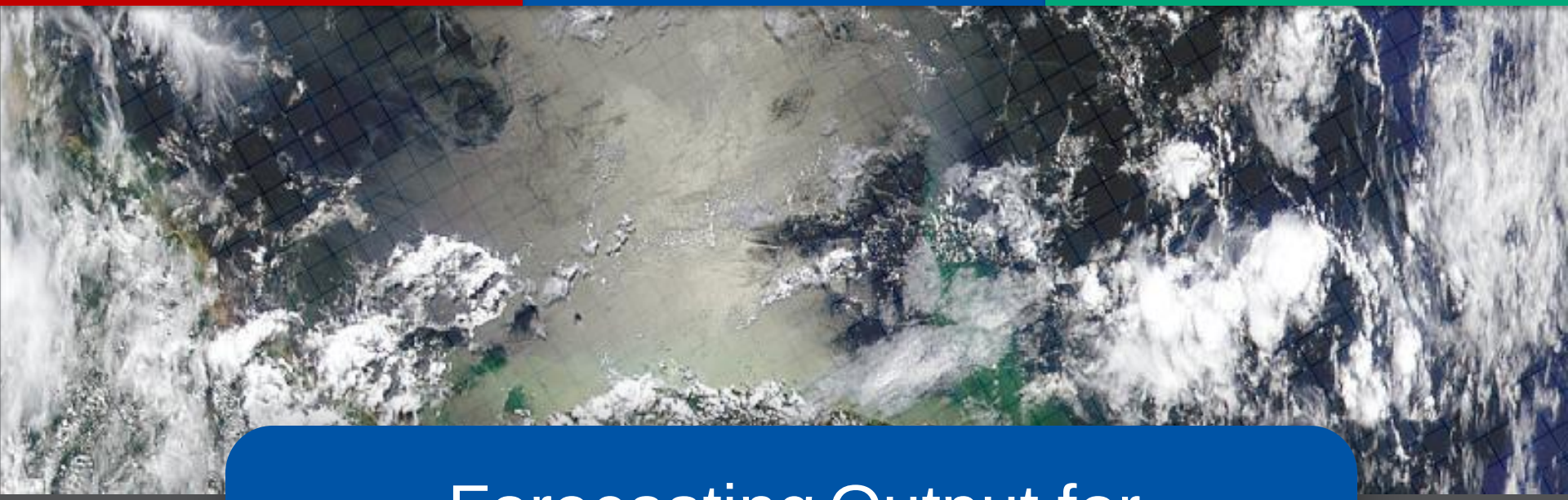

Forecasting Output for 130,000 PV Systems in California

Tom Hoff
President, Research & Consulting
February 27, 2013

Clean Power Research®

v021813

Project: Integrating PV into Utility Planning and Operation Tools

Project Lead

Clean Power Research®

Project Partners

University at Albany, State University of New York

UCSD

EPRI

SEPA

Primary Funders

GO solar CALIFORNIA

Itron

Public Utilities Commission, Eureka, State of California

pier

Power Industry

SMUD™

California ISO, Your Link to Power

PG&E

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
- 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.

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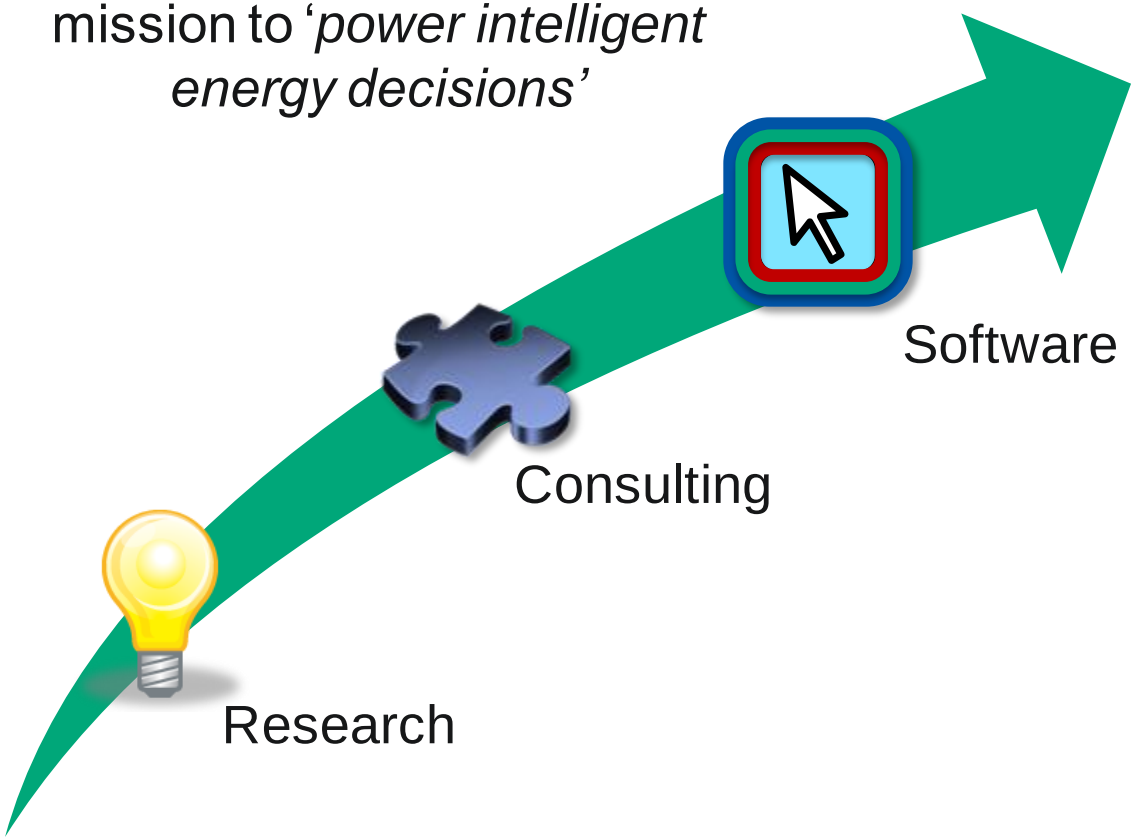
Founded in 1998 with the mission to '*power intelligent energy decisions*'



SOLAR PREDICTION

Most widely used solar resource database

ECONOMIC VALUATION

> 22 million solar estimations performed

PROGRAM OPTIMIZATION

2.75 GW of renewable incentives processed

Utility System Integration Issues

Area of Impact

- Planning
  - Resource planning
  - Distribution voltage
- Operation
  - Load scheduling
  - Frequency regulation

