18, 2011)
Validate SolarAnywhere FleetView Methodology

- Validate Correlation Models (66 irradiance sensor network from SMUD)
- Validate High Speed PV Fleet Simulation (10 PV systems from CAISO)
- Validate Forecasted PV Fleet Simulation (100 PV systems from PG&E)
Validate SolarAnywhere FleetView Methodology

- Validate Correlation Models (66 irradiance sensor network from SMUD)
- Validate High Speed PV Fleet Simulation (10 PV systems from CAISO)
- Validate Forecasted PV Fleet Simulation (100 PV systems from PG&E)
Variability Results: SMUD’s 66 Sensor Network

Results based on most variable days in SMUD’s network from July 1, 2011 to December 31, 2011
Validate SolarAnywhere FleetView Methodology

- Validate Correlation Models (66 irradiance sensor network from SMUD)
- Validate High Speed PV Fleet Simulation (10 PV systems from CAISO)
- Validate Forecasted PV Fleet Simulation (100 PV systems from PG&E)
CAISO Fleet Results

Measured Data
- 18 PV systems
- Half-hour data
- Capacity normalized to eliminate effect of PV size
- Presented on scale of 0 to 100%
SMUD Fleet Results

Results are preliminary and may change as a full year of data is included

Measured Data
- 1,048 PV systems
- April – October 2013 (6 months)
- Hourly data

Screening
- 13 systems removed for data issues
- +/- 1 hour time shift issues identified for 30% of systems
- Required measured power > 1% of max
- Scaled annual simulated to match annual measured

rMAE = 4.9%
Integrate SolarAnywhere FleetView into Utility Software Tools

- Distribution planning (SMUD)
- Smart grid operation (SMUD)
- Utility load scheduling (PG&E)
- Balancing area planning and operation (California ISO and SMUD)
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Approach

✓ Obtain PV system specs (~150,000 PV systems in CA)

✓ Map each system to correct balancing area

✓ Implement forecasting system (forecast ½ hour output for every system and sum results by region)

▪ Validate accuracy
Simulate Fleet Output Using SolarAnywhere FleetView™

PV Specifications From powerCLERK® and Other Sources

FleetView Simulation Methods

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<th>Historical</th>
<th>Forecast</th>
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- Fleet Planning
- Fleet Operations
CAISO Customer Owned Mapping

- 4.49 kW-AC
- SunPower Inverter (SPR-5000X, 240V)
- 27 Modules (SunPower 210 W, SPR-210-WHT)
- 37.76281° N, 122.44313° W
- Commissioned April 2008
Using FleetView for Capacity Planning

Peak Day: August 13, 2012

Demand (MW)

Time of Day

2020 Peak (w/12 GW PV)
2012 Peak (w/1.3 GW PV)

System Demand
Total Demand

1.7%/yr. growth
Using FleetView for Capacity Planning

Peak Day: August 13, 2012
Using FleetView for Forecasting

California Solar Resource Portfolio

Note: Utility Sited systems include intertie systems in NV and AZ
Conclusion

- SolarAnywhere Enhanced Resolution (1 km, ½ hour) data is publicly available at www.solaranywhere.com

- SolarAnywhere High Resolution (1 km, 1 min) data can be produced throughout CA

- Initial validation efforts are promising

- Satellite-derived PV simulation holds good promise for a low-cost method for addressing grid-integration issues through PV planning and forecasting
Next Steps

- Continue balancing area integration efforts for both planning and operational needs

- Continue model validation

- Extend tools to:
  - Utility load scheduling
  - Distribution planning
  - Smart grid operation
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THANK YOU