Staff Subcommittee on Electricity and Electric Reliability

NARUC Summer Policy Summit

Staff Subcommittee on Electricity & Electric Reliability and Staff Subcommittee on Energy Resources and the Environment

How to Coordinate Smart Inverters with the Distribution Grid

NARUC Summer Policy Summit

Coordinating Smart Inverters with the Distribution Grid

NARUC Summer Meetings 2017

Paul De Martini
July 17, 2017

NEWPORT CONSULTING GROUP

Caltech Resnick Institute

Why Smart Inverters?

Smart Inverters can provide 2 essential capabilities:

1) Reduce the unwanted service quality impacts from the variability of distributed solar PV

2) Provide advantageous reactive power to assist in managing grid service quality

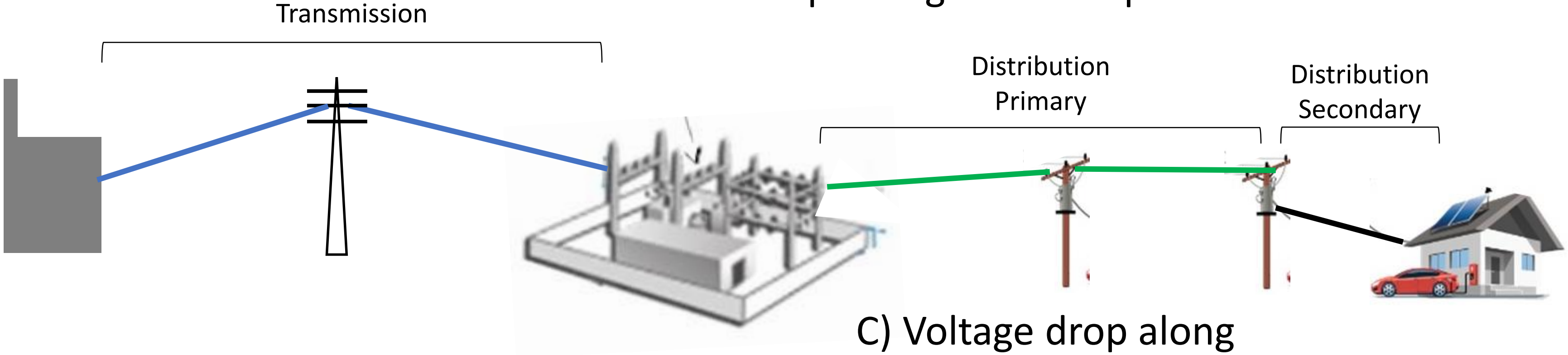
Solar PV creates voltage rise and drops as well as random transient variability since often there isn't diversity (aggregated smoothing) that is typical of load.

Customer Service Voltage Primer

Traditional Approach Manages Voltage Drop from Generator to Customer

A) System voltage set by generators on transmission

B) Voltage drop adjusted at substation by load tap changers and capacitor banks



C) Voltage drop along primary circuit adjusted by cap banks

Why are Smart Inverters Important?

Unacceptable voltage variations will harm customer service quality, operations and equipment - Question is, what to do about it?

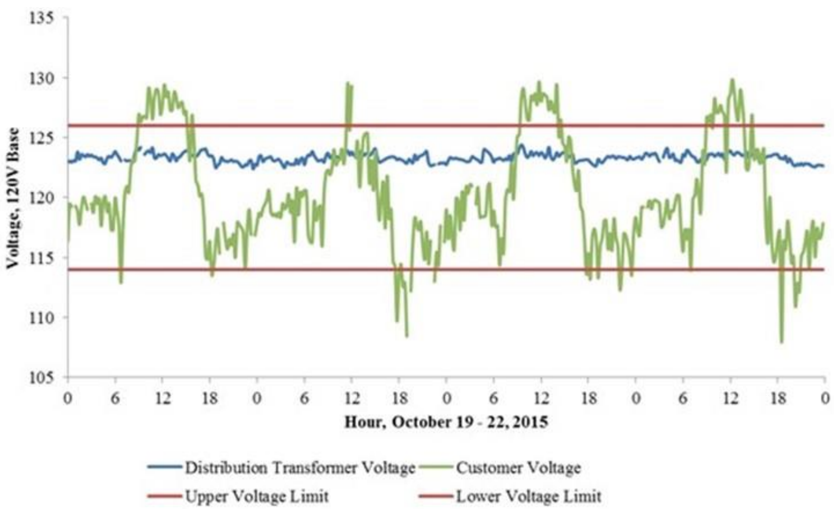
Rooftop Solar PV

- Creates unacceptable voltage variations for all customers connected to the secondary of a service transformer
- May also create local voltage violations beyond the service transformer