Partial Solutions

- Planning
  - Provide planners w/ future load shapes
  - Quantify variability of distribution-level fleets
- Operation
  - Provide schedulers w/ PV output for “net” load
  - Forecast PV fleet variability

Focus of Presentation

Area of Impact

- Planning
  - **Resource planning**
  - Distribution voltage
- Operation
  - **Load scheduling**
  - Frequency regulation

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  - Quantify variability of distribution-level fleets
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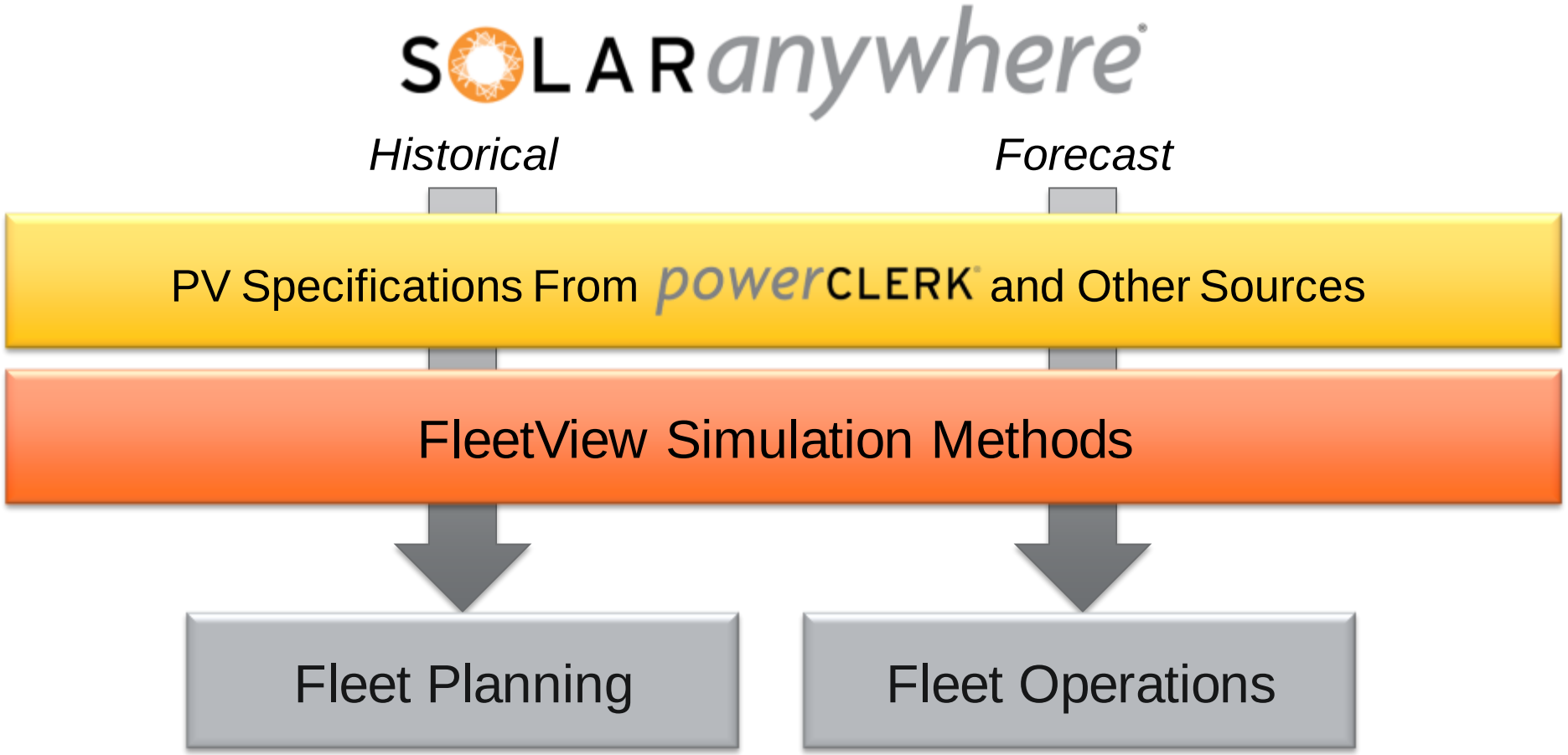
Simulate Fleet Output Using SolarAnywhere® FleetView™



