TAD-EPC Project Update – Smart Consumer Devices (Smart Inverters)

Date: 09/07/18 - Updated

Name: Julie Hayes

Role: TA&D Project Consultant

EXECUTIVE SUMMARY
Name of the Project CEC EPC-14-079: Assessing the Ability of Smart Inverters and Smart Consumer Devices to Enable More Residential Solar Energy
Issue driving the need for the Project The California Public Utility Commission's Electric Program Investment Charge (EPIC) program supports this goal and Decision (D.) 11-12-035 provides the funding for public interest investments in applied research and development, technology demonstration and deployment, market support, and market facilitation, of clean energy technologies and approaches for the benefit of electricity ratepayers. Increasing solar generation along with expanded distribution channels is critical to meeting the state's clean energy and carbon reduction goals. One of the most prominent limiting factors for solar generation on California distribution systems occurs when multiple PV systems are installed behind a single distribution transformer. As a result, inverters have experienced shutdown due to local overvoltage conditions, making expansion of solar applications more difficult. High PV penetration on the feeder and the voltage profile may be fine, but local over-voltage, variability, and equipment stress may occur on the customer side, limiting PV deployments and production. It is not known to what extent onsite advanced loads can help mitigate impacts of distributed solar generation and enable higher penetrations thereof. This project supports research needed to advance the industry's knowledge regarding how customer loads can be managed most effectively to enable more PV on the grid.
Description of the technology(s) and the potential it holds for solving the issue *Project 1: Smart Inverters – SCE is moving away from further research on smart inverters providing a reliable solution for the issue. SCE is still interested in further research on the viability of onsite DER.* Project 2: Onsite DER – EPRI laboratory testing of controllable load devices that may enable higher penetration of solar generation. They include the following four devices: 1. Programable thermostats 2. Heat Pump Water Heaters 3. Variable Speed Pool Pump 4. Electric Vehicle Service Equipment
Research Question for this project:

Can onsite DER, such as electric vehicle chargers, advanced heating and cooling, water-heating and pool pumps, act in a way to enable substantially higher penetrations of solar generation while still meeting consumer expectations for these products?

Timeline for the Project
The project term is 6/30/2015 to 3/29/2019.

PROJECT DETAILS

Overview of the Project – what is it?
The purpose of this project is to determine if onsite DER can enable higher penetrations of solar and perhaps provide an option for the limiting conditions that occur on California Distribution systems when many PV systems are installed behind a single residential distribution transformer.

As the project lead, Electric Power Research Institute (EPRI) is identifying, implementing, and testing (both in lab and field) optimal methods by which naturally-occurring consumer devices, such as electric vehicle chargers and other smart loads, can serve to further enable high-levels of solar PV.

Goal for the project – what do we hope to learn/develop/solve?
Advance the industry's knowledge regarding how consumer loads can be managed most effectively to enable more PV on the grid.

Methodology and Technical Approach – what methodology is being used?

