Smart Inverters/ Smart Consumer Devices

CEC EPC-14-079

Assessing the Ability of Smart Inverters and Smart Consumer Devices to Enable More Residential Solar Energy

Smart Inverters/Devices
Supporting California's Clean Energy Challenge

ALLOWING FOR MORE PV ON THE GRID

- Increasing solar generation is critical to meeting California's clean energy and carbon reduction goals.
- Overvoltage on the customer side can cause inverter shutdown.
- EPC 14-079 hopes to identify solutions that could mitigate the negative impacts of distributed solar generation through smart technologies.
- Led by Electric Power Research Institute (EPRI)

Smart Inverters/Devices

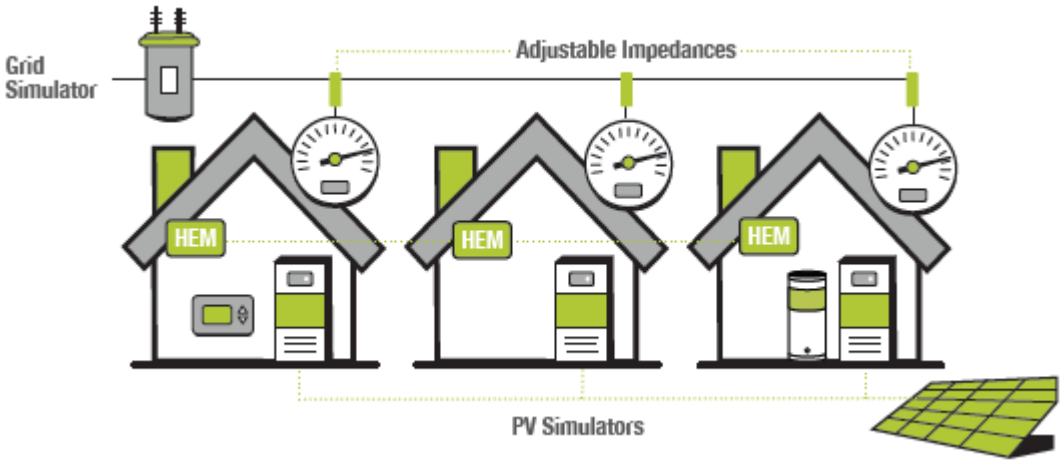
Project Goals

1. Test methods by which **smart inverters** can mitigate the issues that limit residential PV.
   a) Identify how Rule 21 functions can be used so that multiple smart inverters work in harmony.

2. Identify how **smart consumer devices** can enable high penetration of residential solar PV on the grid.

Smart Inverters/Devices

Test Bed Design



Lab Testing

- Three simulated homes, each with a solar inverter and a collection of controllable devices.
- Bulk impedances inserted between the homes at the common tie point to the transformer.
- Lab testing carried out in two steps: multi-inverter testing and tests with inverters plus controllable devices.

Field Testing

- PV systems will be outfitted with smart inverters, providing California Rule 21 revisions.
- Controllable loads will be deployed to test effectiveness and customer acceptability of load management strategies.