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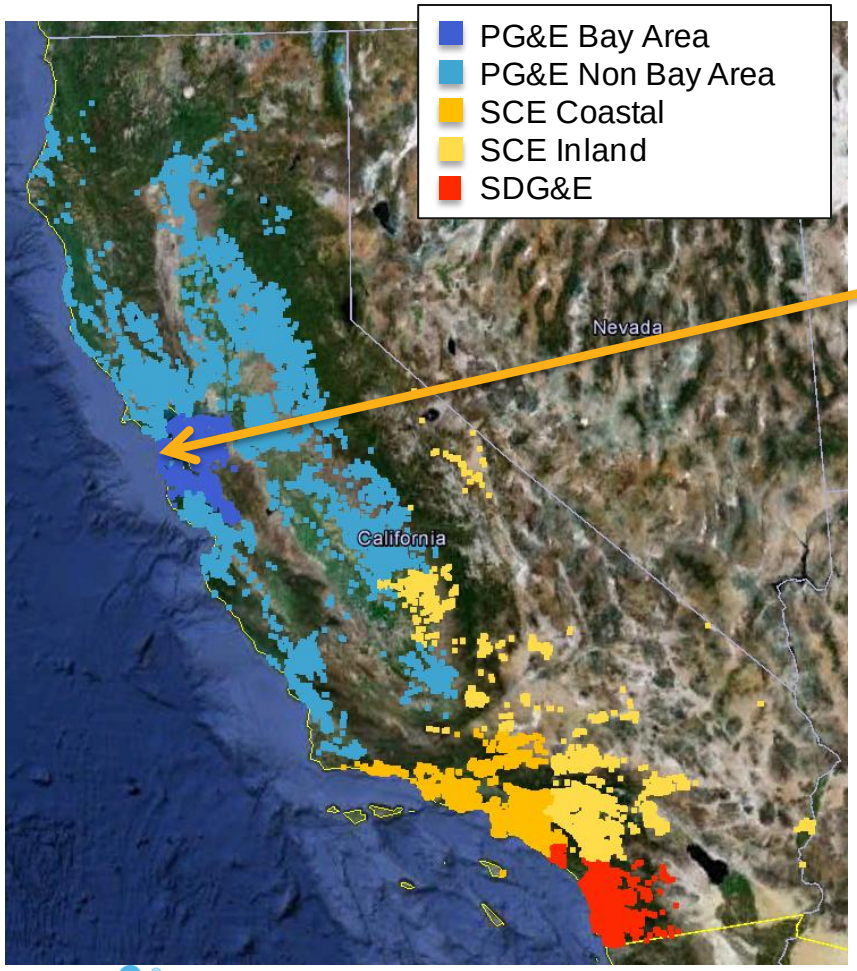
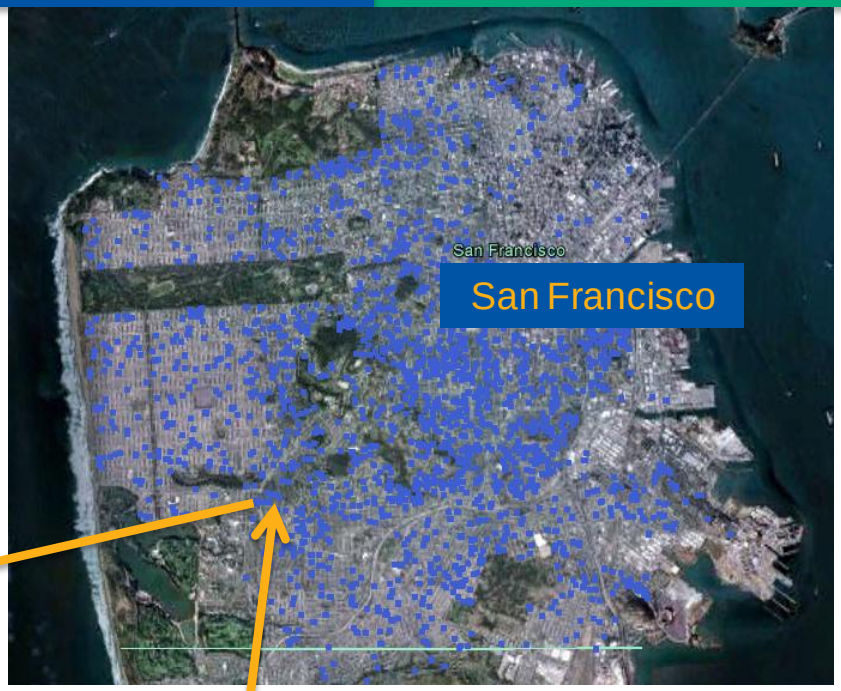
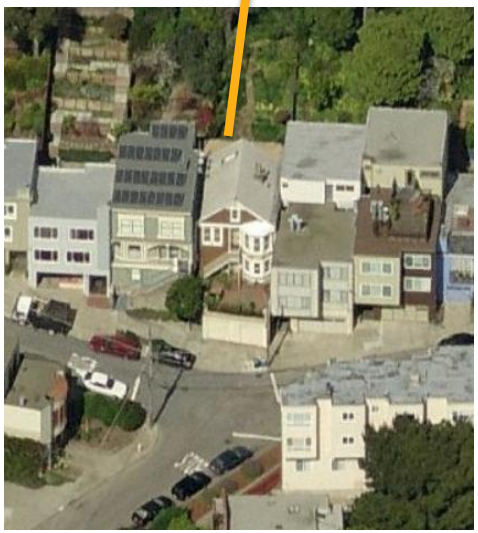
CAISO Customer-Owned Mapping







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

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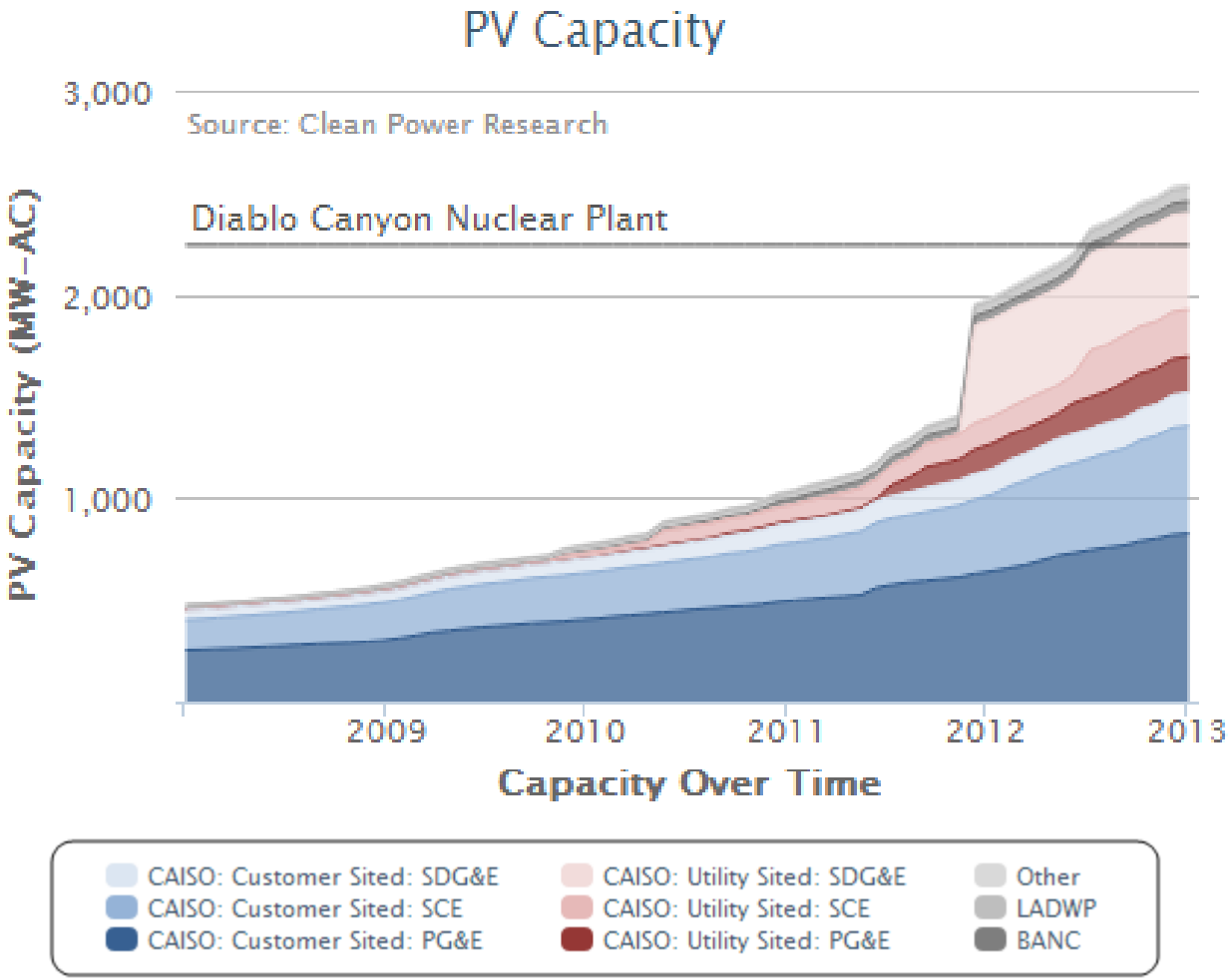
California PV Capacity by ISO Areas