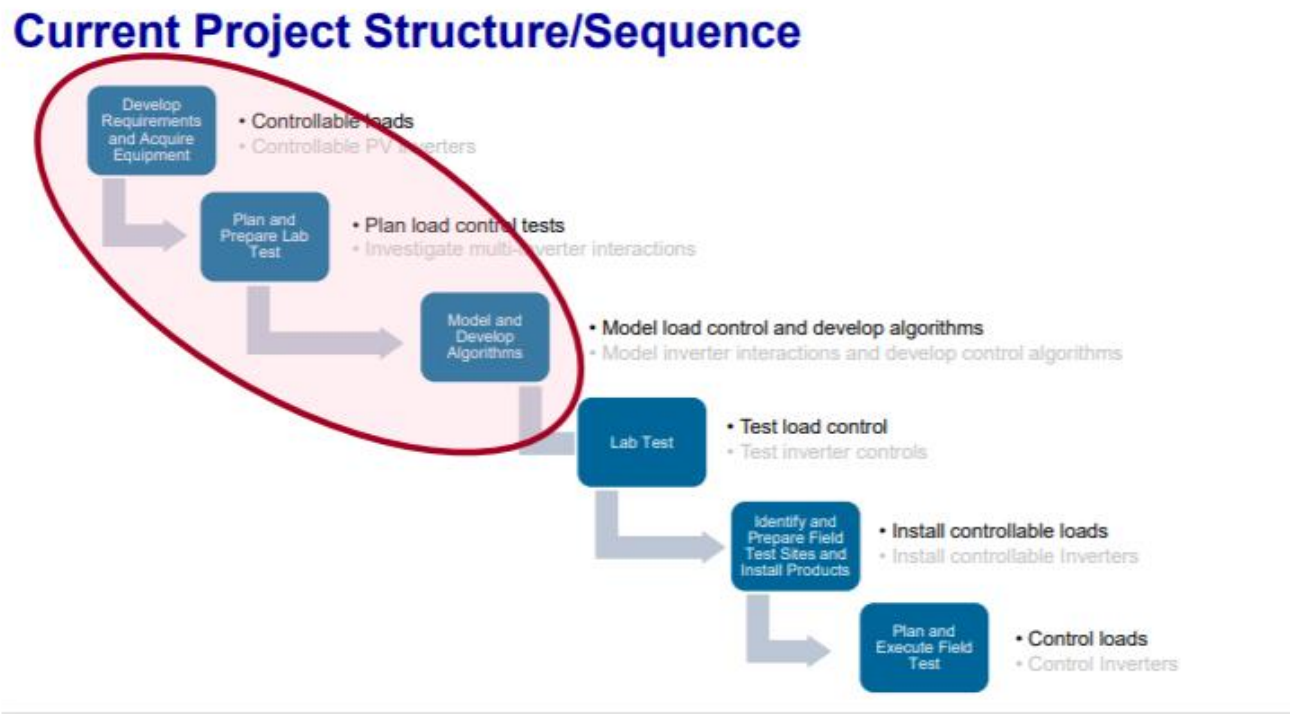
1. The learnings and benefits of this project will be achieved through a combination of laboratory and field testing.
    a. Laboratory testing allows voltage, frequency, solar viability and consumer activity to be varied in a controlled fashion, thereby evaluating the full range of possible conditions.
    b. Field testing brings in real-world conditions that might be difficult to simulate in the laboratory, including grid impedance, voltage changes, and other factors
2. In both environments, the experiments will be carried out with a specific focus on one question: How much additional PV-hosting capacity can be achieved by managing consumer loads in a fashion that is optimized for PV?

Phases of the Project – Technical Tasks

2. Requirements Development and Acquisition of Equipment
    - Smart Inverter Requirements and Communications/Control Hub Requirements
    - Functional Specifications for PV Support: for EV Chargers and for Consumer Devices
3. Laboratory Test Plan
4. Modeling and Algorithm Development
    - PV Support Algorithms
5. Laboratory Testing
    - Laboratory Test Results
6. Field Test Site Identification, Preparation, and Product Installation
    - Field Test Site Description
7. Communication and Control System Development
    - Ready and Tested Communication and Monitoring System Summary Report
8. Field Test Plan and Test Execution
    - Field Test Plan and Field Test Results

Current Phase/ Task

- Task 2: Develop requirements and acquire equipment: Controllable Loads and Controllable PV Inverters
- Task 3: Plan and prepare lab test
- Task 4: Model and Develop Algorithms



Laboratory Testing of Smart Consumer Devices (The project is currently in preparation for laboratory testing)

Laboratory testing allows solar variability and consumer activity to be varied in a controlled fashion, thereby evaluating the full range of possible conditions. The experiments will be carried out with a specific focus on how much additional PV-hosting capacity can be achieved by managing consumer loads in a fashion that is optimized for PV. Consumer devices being used for testing:

1. Programable thermostat
    a. Emerson has provided prototype units for lab testing
    b. Field units will be purchased from Emerson
2. Heat Pump Water Heater
    a. A.O. Smith Voltex Hybrid Electric units have been purchased
    b. 50-, 66-, and 80-gallon sizes have been installed at the PG&E lab
3. Variable Speed Pool Pump
    a. Pentair Intelliflo Variable Speed units have been purchased and installed at the PG&E lab
    b. Pentair Connected Demand Response Controllers used in a previous project are being refurbished by Pentair
4. Electric Vehicle Service Equipment

a. Acquired and installed Siemens Versicharge Electric Vehicle Chargers with Wi-Fi Enabled Smart Grid

Field Testing of Smart Consumer Devices

Once load control has been tested in the lab, field testing will commence. Ideal field settings include multiple homes with a combination of PV, EV and electric water heaters, and pools pumps fed from the same or adjacent transformer.

