GO solar CALIFORNIA

CSI RD&D PROGRAM

Grid Integration

Grantee:
University of California, San Diego

Phase I Partners:
EnerNex, California Independent System Operator, San Diego Gas & Electric, Clean Power Research

Phase II Partners:
Green Power Labs, Clean Power Research, Sacramento Municipal Utility District, National Renewable Energy Lab, Power Analytics

CSI RD&D Funding:
Phase I $548,094
Phase II $1,261,828

Match Funding:
Phase I $137,037
Phase II $1,353,707

Project Timeframe:
Phase I 2011-2013
Phase II 2012-2015

RD&D Project Portal:
Phase I
calsolarresearch.ca.gov/csi/65
Phase II
calsolarresearch.ca.gov/csi/87

Itron | CSI RD&D PROGRAM MANAGER

Improving the Economics and Integration of Solar Power through Resource Analysis, Forecasting, and Modeling

OVERVIEW AND OBJECTIVES

Integration of large amounts of photovoltaics (PV) into the electricity grid poses technical challenges due to the variable nature of the solar resource. Solar distributed generation (DG) is often behind the meter and invisible to grid operators. The ability to understand the actual variability of solar DG will allow grid operators to better accommodate this resource in terms of planning, scheduling, and dispatching of electricity. From a system operator standpoint, it is especially important to understand when aggregate power output is subject to large ramp rates (increased or decreased output).

Phase I: The overall goal of the project was to accelerate the placement of higher levels of PV into distribution circuits. The University of California, San Diego (UCSD) research team studied:

- The accuracy and performance of solar resource models.
- Aggregated PV variability and ramp rates.
- PV performance and soiling analysis.
- PV impacts on distribution feeders.

Phase II: The goals of this project were to:

- Reduce solar integration costs through more accurate solar forecasting.
- Demonstrate distributed generation solar forecasting in aggregation at the system level and the distribution level.
- Demonstrate forecast applications to net load forecasting, feeder control, and fast demand response. Specifically, the UCSD team demonstrated forecast performance during meteorological conditions with the greatest impact on San Diego Gas & Electric (SDG&E) operations, developed day-ahead solar forecast models for marine layer clouds, produced localized solar forecasting and distribution feeder models, and integrated solar forecasts with utility models for resource adequacy.

This document provides a brief project description. For more detail on the project and the California Solar Initiative's (CSI) Research Development, Demonstration & Deployment (RD&D) Program, please visit calsolarresearch.ca.gov

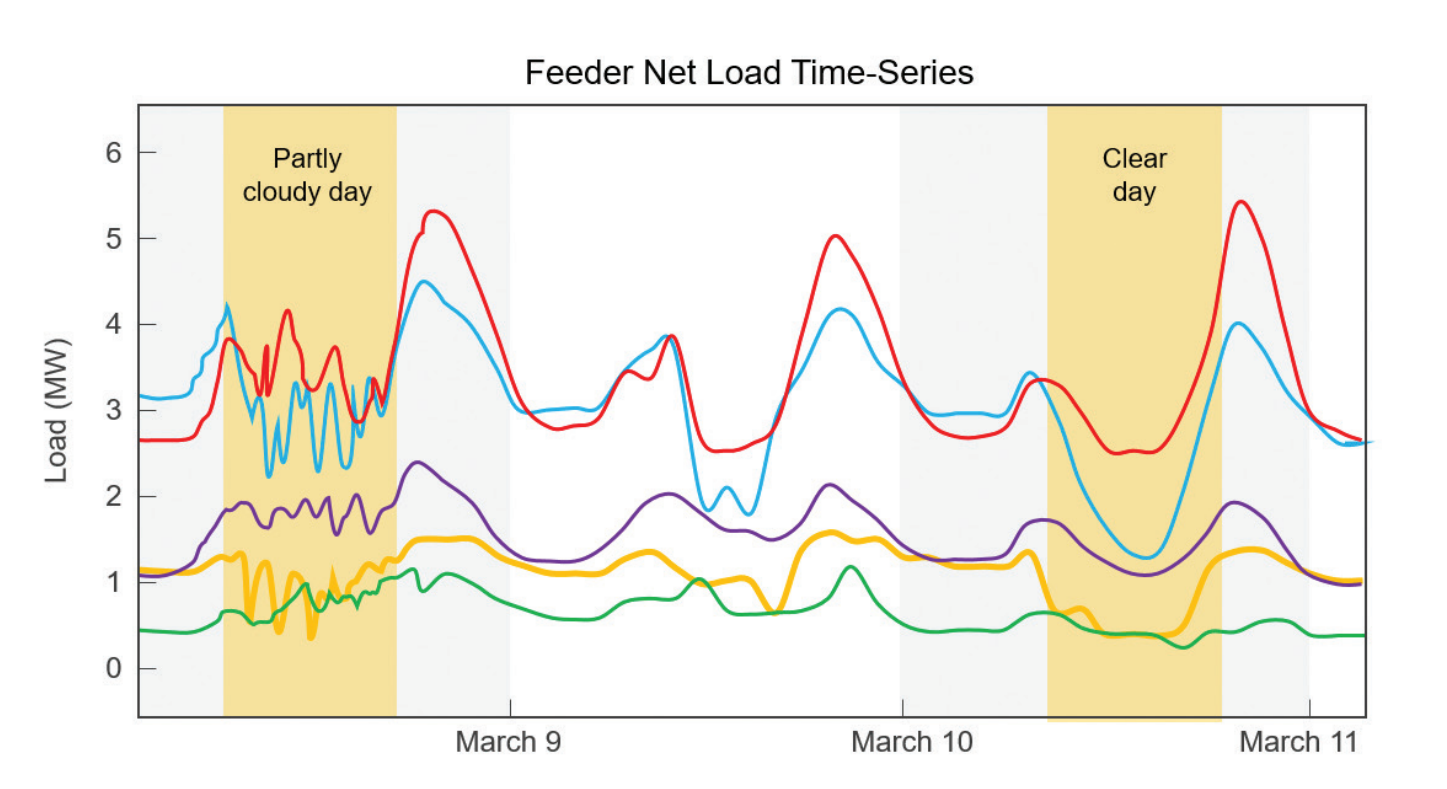
The CSI RD&D Program is managed by Itron on behalf of the California Public Utilities Commission (CPUC).