Community Solar PV

(connected to distribution system)

- Creates unacceptable voltage variations on the distribution primary that can impact customers in area
- May also cause undesirable operation of existing grid voltage management devices (e.g., LTCs & Cap Banks)

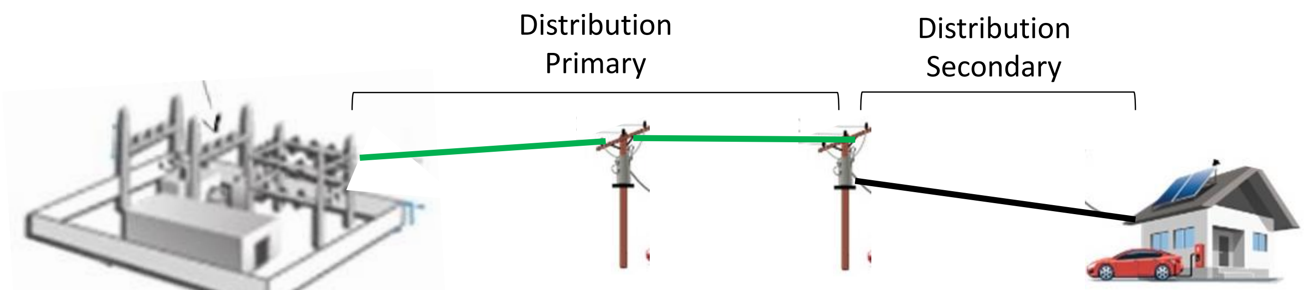


Source: Hawaiian Electric Companies

Holistic Voltage Management

Smart Inverter Coordination with Grid-side Voltage Management

B) Voltage adjusted at substation by load tap changers and capacitor banks



C) Voltage drop along primary circuit adjusted by cap banks

D) Smart Inverter Functions

E) Secondary Reactive Power (var) Controllers

Smart Inverter Considerations

- The need for any incremental voltage and/or reactive power management should be based on distribution engineering planning studies.
- Leverage the new autonomous and/or controllable functions into existing distribution Volt-var management systems and related interconnection requirements.
- Recognize that not all existing inverters are “smart” or will be upgraded and therefore will not have the new 1547 functionality. The number of these non-smart inverters may be quite large where significant adoption of solar PV has occurred over this decade.
- Benefits from new smart inverters will be substantially less if a large number of existing inverters are not upgraded.

Smart Inverter Considerations

- Typically there are no single accessible data repositories on inverter asset information for all inverters connected to the grid.
  - For example, information including device type, date installed, functionality, computer models, software version and upgradability, and communication capability that would be helpful to understand the potential to leverage smart inverters

- It is not yet clear the number of controllable inverters that may be needed to mitigate specific issues beyond those addressable through autonomous operation.

- Grid side power electronics (similar to inverters) can also address the more complex issues requiring controllability and may be simpler and less costly to implement and operate.
  - Given the mix of existing non-upgradable and smart inverters, it will be necessary for grid side power flow controllers to augment the smart inverter functionality as part of a holistic voltage management system.

Smart Inverter Considerations

- Cybersecurity considerations are important for any grid interconnecting DER. This is particularly true for inverters
- IEEE 1547 does not address cybersecurity
- Grid cybersecurity standards are not required, applied or adhered to by smart inverter manufacturers or DER providers in the device manufacture or system integration and operating systems that integrate with the grid
- This is a significant and growing gap in the grid cyber defenses as inverter based DER (solar PV and battery storage) increase

"When integrated with energy demand management programs and technologies, these combined technologies significantly increase the attack surface of the national power grid and opportunity for risk to system operation from malicious actors."

Sandia National Laboratory 2017

Implementation Considerations

Walk: Autonomous voltage control & reliability functions (start here)

At higher levels of distributed solar PV, the majority of hosting capacity and service quality issues stem from voltage quality violations. An approach is to leverage smart inverters' capability (under revised IEEE 1547 standard) to operate autonomously.

As an initial step, the inverter can be set to operate autonomously based on parameters provided through interconnection requirements based on results from interconnection studies and/or distribution planning process.

Jog: Periodic Inverter set-point changes (as needed)

As may be needed at higher DER levels, periodic adjustments to inverter settings as part of an overall Volt-var management can be made. If set-point changes are desired they can be sent from a distribution operator directly to the inverter or through an aggregators' links to the inverters.

