GO solar CALIFORNIA

CSI RD&D PROGRAM

Grid Integration

Grantee:
Electric Power Research Institute

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National Renewable Energy Laboratory, Sandia National Laboratory, Southern California Edison, Pacific Gas and Electric, San Diego Gas and Electric

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National Renewable Energy Laboratory, Sandia National Laboratory

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RD&D Project Portal:
Phase I
calsolarresearch.ca.gov/csi/88
Phase II
calsolarresearch.ca.gov/csi/110

Itron | CSI RD&D PROGRAM MANAGER

Screening Distribution Feeders: Analysis to Inform California Grid Integration Rules for Photovoltaics

OVERVIEW AND OBJECTIVES

Utility incentive programs have significantly increased the number of installed photovoltaic (PV) systems, requiring utilities to evaluate these interconnection requests to ensure proper grid operations. To assist utilities in quickly evaluating these systems, screens have been developed that help identify when issues may arise. The most common screening approach looks at the ratio of solar PV to peak load (15%); however, this method does not account for the locational impact of PV or the characteristics of specific feeders. Some of the factors known to be important to feeder hosting capacity include steady state voltage regulation limits, tap changer cycling issues, reverse power flow issues, unintentional islanding risks, fault current contribution issues, ground-fault relaying desensitization issues, neutral grounding compatibility, ground fault overvoltage issues, and harmonics.

Phase I: For the first phase of the project, the Electric Power Research Institute (EPRI) team developed an interconnection screening methodology that takes into account individual distribution feeder characteristics. Distribution modeling and simulation techniques were used to determine the level of PV that can be accommodated on individual feeders without impacting distribution system operations. This measure of hosting capacity is expected to become more critical as PV deployment increases. Major California utilities participated in the project and helped to detail which tools and penetration screens have most commonly been used and which procedures have been most effective for evaluating PV interconnection requests in California. The utilities also helped review distribution feeder classification methods to identify and map areas with additional capacity for hosting PV.

Phase II: For the second phase of the project, the EPRI team examined the impacts of using advanced inverters to perform different functions at different complexity levels, with a focus on expanding hosting capacity. This research addressed both simple and advanced methods for determining the most effective and beneficial smart inverter settings based upon feeder characteristics, PV penetration levels, and distribution. Locations where advanced inverter controls are most effective were also identified.

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 EPRI team began by documenting current practices for screening PV interconnections both inside and outside of California and determining the range of feeder configurations for utilities in the state. A database of feeder characteristics was developed and sample feeders were selected from each utility and placed into two groups — one group of 16 feeders for detailed analysis and another group of six feeders for screening validation.

A detailed feeder model was developed for each of the selected feeders and EPRI's Distributed PV (DPV) Feeder Analysis Method was used to simulate a wide range of PV deployment scenarios and penetration levels on each feeder to determine hosting capacity. The hosting capacity analysis determined the amount of PV that can be accommodated on a distribution feeder without exceeding utility-guided thresholds. The hosting capacity for each feeder is unique for voltage and protection issues. A formal validation process was conducted to determine the accuracy of the screening methodology.

