

## Project Lead



Clean Power Research®

## Project Partners



## Primary Funders



## Power Industry



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# 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

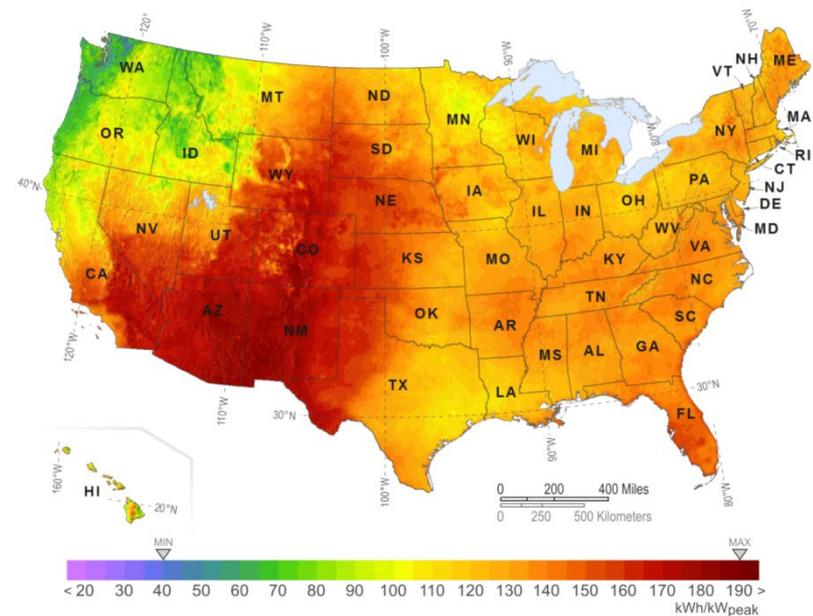
*Web-accessible solar irradiance data & analytical tools*

## 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)



A screenshot of the SolarAnywhere web application interface. At the top, there are navigation tabs for "Home", "Data", and "Contact". Below these, there are options for "Standard Resolution" and "Enhanced Resolution", with "Enhanced Resolution" selected. A user login status "You are logged in as public" and a "Change Login" link are visible. The main area features a map of the United States with California highlighted in a dark blue outline. A search bar at the top right of the map contains the text "Seattle, N35 W95 etc" and a "Find" button. The map includes various city labels such as Sacramento, San Francisco, San Jose, Los Angeles, San Diego, Las Vegas, Phoenix, Tucson, and Ciudad Juárez. A scale bar at the bottom right of the map indicates "300 miles". Below the map, there is a "Select Time Period" section with a dropdown menu set to "2012", and input fields for "Start Date" (1/1/2012) and "End Date" (12/31/2012). There is also a checkbox for "Include Wind/Temperature\*" and a "Solar Model" dropdown set to "v2.2". A "Get Data" button is located to the right of these options. At the bottom of the interface, there is a copyright notice: "Copyright © 2008-2013 Clean Power Research, LLC. All rights reserved." and a "Contact Us" link.

# Produce, Validate, and Extend SolarAnywhere Data

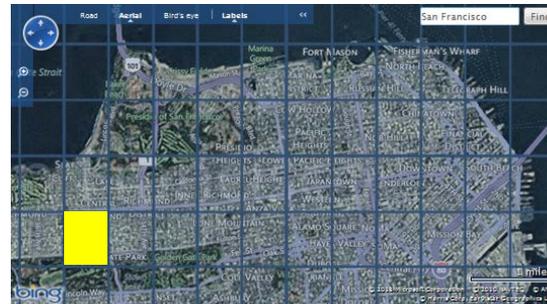
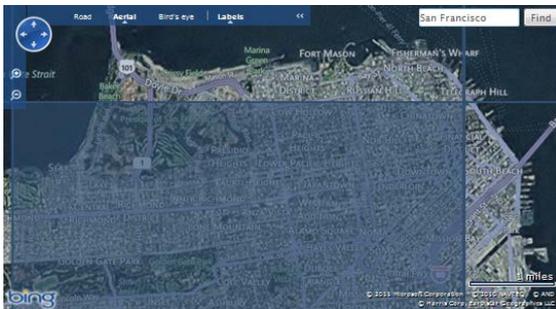
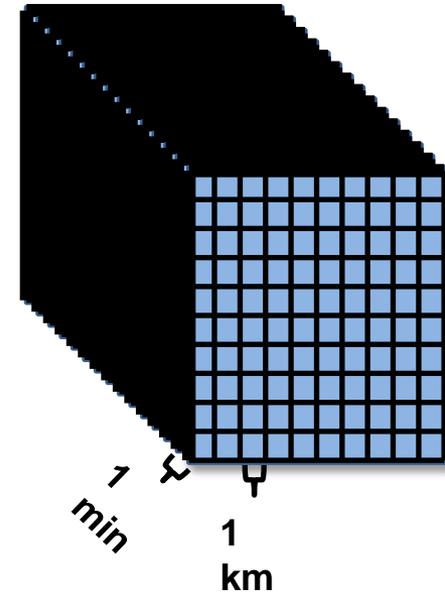
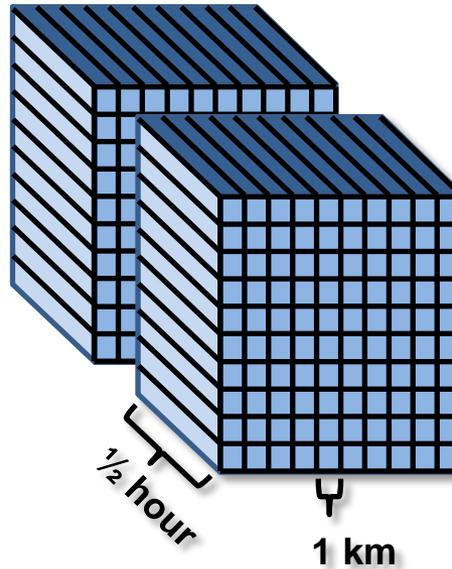
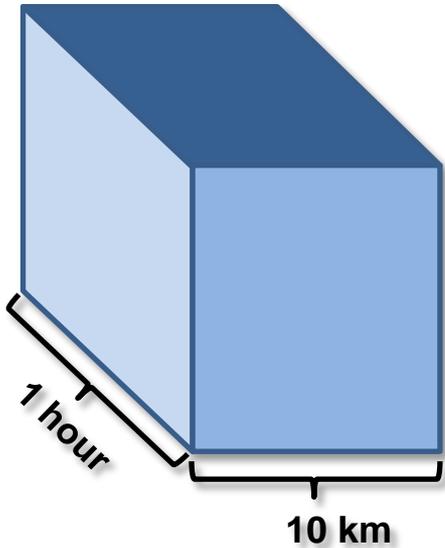
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# Three SolarAnywhere Resolutions