Field deployment site specifics (ISGD) have been identified as such:

- Potential 22 homes across 3 structures with PV (3.0kW-3.9kW)
- Potential 13/22 electric vehicles from 2-3 adjacent structures
- Previous participants in the Irvine Smart Grid Demonstration (ISGD) – they looked at
- Gauged local interest via email, responses were encouraging

The system architecture will consist of one Intwine Connect Gateway and one CTA -2045 device for each controlled load. The CTA -2045 devices will communicate to the Intwine Gateway via Wi -Fi. Currently there is no communication between the residential system and the utility. Intwine Gateway uses 4G cellular connectivity.

Based on site survey and the controllable devices to be tested, Intwine will kit:

- Intwine Connected Gateway with 4G LTE radio
- CTA-2045 AC Module(s)
- CTA-2045 DC Module(s)
- Installer's Guide

Installation is as simple as plug in and go and validation can be done remotely by the Intwine team during installation.

Current Phase/ Task

Task 2: Requirements Development and Acquisition of Equipment

Also doing forecasting of loads – operating day look ahead to increase capacity by looking at the loads

What potential challenges exist in the next phases of the project?

- If you are selling power back to the grid and sharing it with your neighbor, how does the utility charge for this? (Rate inconsistencies – behind the transformer but not behind the meter)
- How willing is a customer to work with their neighbor to accommodate more PV?
- The length and impedance between the home and the transformer matters
- Need to be connected to the same radio transformer

Opportunities

- *Maximize the ROI on PV systems – we are building all this generation that we can't use because the system can't support it*
- *Home Energy Management Systems – could provide a platform that works around the limitations of Rule 21*
- *Mark's transactive management project might be an opportunity*
- *Balancing the load against the PV output but the DR version could*

MARKET POTENIAL

Target Audience – who is this solution being developed for?

- Utilities interested in expanding safe, reliable PV applications across service territory
- Homeowners interested in PV applications

Potential Benefits – if the technology is adopted by the target market, what is the perceived long-term benefit?

For utilities:

- Greater penetration of PV across the state
- Reduction in system failure, great stability
- Ability to meet CPUC goals for renewable generation and carbon reduction

For consumers:

- Easy, safe application of solar to the home
- More control over power usage and costs
- Feeling of contributing to the health of CA – "doing my part"

Potential Market Challenges – what market actors or factors currently exist that may affect adoption?

For utilities:

- California does not have a deep penetration of electric water heaters. Will need to secure multiple test sites in SCE service territory that meet the PV/ EV/ HPWH/ Pool combination while also meeting the "multiple homes behind a single transformer" criteria.

For consumers:

- Lack of knowledge of technology and/or benefits
- New to the market – may be appealing to first movers only

Delivery Channel – What delivery channels exist? Have any been engaged to date? What opportunities or challenges currently exist?

- Still in pre-lab testing but Intwine is a potential delivery partner for the wi-fi enabled system

ADDITIONAL LEARNINGS AND OPPORTUNITIES RESULTING FROM THE PROJECT

Have any unexpected or additional opportunities been identified during this project?

Technology Extension for Demand Response

Though not part of this CEC project, it has been identified that the controlled DER devices could easily be expanded to include local storage.

- Architecture – The project architecture can be easily extended to support DR-related control objectives sent directly to the distributed residential gateways for local interpretation and execution
    - DR objectives could be expressed in a variety of forms (such as OpenADR signals) – Absolute total residential P setting is suggested
    - A simple form of DR scheduling has already been implemented by Intwine for another project
- Schedule – The controls vendor (Intwine Connect) estimates that full incorporation of DR capabilities could be completed and tested in six months

NEXT STEPS FOR THE PROJECT

When will the current stage be completed? What activities remain? Lab testing
What activities are involved in the next stage? 1. Get 1-year extension accepted and plan to work with SMUD 2. Lab Test at PG&E
Any additional comments: SCE is excited about the potential for smart consumer load enabling more PV on the grid while also providing storage and DR capability.