Note: Utility-sited systems include intertie systems in NV and AZ

SolarAnywhere

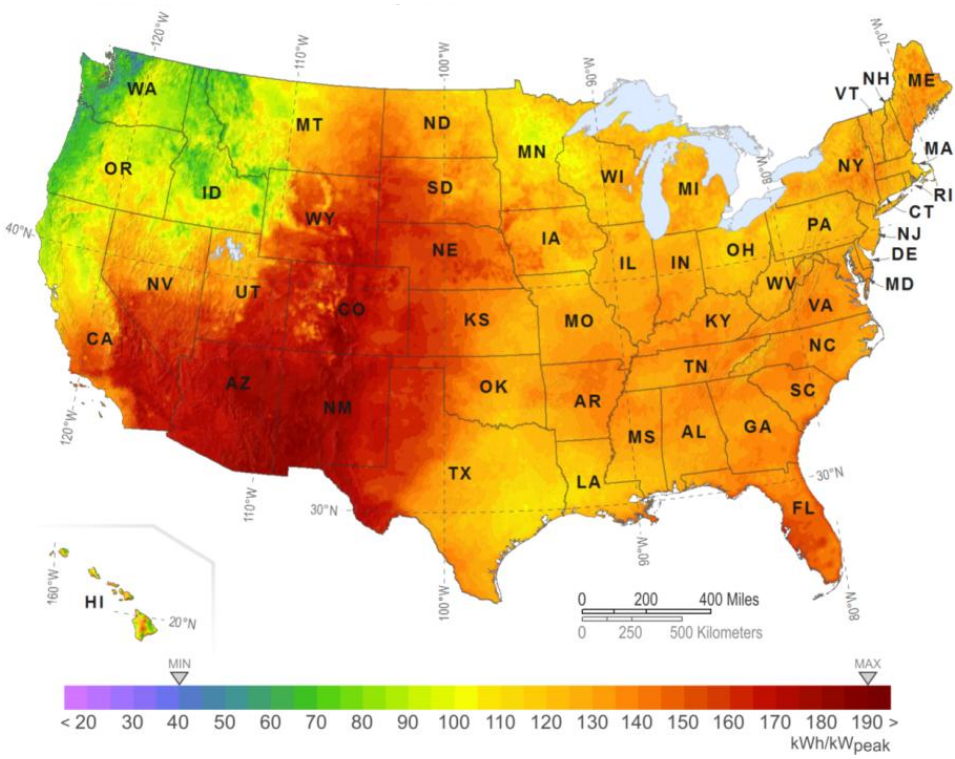
Web-accessible solar irradiance data & analytical tools

Irradiance data

- Historical satellite-derived time-series data from 1998 through latest hour
- Forecasts up to 7-days in advance by combining cloud motion vector and NWP approaches

Analytical tools

- PV system modeling (FleetView)
- PV benchmarking (DataCheck)
- PV fleet variability



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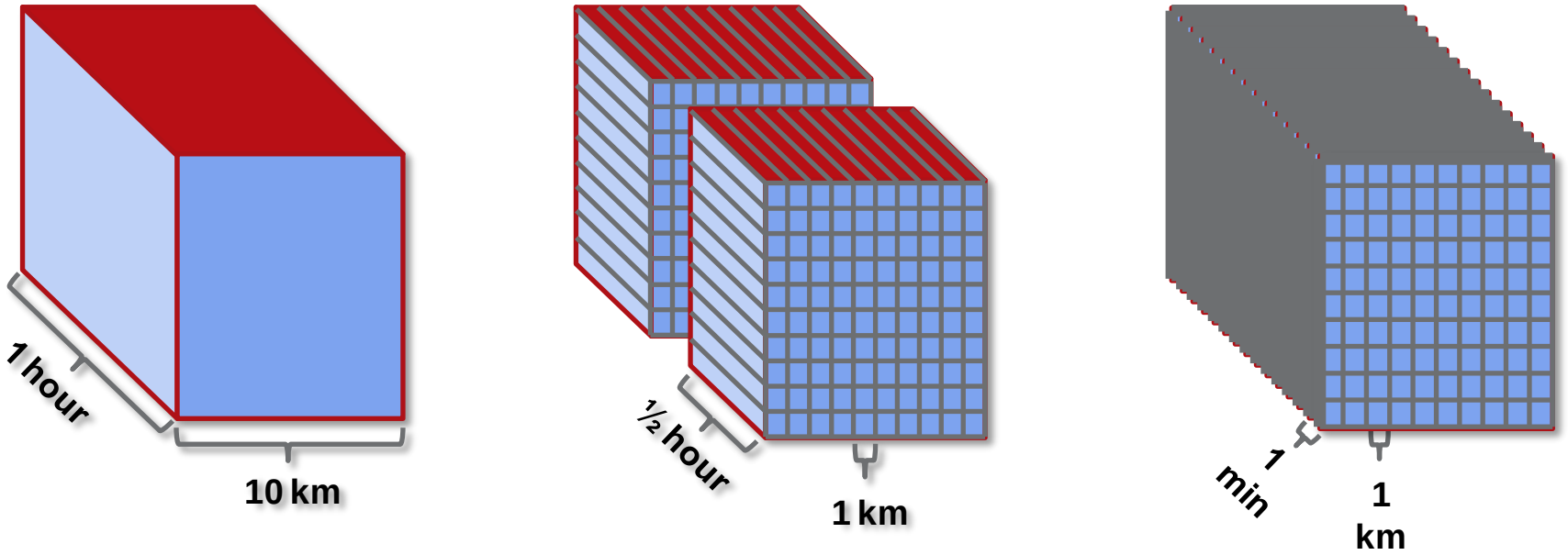
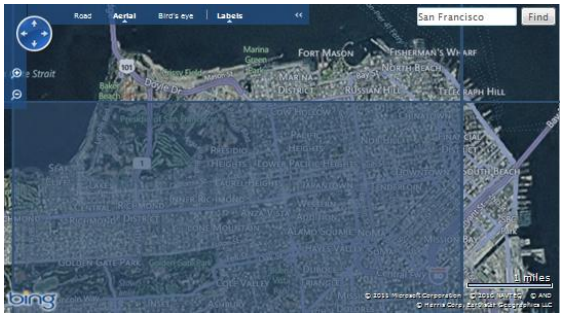
Three SolarAnywhere Resolutions