*Standard Resolution*  
10 km, 1 hour

→ *Enhanced Resolution*  
1 km, ½ hour

→ *High Resolution*  
1 km, 1 minute

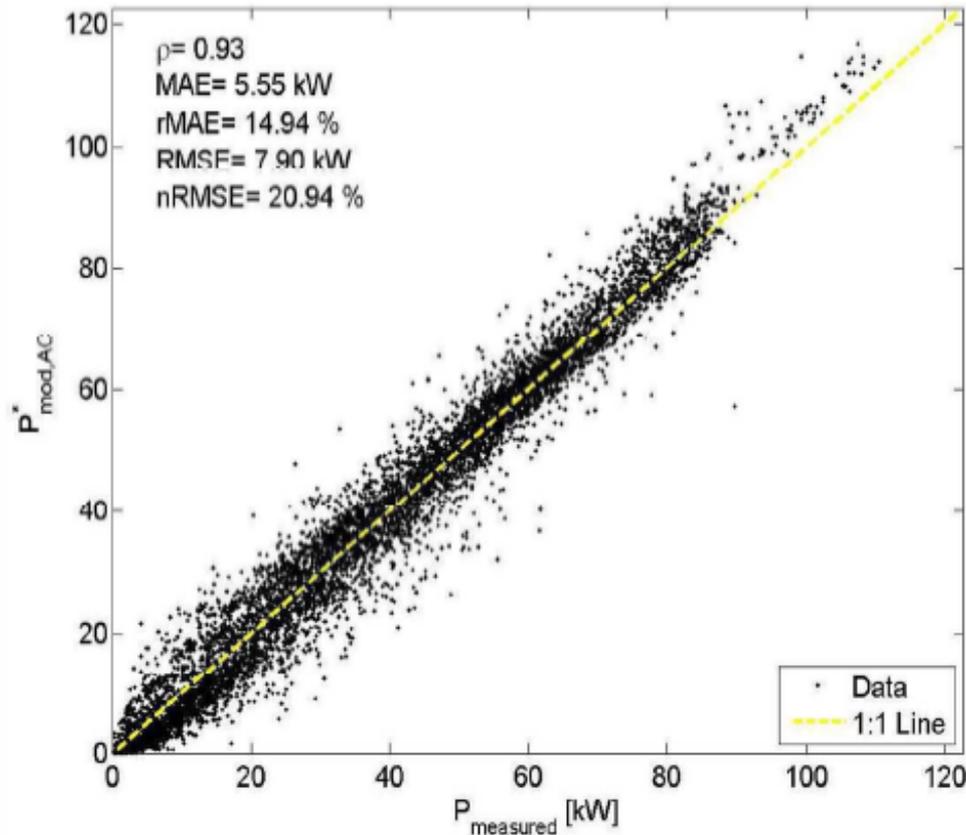


Example: San Francisco, CA

# Produce, Validate, and Extend SolarAnywhere Data

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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

