GO solar CALIFORNIA

CSI RD&D PROGRAM

Grid Integration

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National Renewable Energy Laboratory

Partners:
Southern California Edison, Clean Power Research, Electrical Distribution Design, Satcon, Quanta Technology

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2010-2013

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calsolarresearch.ca.gov/csi/67

Analysis of High-Penetration Photovoltaics into California's Distribution Grid

OVERVIEW AND OBJECTIVES

Distribution utilities have limited experience with high-penetration PV integration particularly in terms of methods to mitigate impacts. Sustaining high growth rates in the photovoltaic (PV) industry requires being able to successfully integrate PV into the electric power system while maintaining reliability. This National Renewable Energy Laboratory (NREL) research project addresses the integration of high levels of PV into the electrical distribution system by fully examining the issues, developing solutions, and transitioning those solutions to the field for large-scale deployment. This project was designed specifically to benefit from the experience that Southern California Edison (SCE) and the project team gained during the installation of 500 megawatts (MW) of utility-scale PV systems (with 1–5 MW typical ratings) from 2010 to 2015 within the SCE service territory. At that time, this installation represented the highest level of distributed PV in any utility service territory in the United States and included several distribution circuits with high penetrations of PV.

PV system on Fontana warehouse

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).

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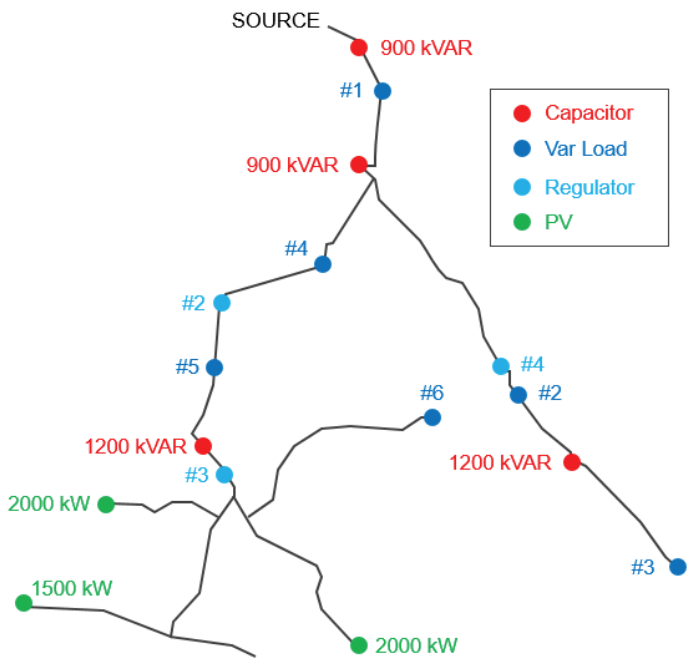
METHODOLOGY

To understand the impact of these new PV installations on the distribution grid, the project team conducted modeling and simulation, laboratory testing, and field demonstrations of the effect of high penetrations of PV on electrical distribution systems. The project team first defined a number of factors and impacts related to introducing high-penetration PV systems into the system and defined hardware and software solutions. NREL conducted laboratory testing on advanced inverters and control systems. These advanced systems were installed on projects in the SCE service territory to help eliminate issues that arise due to high penetration levels of PV, such as voltage regulation or unintentional islanding. The NREL testing consisted of developing the functional requirements and then implementing them in hardware and testing them in the field.



Reduced version of the test feeder used for simulated time-series studies

RESULTS AND OUTCOMES

The final results from this project are summarized into technical reports on best practices, designed to instruct utilities on how to integrate high levels of distributed PV systems into the electrical distribution grid. This will accelerate the placement of high levels of PV into existing distribution circuits and identify new circuit configurations that will help increase PV penetration levels. Various visualization tools were developed for measuring the extent and frequency of potential problems as well as comparing mitigation measures. The research team found that inverter control with the following capabilities can be implemented with little additional equipment cost: reactive power control, real power control, steady-state voltage control, and fast automatic voltage control (flicker reduction). The research and testing results collected during the entire project will be compiled into a *High Penetration PV Integration Handbook* for use by distribution utility engineers facing the challenges of high penetration PV interconnections.

PUBLIC BENEFITS

Improved PV impact modeling capabilities using experience and data gained with the demonstration project.

Modeled impacts of high-penetration PV integration on real distribution circuits and validated PV impacts using field data and mitigation strategies to reduce PV related impacts.

Demonstrated (via field deployment) the ability of PV inverters to implement advanced functionality to mitigate the impacts of high-penetration PV integration.

Advanced PV inverter control requiring minimal equipment upgrade costs. Inverter control was tested at the 500kW level to provide verified mitigation of PV impacts.

New knowledge and experience for high- penetration PV integration on the SCE system. These findings are shared and disseminated to the wider distribution engineering community to accelerate the rate of PV interconnection in a safe, reliable and cost-effective manner.