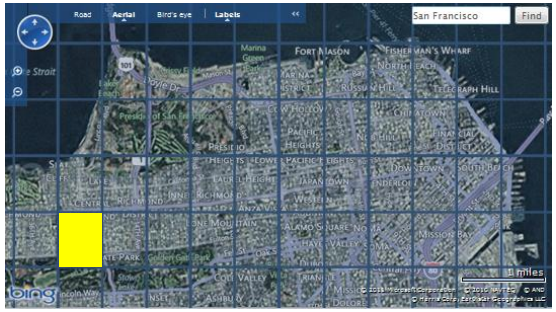
Standard Resolution
10 km, 1 hour

Enhanced Resolution
1 km, ½ hour

High Resolution
1 km, 1 minute

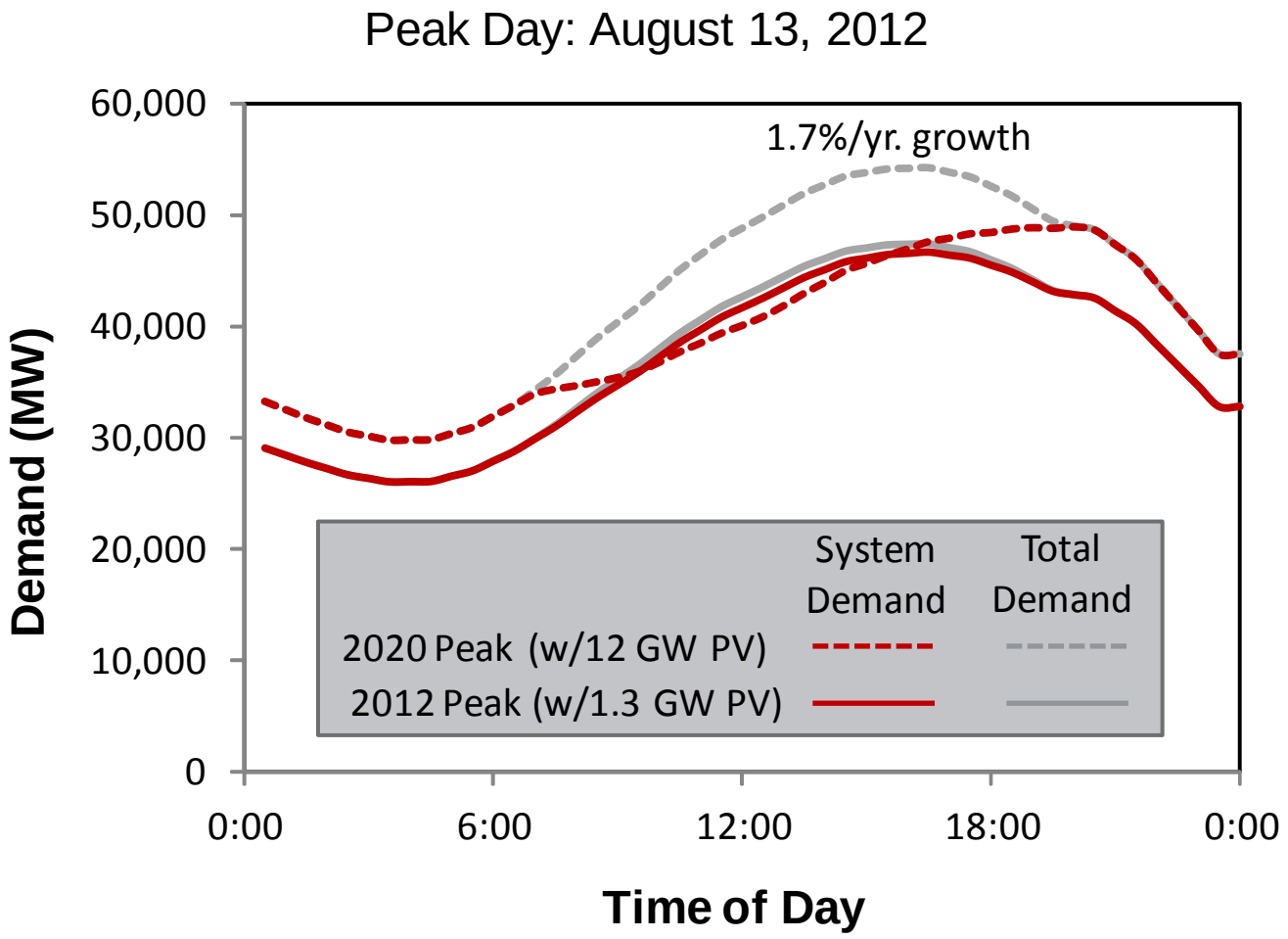






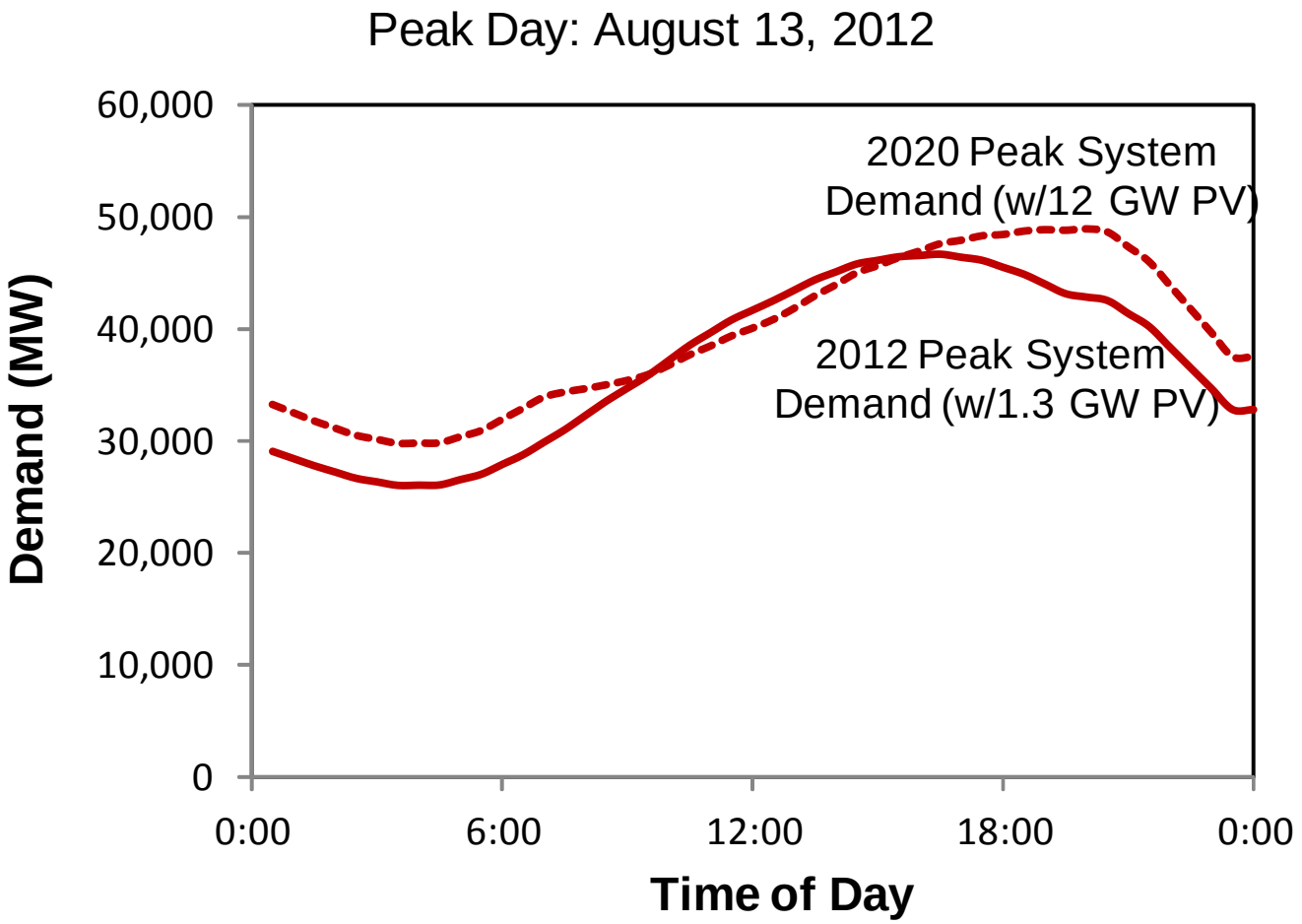
Example: San Francisco, CA

Using FleetView for Resource Planning