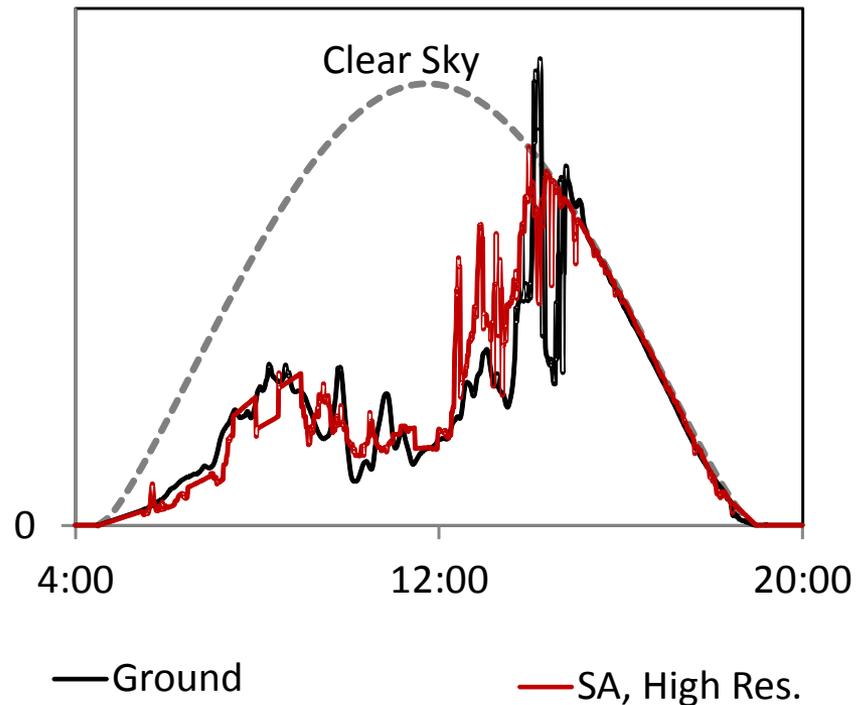
Source: Jan Kleissl, UCSD

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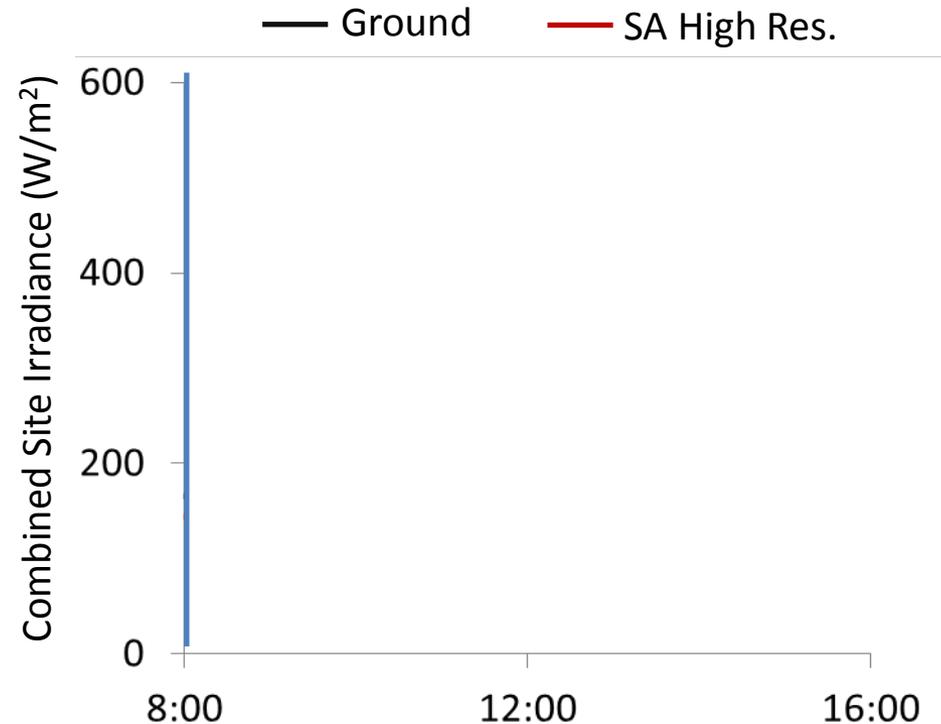
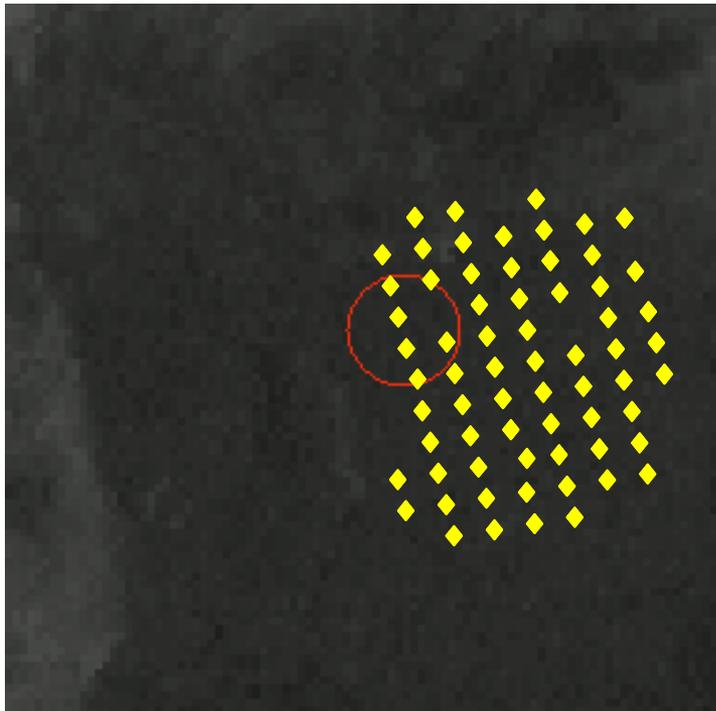
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- **Validate SA High Resolution (California ISO and SMUD irradiance data)**