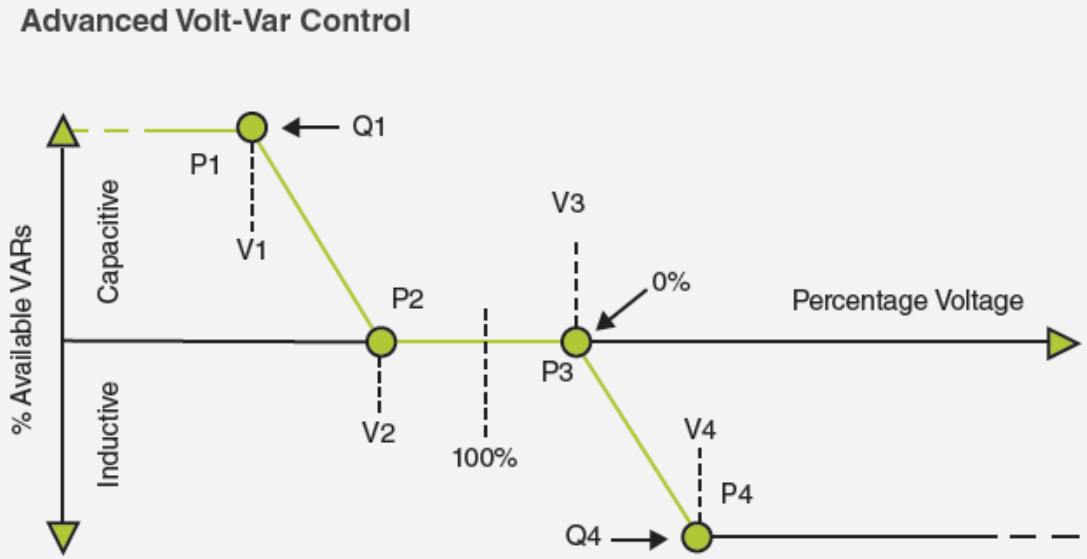
1 Smart Inverters

RESEARCH QUESTION

Can multiple inverters performing smart-inverter functions operate side-by-side in a stable and beneficial fashion to support more PV on the grid?

Smart Inverters

Lab Testing



Current findings:

Research was delayed due to limited availability of mature smart inverter units. Missing pieces to date include:

- Access to additional inverter models for lab testing
- Application of mature Rule 21 inverters for field testing
- A second field test utility partner
- CA-wide Rule 21 standard

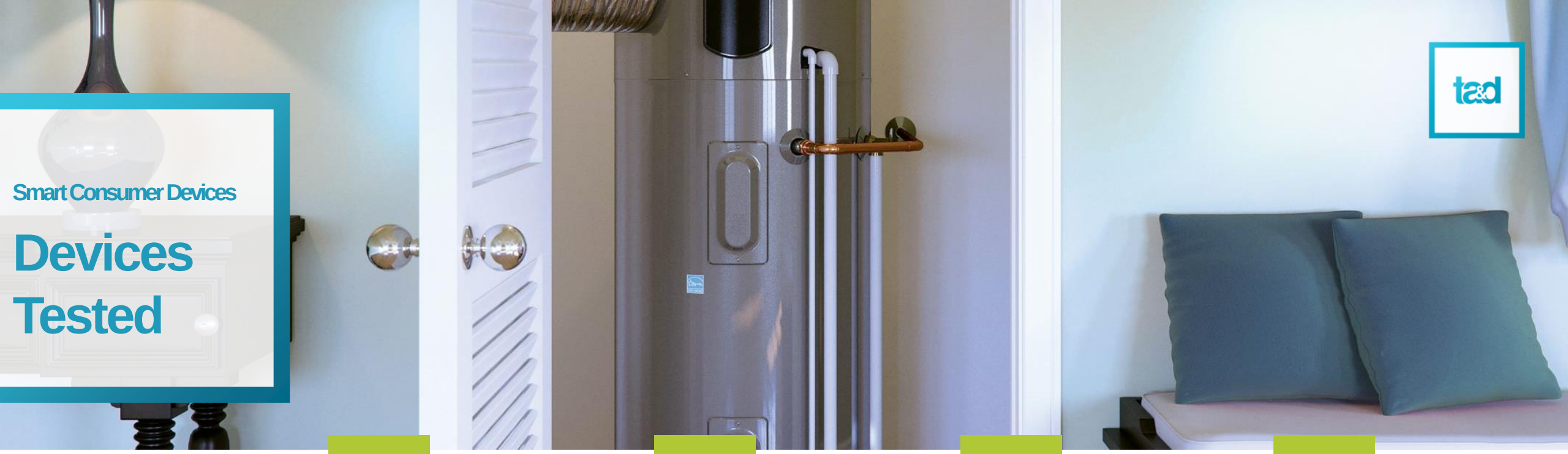
Suggested Next Steps

- Secure second utility project sponsor
- Confirm acceptable behavior of adjacent Rule 21 inverters
- Improve settings in lab to avoid undesirable interactions
- Schedule field testing

2 Smart Consumer Devices

RESEARCH QUESTION

Can residential smart consumer devices be effectively managed to enable more PV on the grid, while still meeting customer expectations?



Smart Consumer Devices

Devices Tested

1

Variable-Speed Pool Pump

Pentair Intelliflo units & Pentair Connected DR Controllers installed at PG&E lab.

2

Heat Pump Water Heater

AO Smith Voltex Hybrid 50-, 66- and 80-gallon installed at PG&E lab.

3

Programmable Communicating Thermostats

Emerson has provided prototypes for lab and field testing.