PHASE I: METHODOLOGY

The UCSD team validated SolarAnywhere, the high-resolution solar resource model, against ground measurements and developed additional modeling capabilities to account for the effects of topography shading and PV soiling on PV output and spatial solar resource data. A PV performance model was developed that can be applied to satellite solar resource data to simulate PV power output taking local weather conditions into account. Lastly, satellite forecast models were compared against numerical weather prediction to examine how to best integrate the different models into seamless solar forecast products.

PHASE I: RESULTS AND OUTCOMES

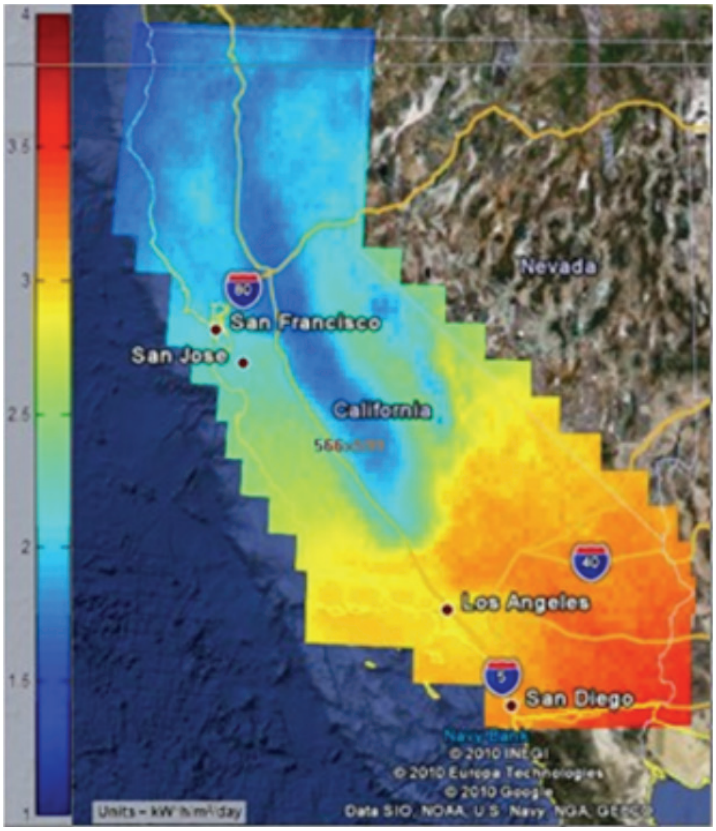
The SolarAnywhere model validation against ground measurements was found to be slightly biased high, but generally of high accuracy. The effects of topographic shading and PV soiling were found to be small. A high resolution PV output dataset for over 115 PV sites across the state was developed to facilitate integration studies. Ramping was found to be most significant during sunrise and sunset periods. Weather-induced ramps were small at the California Independent System Operator (CAISO) level but can be significant for smaller utilities. Generally, these findings show that for load balancing over large areas, the impact of distributed PV generation is smaller than previously thought and often highly predictable. For very short-term forecasting, cloud speed sensors and algorithms were developed to predict and mitigate short-term fluctuations in solar power output caused by weather variability.



Net load time-series of multiple residential feeders. Net load is higher and more variable on cloudy days than on clear days, illustrating the daytime impact of solar PV.

PHASE II: METHODOLOGY

The project team developed forecasting tools through a combination of very high resolution numerical weather prediction, statistical modeling, and dense measurement infrastructure installed by SDG&E. Distribution feeder power quality analysis was conducted with total sky imager forecasts feeding into power flow modeling to identify voltage control needs. The modeling was conducted on five representative feeders with variations in PV penetration, location, meteorology, and voltage regulation equipment. For these same feeders, net load forecast models were also developed and validated.



The forecasting tools developed in this phase support more accurate solar resource assessments.

PHASE II: RESULTS AND OUTCOMES

The model outputs were integrated into utility forecasting tools and transmission and distribution models based upon the needs of the CAISO and the utilities in the state. SDG&E was supplied with forecasting data for distributed PV facilities in their territory. Net load forecasting was provided to CAISO on the meter- and feeder-levels. High penetration PV impacts on distribution circuit loads were quantified and used to produce power demand forecasts to CAISO. Solar forecasting and power flow models were validated against PV system performance. Finally, data management and visualization software was used to provide more detailed access of microgrid data to CAISO.

PUBLIC BENEFITS

Variability and forecasting models and datasets can be made available to other researchers for validation. The PV performance model is posted at http://www.calsolarresearch.ca.gov/ and the horizon database and PV output data are available upon request from jkleissl@ucsd.edu.

SDG&E is implementing hours-ahead and day-ahead solar forecast strategies which has been considered the largest source of uncertainty to utility resource adequacy operations.

Solar power integration provides better foresight for power system operation, better understanding of distribution system operation and maintenance costs and mitigation options, and smarter investment in monitoring infrastructure.