## 2.4. Validate 1 km, 1 Minute Irradiance Data

July 4, 2011, CAISO Site A



# 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)

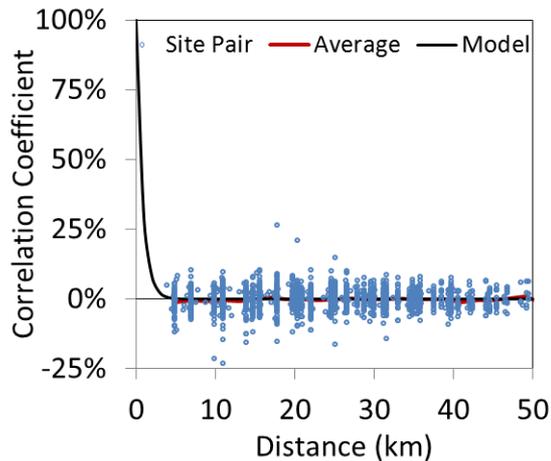
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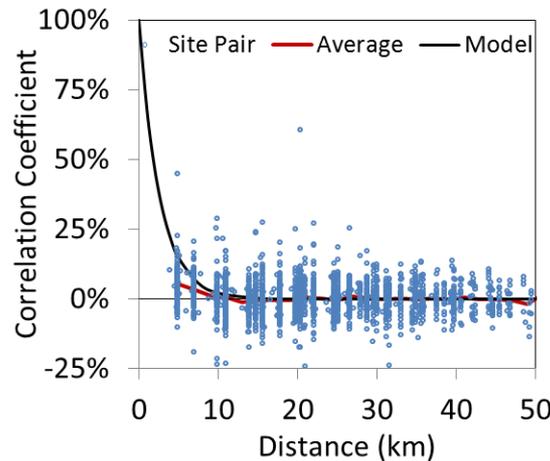
# Variability Results: SMUD's 66 Sensor Network

## Time Interval

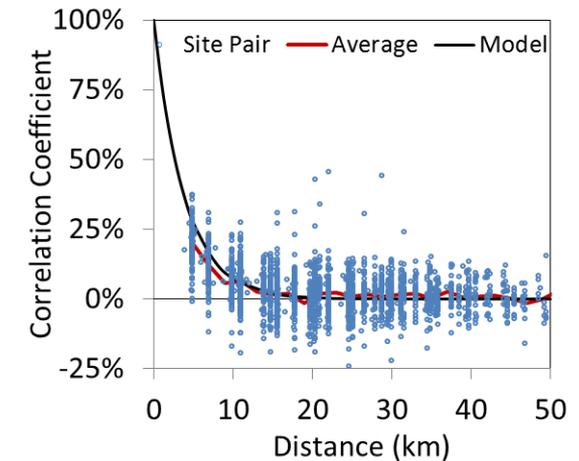
1 Minute



5 Minutes



10 Minutes

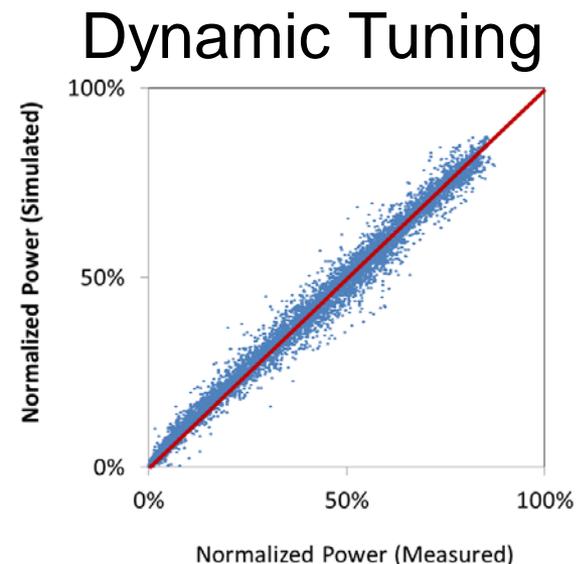
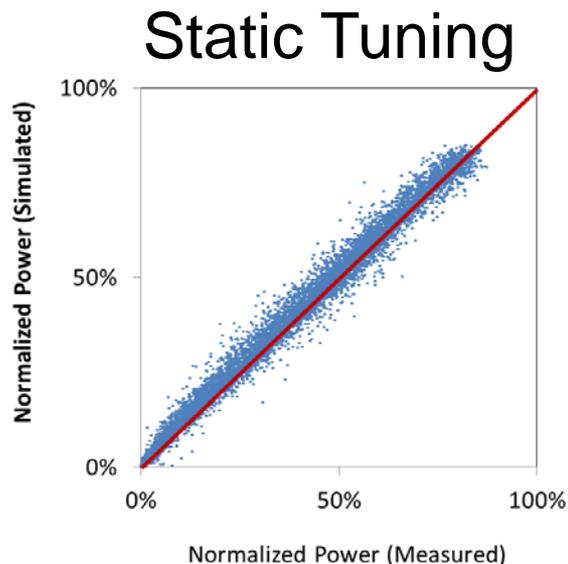
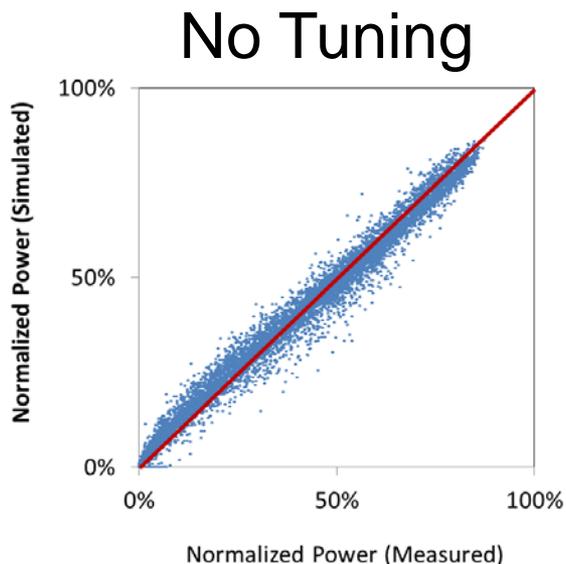