Note: Full analysis requires examination of all days of the year

Using FleetView for Resource Planning



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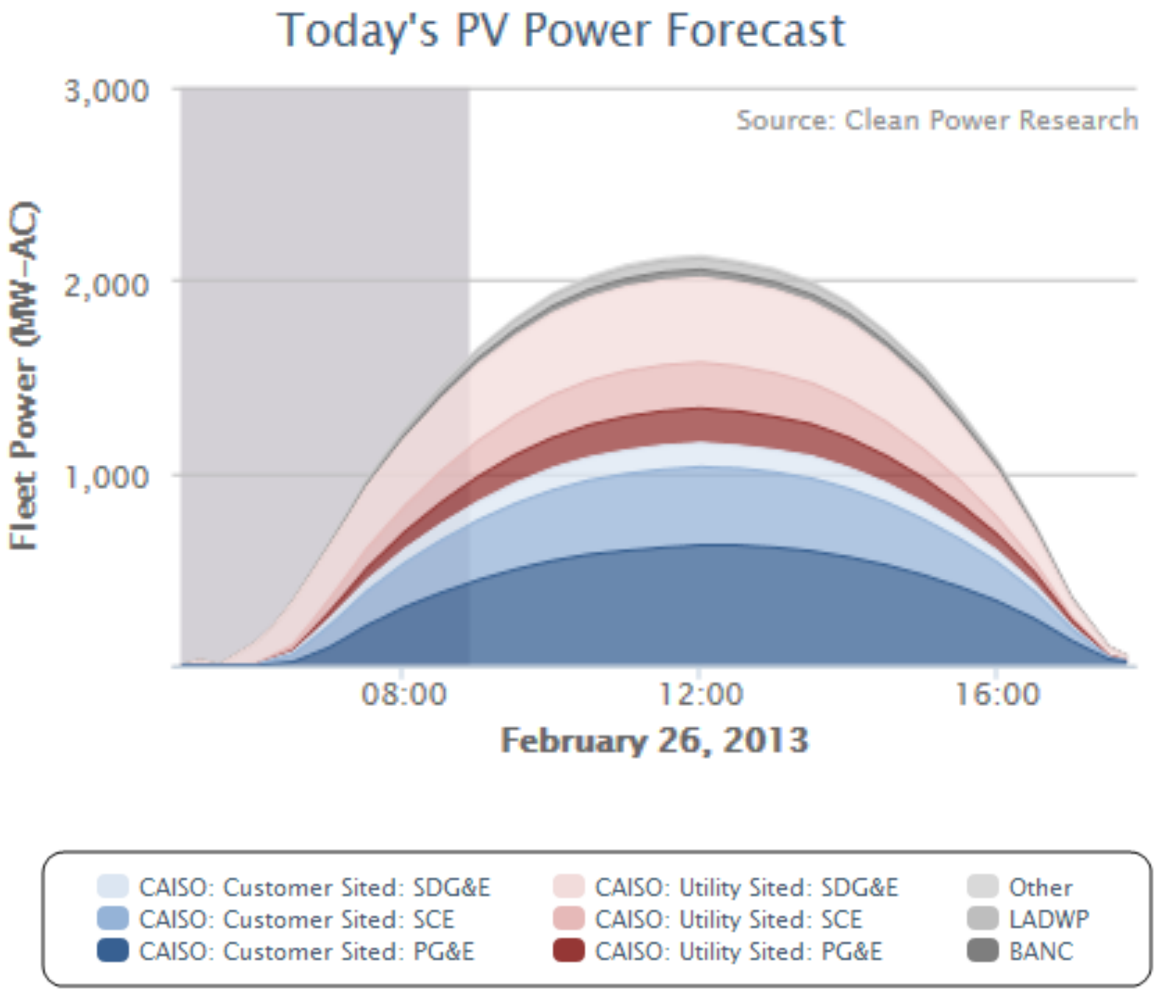
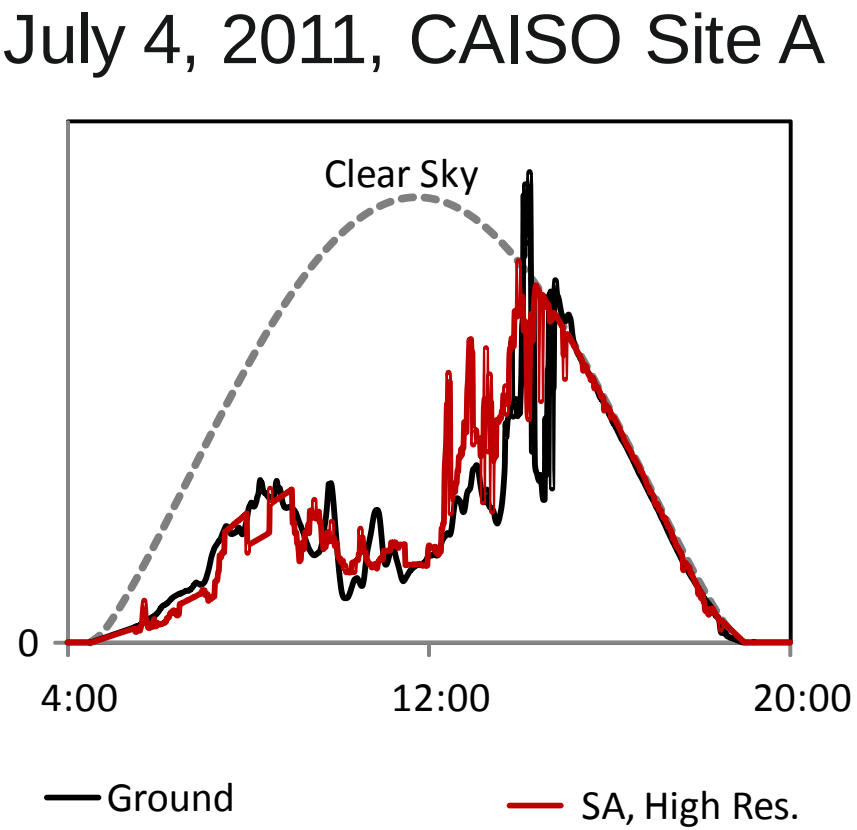
Using FleetView for Net Load Forecasting



