Grid Modernization via Breakthrough System Monitoring, Control, and Optimization Using Distributed Energy Resources

Fei Ding
Senior Research Engineer
Fei.Ding@nrel.gov

Workshop on Advanced Distribution Management System (ADMS) Test bed
Golden, Colorado
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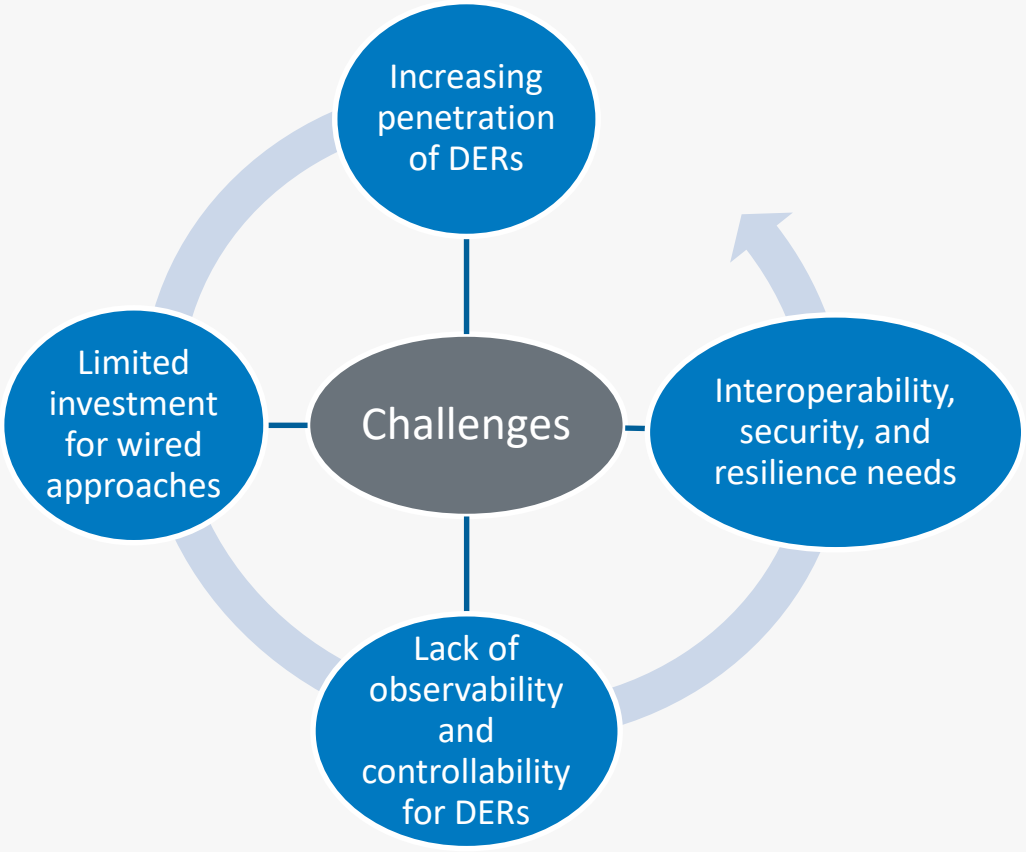
Problem Statement

Lack of:

- **Visualization** of grid operations and distributed energy resource (DER) impacts
- **Controllability** of DERs to provide grid/customer benefits
- **Business model** to demonstrate the value of DERs.