Results based on most variable days in SMUD's network from July 1, 2011 to December 31, 2011

# Validate SolarAnywhere FleetView Methodology

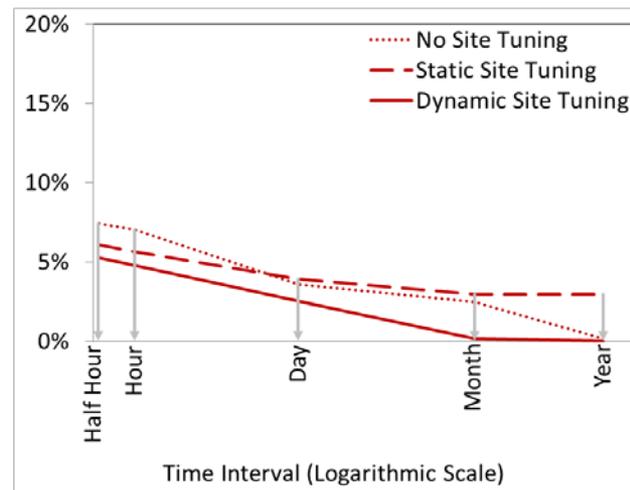
- Validate Correlation Models (66 irradiance sensor network from SMUD)
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# CAISO Fleet Results



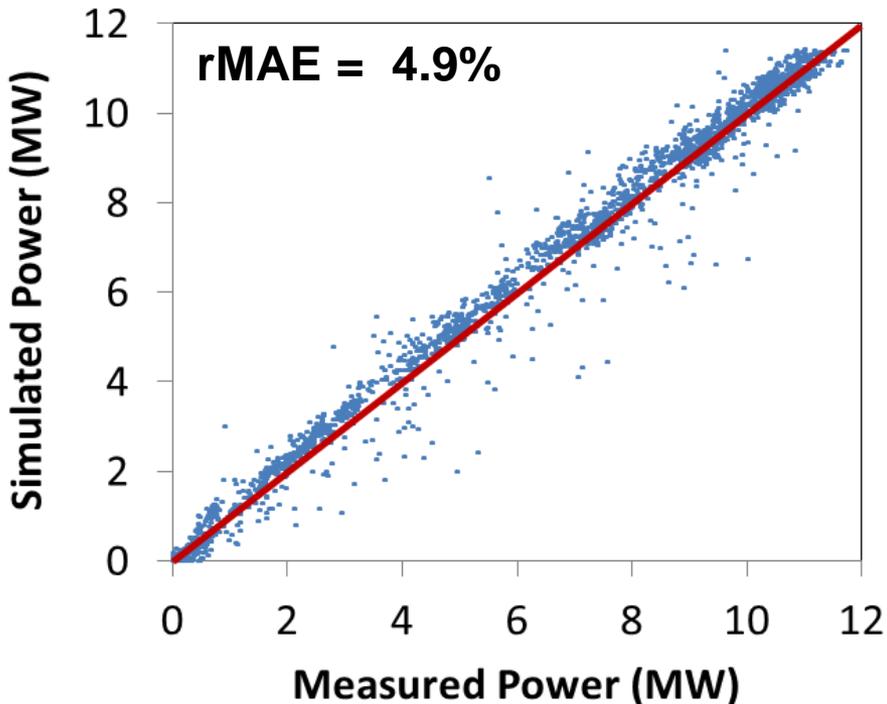
## Measured Data

- 18 PV systems
- Sept. 2011 to Aug. 2012
- 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

# 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)

# Integrate SolarAnywhere FleetView into Utility Software Tools

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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™