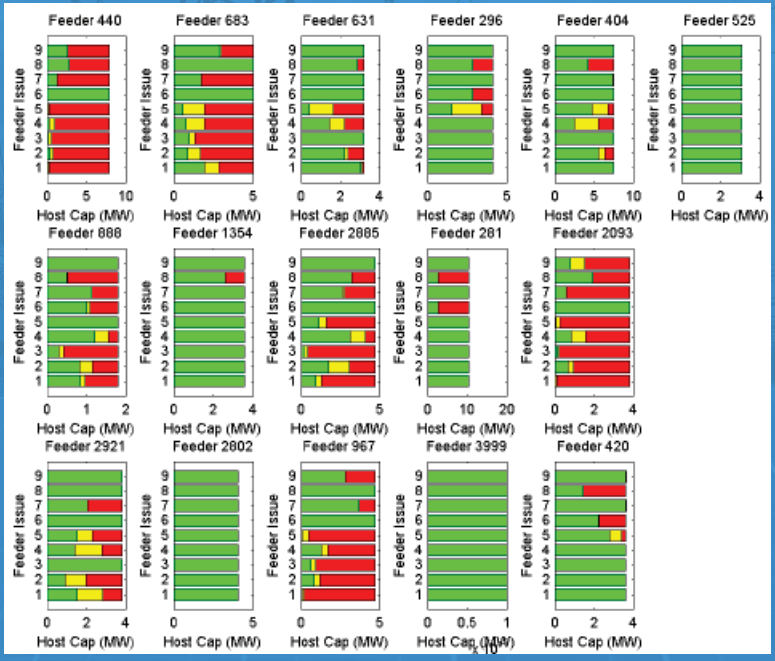
PHASE I: RESULTS AND OUTCOMES

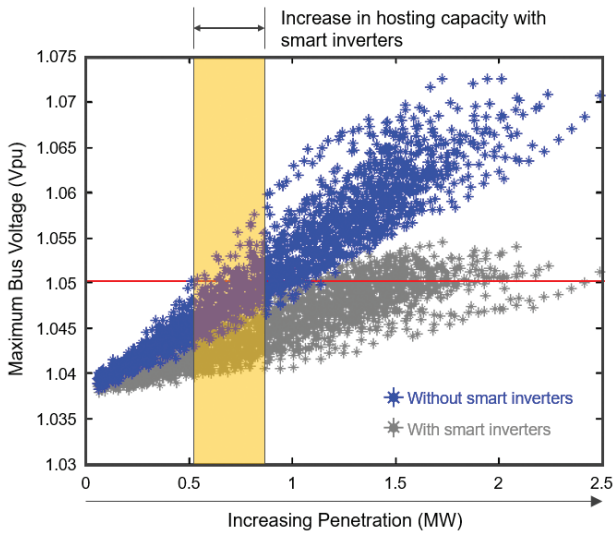
The detailed feeder impact analysis identified when potential issues from aggregate distributed generation were not properly identified and also when a feeder was capable of accommodating considerably higher levels of distributed generation. The *Alternatives to the 15% Rule* found in this project more properly address the impacts from distributed generation and were not solely dependent on load level. These improvements can be used to provide a more detailed screening mechanism while the utilities are developing the distribution resource plans.

The improvements suggested to Rule 21 included:

- Add an Initial Review screen that addresses if the feeder has line regulators.
- Modify the Initial Review to always address aggregate generation.
- Add Supplemental Review equations to be used as a guideline to address the voltage and protection impacts from aggregate generation.

Issue-Specific Residential and Commercial Rooftop PV Hosting Capacity





Smart inverters can improve the integration of solar PV. The above orange highlights the increase in hosting capacity with smart inverters.

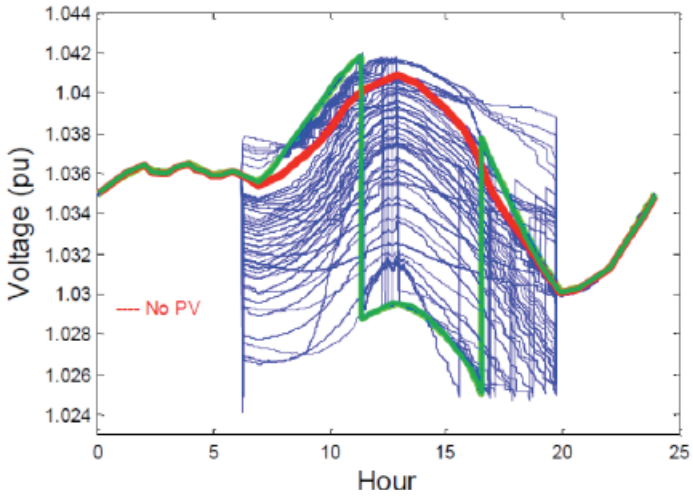
PHASE II: METHODOLOGY

Seven feeders were selected for their diversity in size, location, and overall representation of those present in California. For each feeder, thousands of simulations were run by selecting locations of PV systems and applying advanced inverter logic to typical generation and demand profiles. Each simulation investigated one of three main advanced inverter functions designed to reduce voltage issues: power factor control, volt-var control, and volt-watt control. For the first two methods, three complexity levels were developed:

- Level 1: incorporated basic inverter settings.
- Level 2: added feeder size and location-specific information along with other more advanced settings.
- Level 3 leveraged system-specific load flow information to perform customized calculations.

PHASE II: RESULTS AND OUTCOMES

Based on the findings of this work, the suggested advanced inverter settings and methods to determine settings can be used to improve the accommodation of higher levels of PV on the grid. All three levels for each function of smart inverters resulted in net improvements in hosting capacity for each feeder and had similar benefit to impact ratios, but did so at various rates and efficiencies. The voltage impact from PV can be mitigated using power factor, volt-var, or volt-watt control, while the bulk system impact can be improved with frequency/voltage ride-through. As demonstrated in this research, appropriate inverter control settings are feeder-dependent. Several methods for each control function have been created such that the utility can make use of the data and tools available to make the determination of control settings.



There are multiple inverter settings. The blue lines indicate voltage response using different volt-var settings.

PUBLIC BENEFITS

Provide utilities insight into how to proactively develop cost-effective mitigation strategies incorporating non-traditional technologies and better plan for the high PV penetration future.

Inform on-going grid modernization efforts and Distribution Resources Plan demonstrations, which target increased penetration of distributed energy resources and understanding the value of these resources.

Increase understanding of the issues associated with high solar PV penetration and improve quality of interconnection applications.