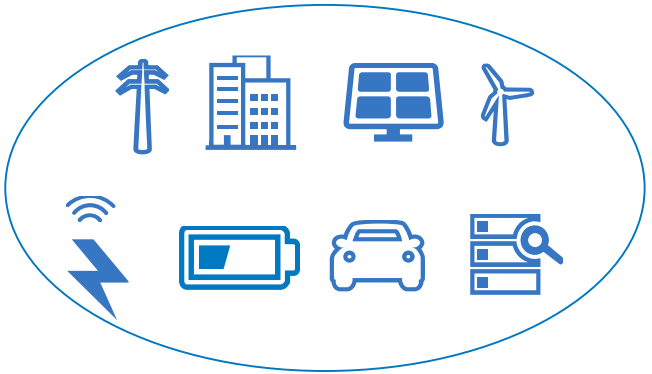


Project Overview

Description

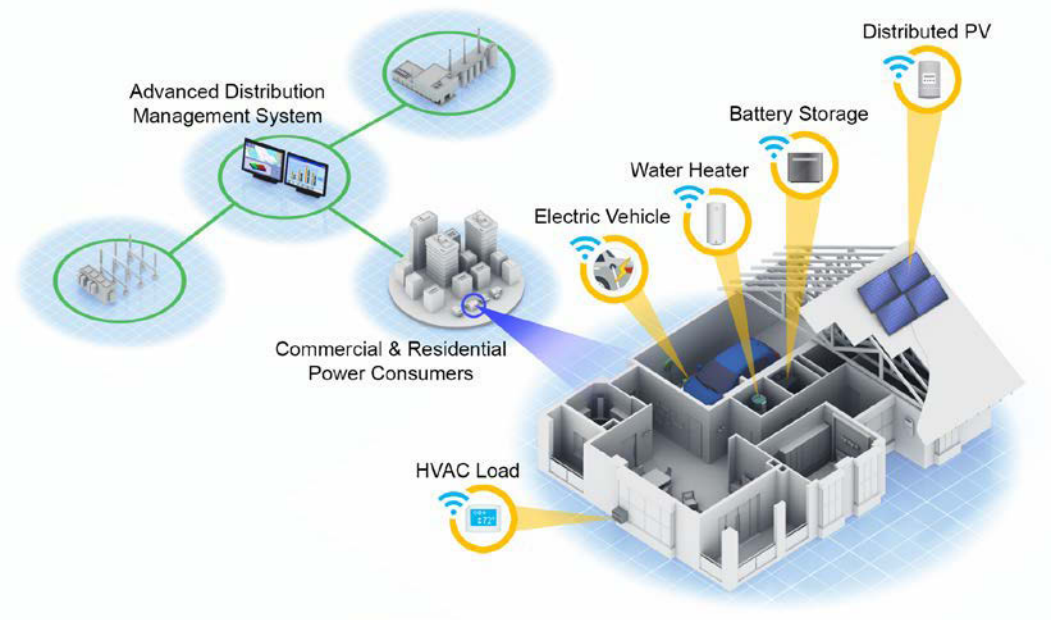
Develop and validate new grid visualization, control paradigms, and business models for Holy Cross Energy (HCE) through integration of grid-friendly, intelligent DER assets.

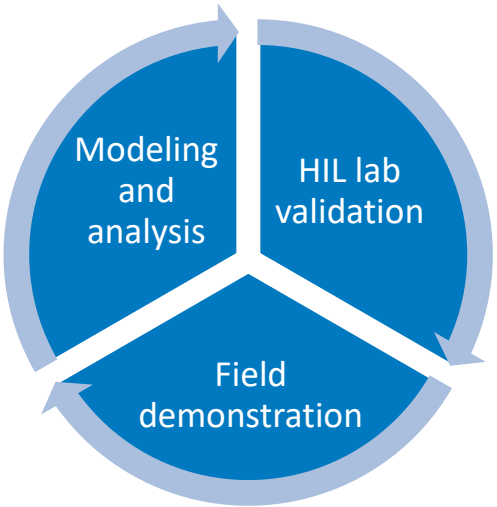
Technologies



- *Enable cooperatives and municipally-owned utilities to fully leverage DERs as part of their strategies for providing safe, reliable, and affordable electric services*
- *Meets U.S. Department of Energy grid modernization goal of achieving at least 10% active devices to provide grid flexibility by 2035.*

Research Overview



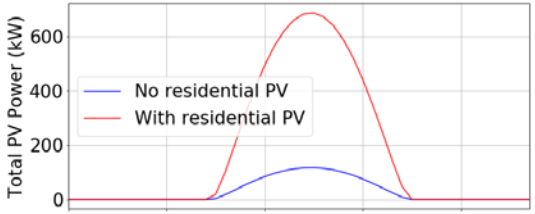


Distributed resources at the grid edge to provide system-level benefit

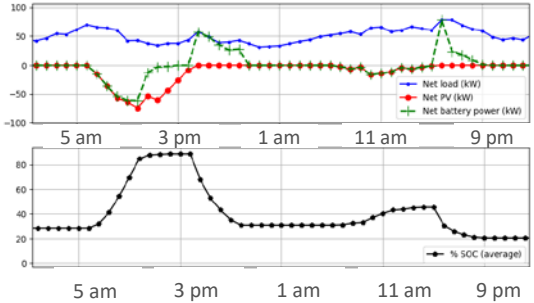
- Distribution voltage regulation
- Peak demand management