**SOLAR** *anywhere*

*Historical*

*Forecast*

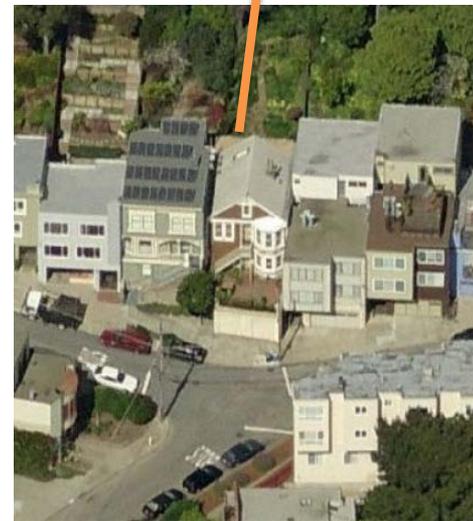
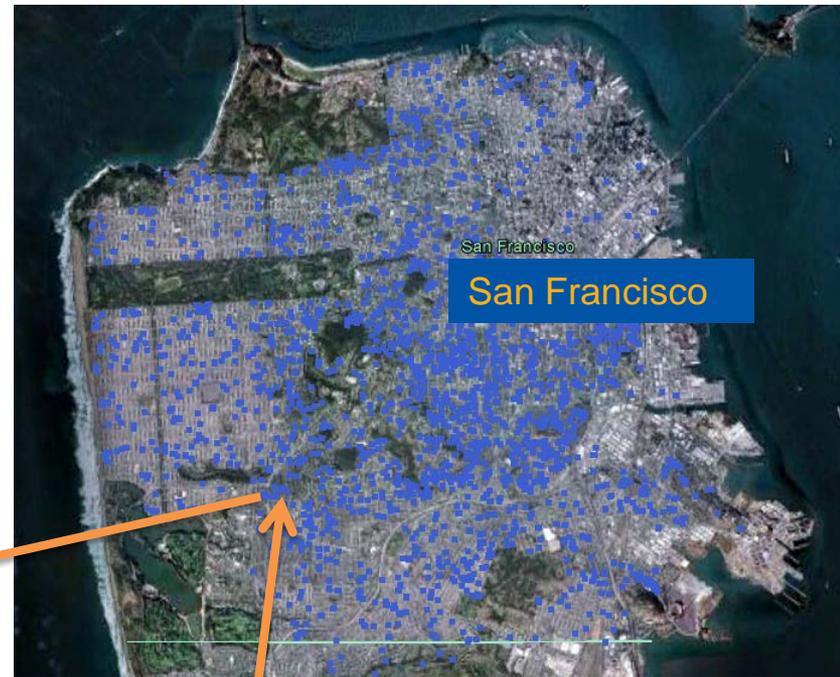
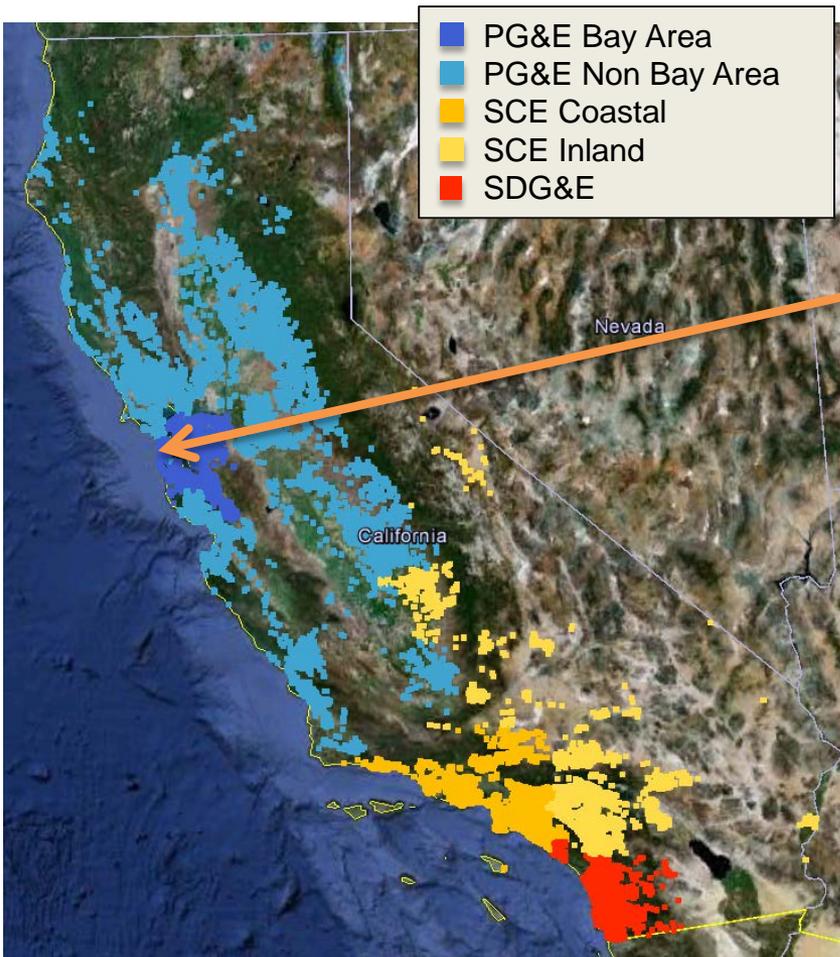
PV Specifications From *power*CLERK® and Other Sources