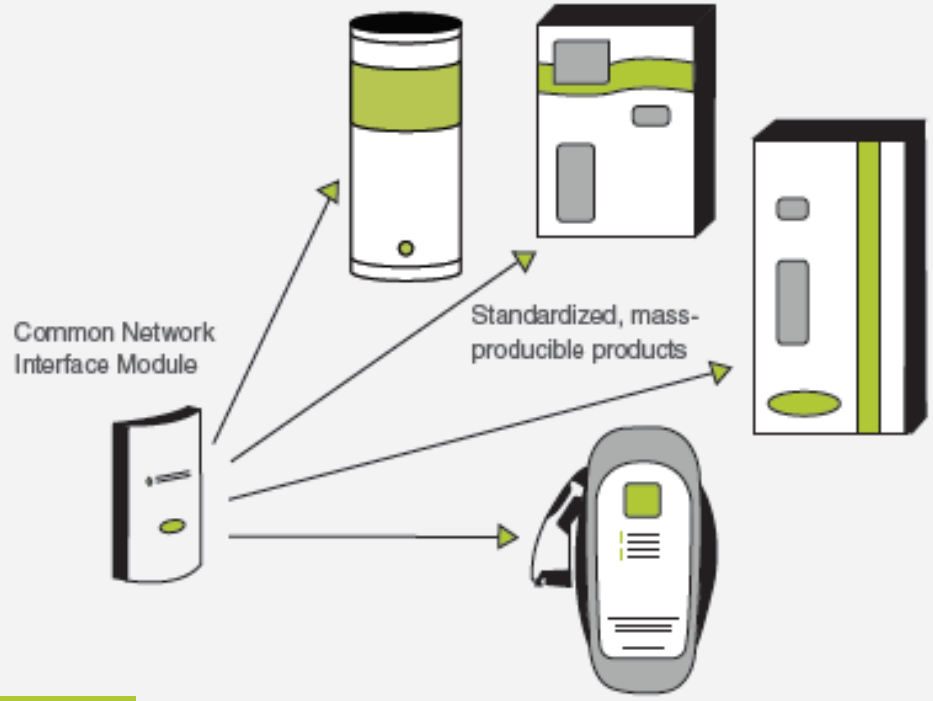
4

EV Charging Equipment

Siemens Versicharge EV chargers with Wi-Fi Enabled Smart Grid.

Smart Consumer Devices

System Architecture

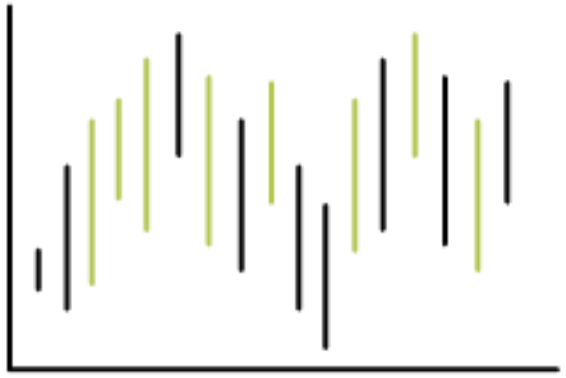


Each home system:

- One Intwine Connect Gateway and CTA-2045 equipped controllable devices
- Device communication via Wi-Fi
- No communication with utility
- Intwine Gateways use 4G cellular communication to coordinate actions between homes

Smart Consumer Devices

Research Activities



Data Collection

Inverter PV
updates (15 min): amount of PV energy produced

Smart Consumer Devices
Load and state

Weather Underground Forecasts
Hourly climate predictions for next 20-30 hours

Installation Settings
Solar panel specs and location set on Gateway page

Homeowner Settings
Availabilities and preferences set by owner on Gateway page

Opt-out
When and for how long users opt out

Smart Consumer Devices

Control Strategy

Control Strategy for Smart Consumer Devices

- Each home solves its own local optimization problem
- Remaining solar is offered to neighbors
- PV prediction is based on hourly weather forecast
- Loads are prioritized based on impact to homeowner comfort
  - Priorities can be modified via the Gateway UI
  - Homeowner can opt-out

Smart Consumer Devices

Current Findings

SUCCESSES TO DATE

- Lab testing justifies moving onto field testing
- Developed a distributed control algorithm with PV-aware scheduling of flexible loads
- Intwine software can be used with smart consumer devices
- Algorithm is fully distributed and requires no communication with the utility
- Software can be field tested within 6 months

ADDITIONAL WIN!

- System architecture can be extended to support DR-control and storage objectives

Smart Consumer Devices

Suggested Next Steps

RECOMMENDED NEXT STEPS

- Secure field test location (multiple homes on the same transformer)
- Engage participants through partner utilities
- Add Extension for DR to field tests – engage champion to support this addition
- Consider system as an integrated application for future models of ZNE homes

Thank you for coming

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