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

Initial Validation: 1 km, 1 Minute Irradiance Data



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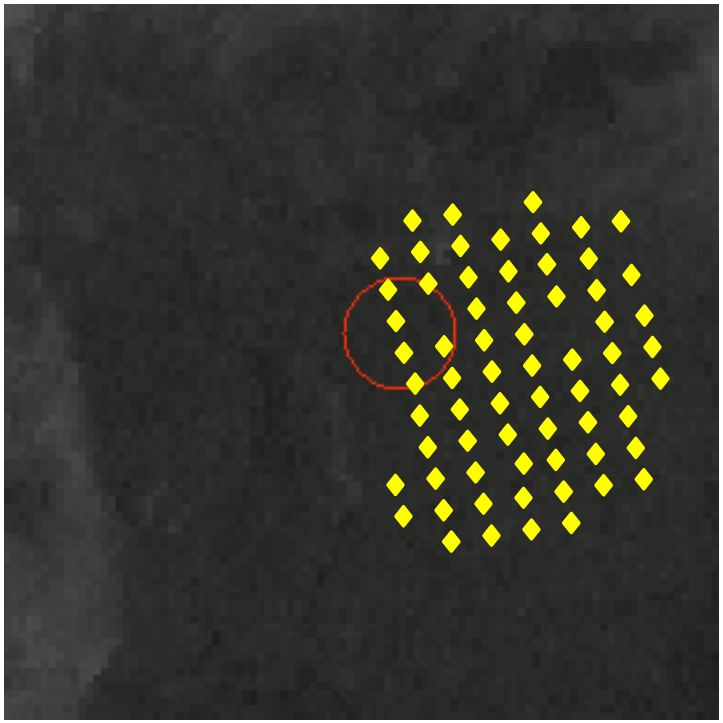
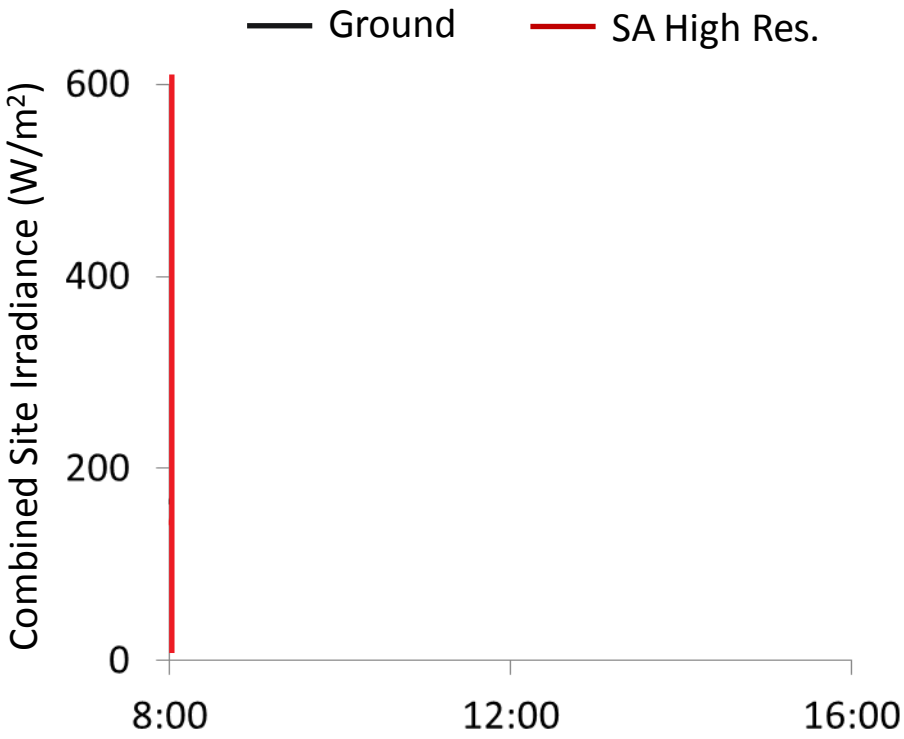
Example Using SMUD's Solar Data Network on Highly Variable Day (Nov. 18, 2011)