This approach would involve periodic updates to the functions based on annual or operational planning or interconnection studies. However, these adjustments would not be expected to be frequent given the inherent limitation of the flash memory in inverters to degrade on frequent rewriting of software code.

Implementation Considerations

Run: Dynamic Volt-var management services (as needed)

Expand the use of inverters for system benefit for incremental performance beyond walk and jog functionality through integration with a grid operator's DERMS/IVVO system. For example, if the utility needs more dynamic operation of the inverter function.

- Need continued development of smart inverters as a potential tool through improving standards like IEEE 1547 and their successful implementation.
- Interoperability will be a significant issue given the diversity of inverter manufacturers and potential differences in the implementation of the standard given the flexibility allowed under the revised IEEE 1547.
- Create clear DER interconnection requirements that allow these devices to support the grid securely.

Smart inverters are not yet ready for grid support, as they are still undergoing demonstrations and the grid controls systems, like DERMS, are still at an early stage of development. The results of these demonstrations should inform the next steps in the use of smart inverters.

Key Takeaways

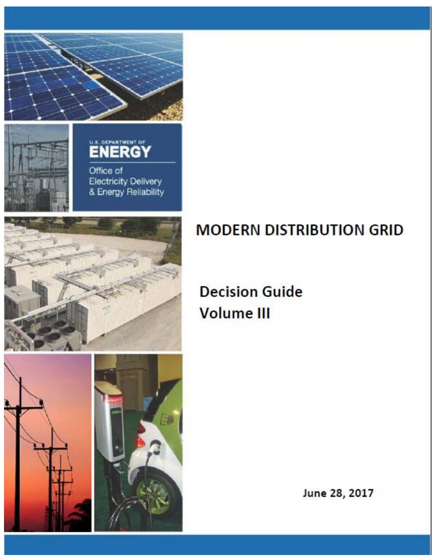
Smart Inverters are Beneficial, But Not a Silver Bullet

- Smart Inverter functionality can be very beneficial to mitigate issues and provide grid support services
- IEEE 1547 implementation needs to be done in a standard manner or it will reduce the benefit potential
- Not all existing inverters will be upgraded
- Cybersecurity gaps need to be addressed
- Smart inverters are not the only power electronics devices that can address the voltage issues, power flow controllers connected to the grid are also effective (performance & cost)

Resources

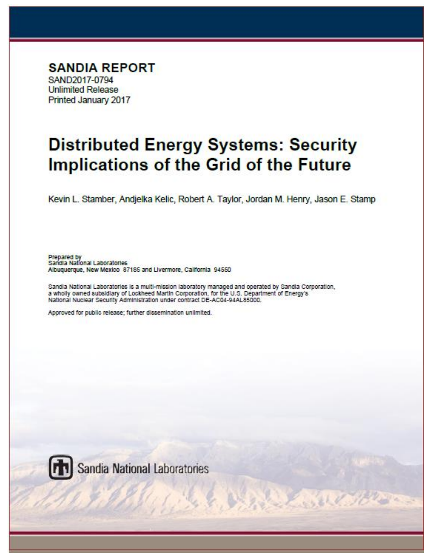
Material in deck adapted from these sources

Modern Distribution Grid Report Vol III: Decision Guide



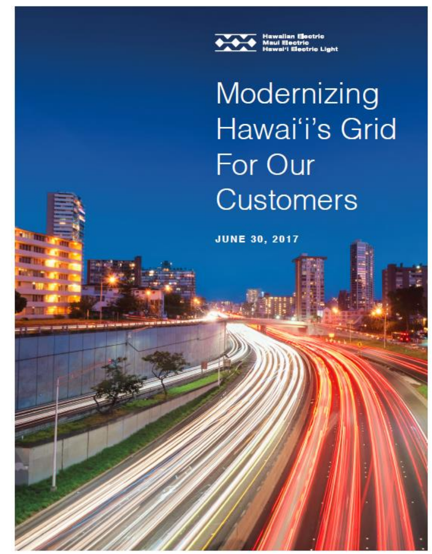
http://doe-dspx.org/wp-content/uploads/2017/06/Modern-Distribution-Grid-Volume-III.pdf

Distributed Energy Systems: Security Implications of the Grid of the Future



http://prod.sandia.gov/techlib/access-control.cgi/2017/170794.pdf

Hawaiian Electric Grid Modernization Strategy



https://www.hawaiianelectric.com/gridmod

NEWPORT
CONSULTING GROUP

newportcg.com

Caltech
Resnick Institute

resnick.caltech.edu

Staff Subcommittee on Electricity and Electric Reliability

NARUC Summer Policy Summit