FleetView Simulation Methods

Fleet Planning

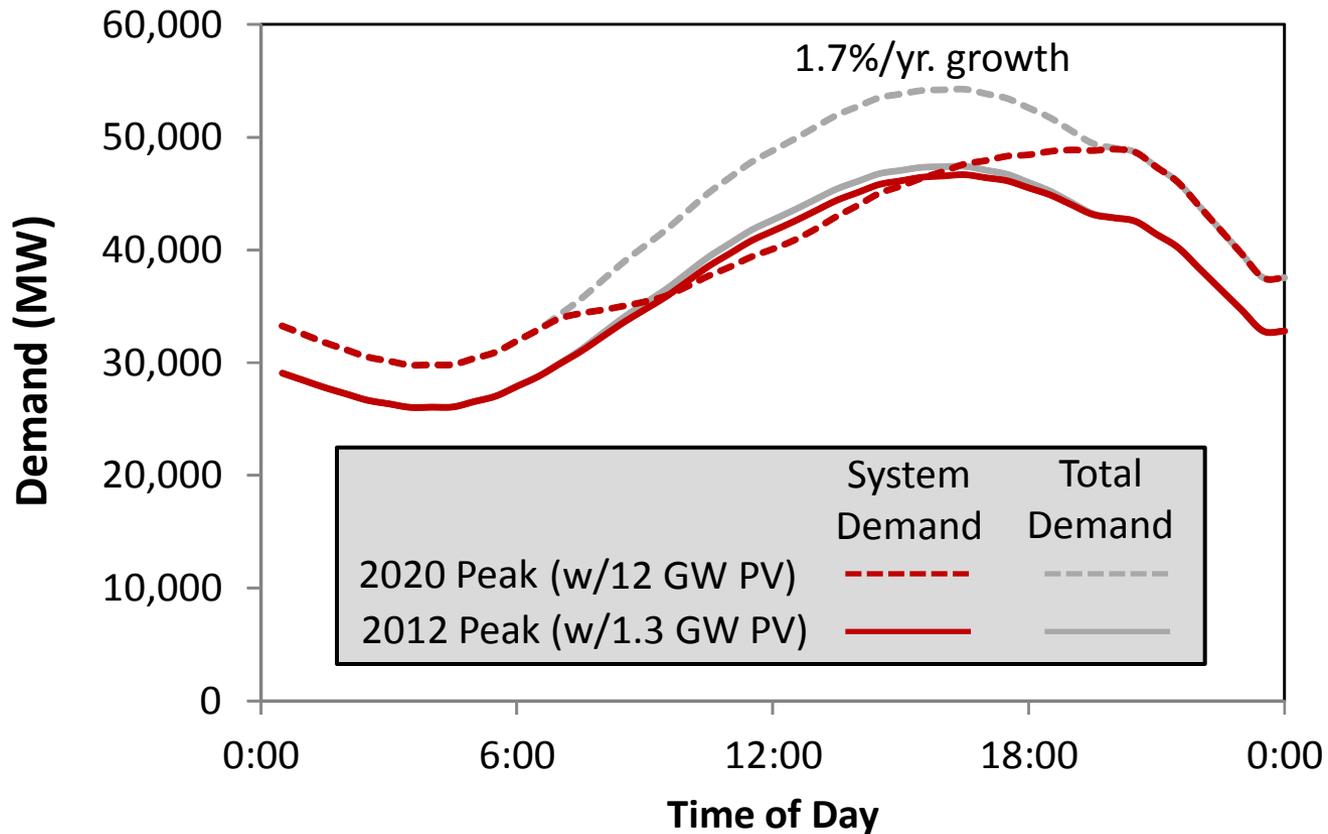
Fleet Operations

# CAISO Customer Owned Mapping



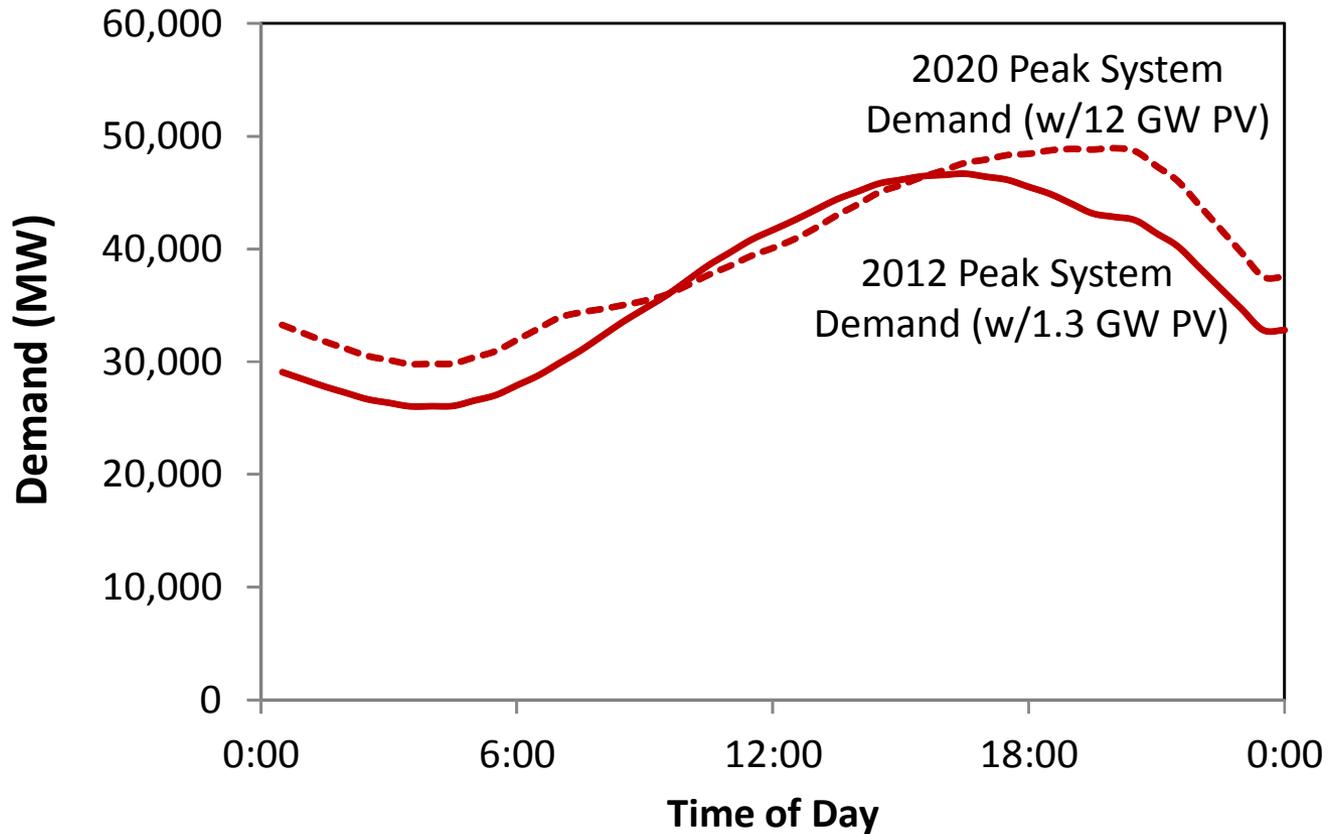
- 4.49 kW-AC
- SunPower Inverter (SPR-5000X, 240V)
- 27 Modules (SunPower 210 W, SPR-210-WHT)
- 37.76281° N, 122.44313° W
- Commissioned April 2008