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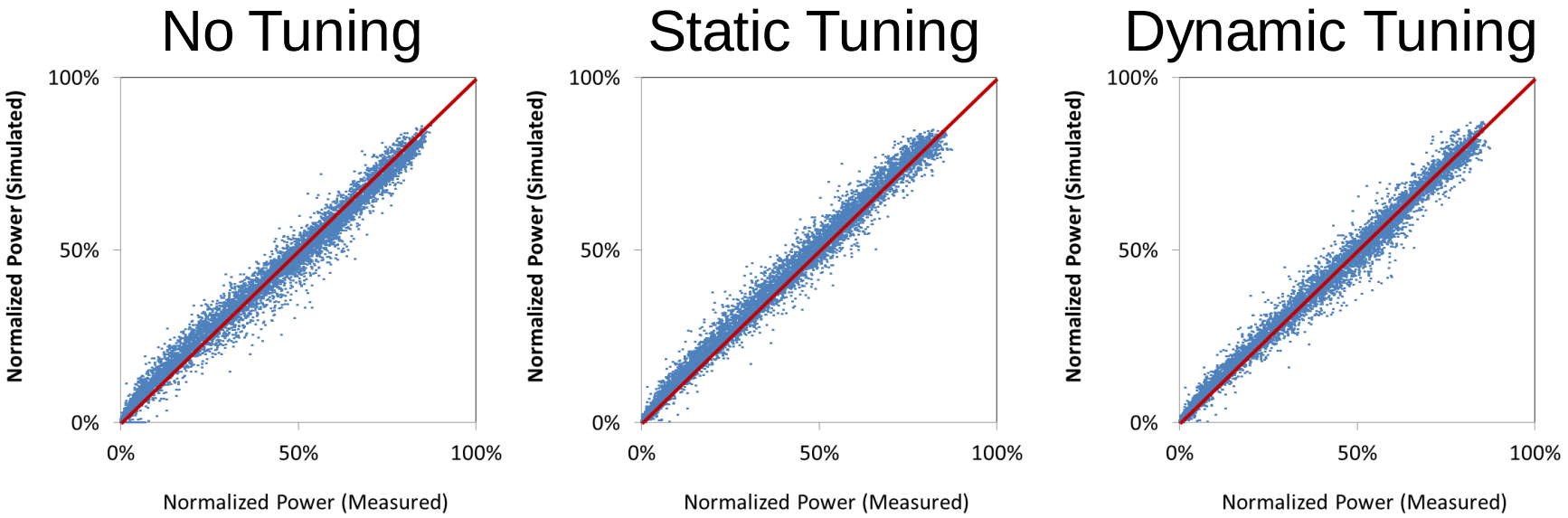
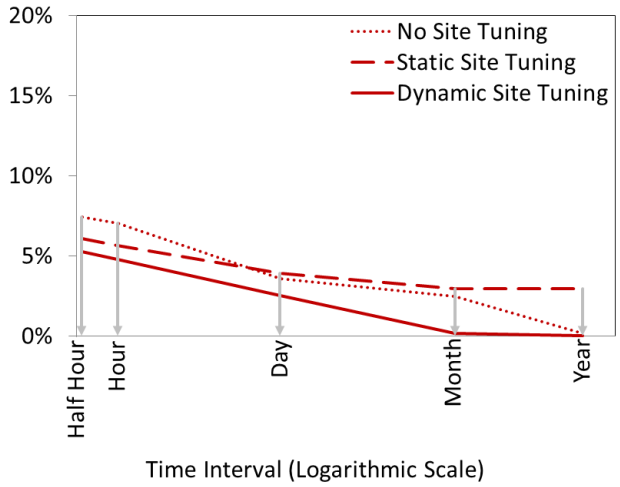
CAISO Fleet Results

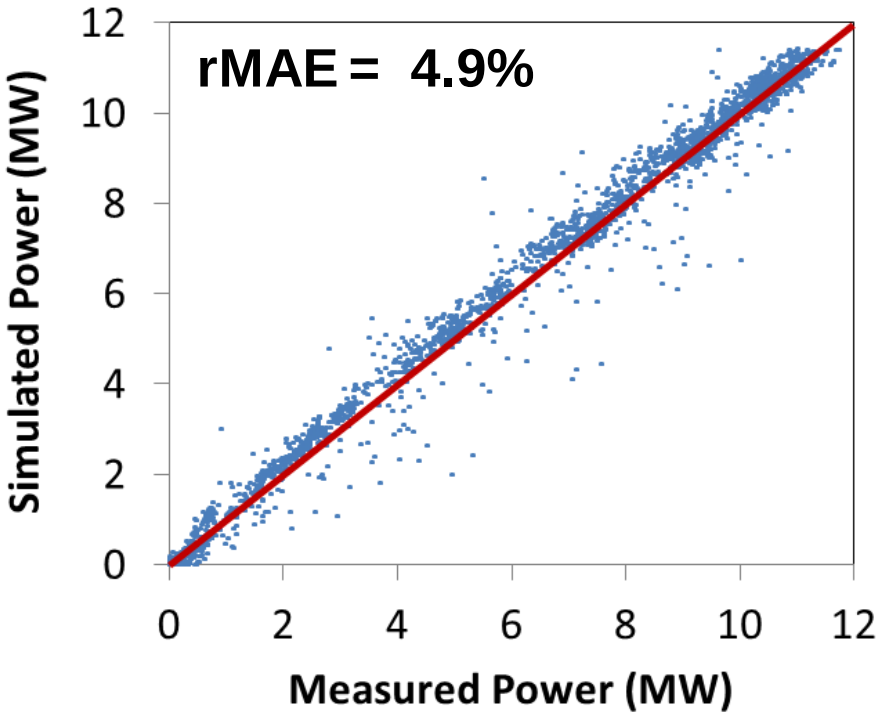


Measured Data

- 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



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

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

Conclusion

- SolarAnywhere High Resolution (1 km, 1 min) data can be produced throughout CA
- Satellite-derived PV simulation holds good promise for a low-cost method for addressing grid-integration issues through PV planning and forecasting
- Initial validation efforts are promising

Thank you

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

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