# Using FleetView for Capacity Planning



Peak Day: August 13, 2012

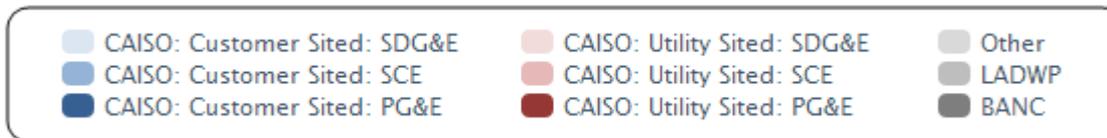
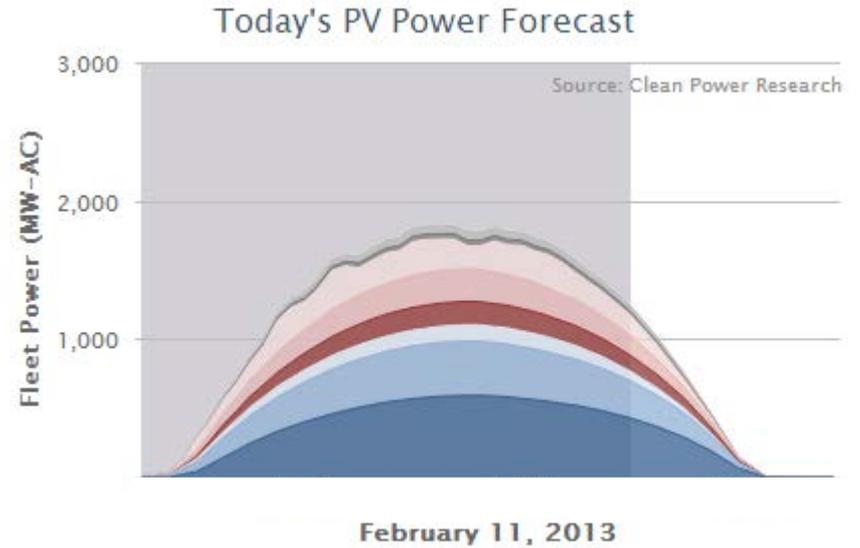
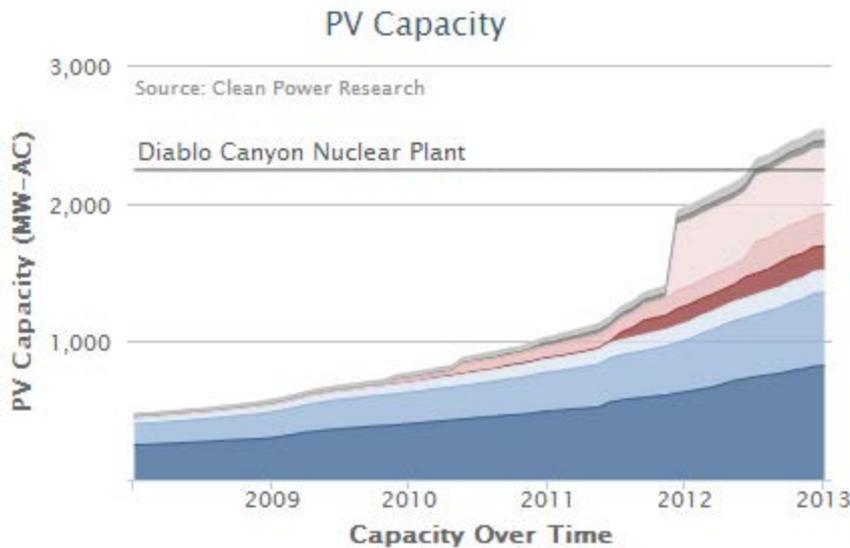
# Using FleetView for Capacity Planning



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](http://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

Please feel free to contact us for any details or clarification related to presentations

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# THANK YOU