Modeling and Analysis

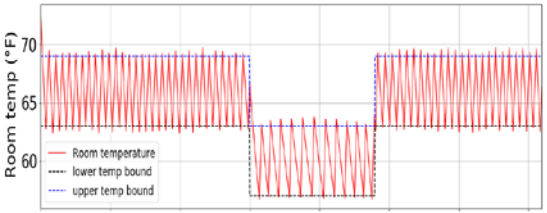
Distributed PV

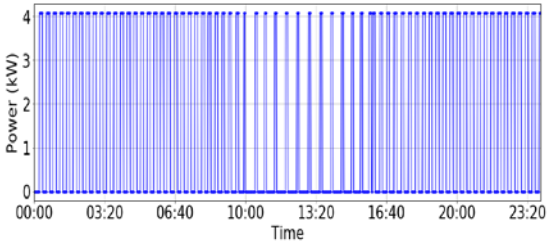


Battery storage

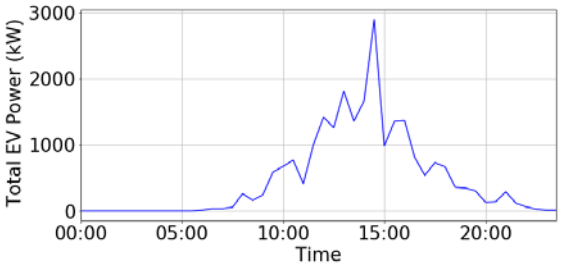


HVAC load

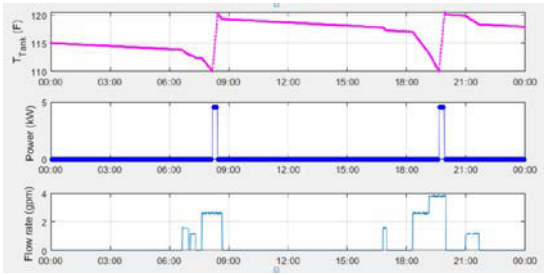




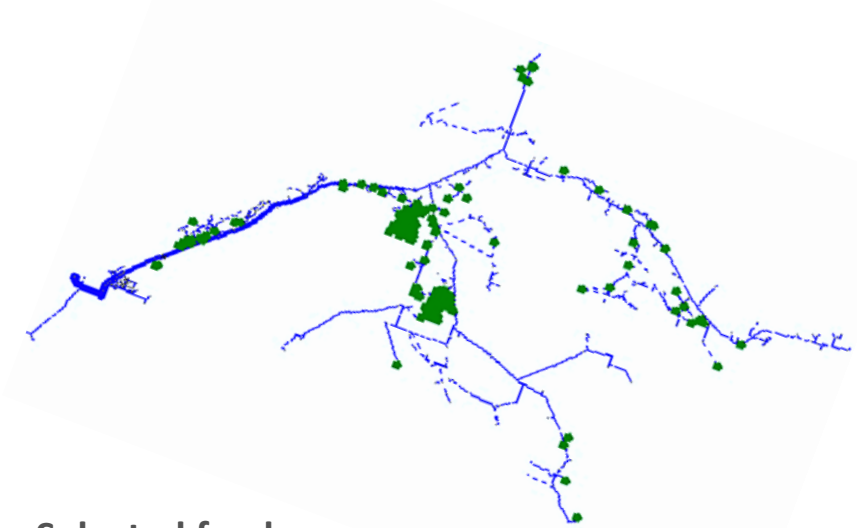
Electric vehicle



Electric water heater



Modeling and Analysis



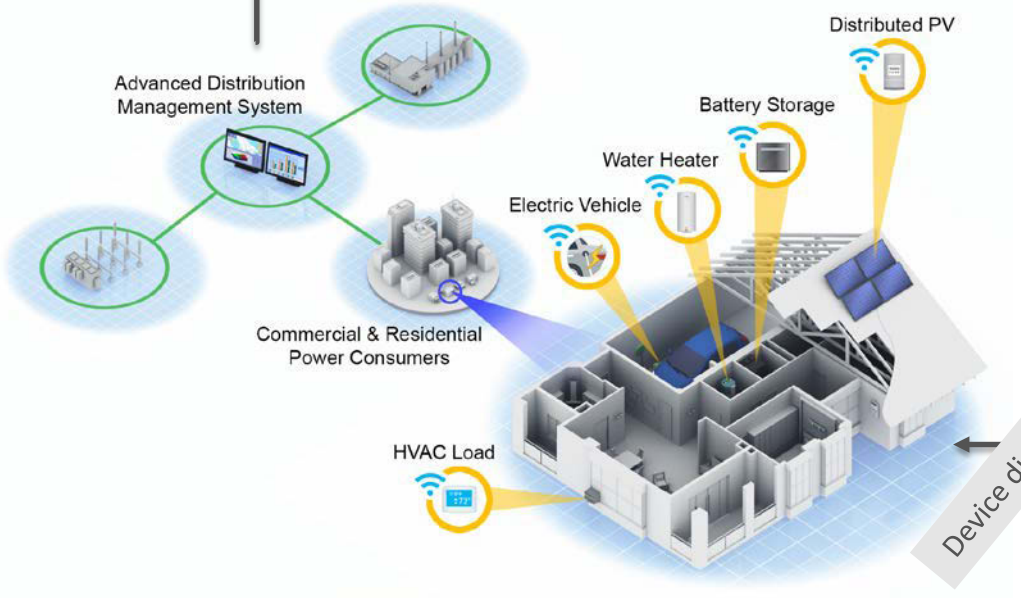
Selected feeder:

- 4,039 buses
- 1,137 loads, peak load on 2017.01.27 8–9 a.m.
- Existing photovoltaic (PV) capacity is 226 kW residential at 38 locations + 200 kW PV power plant

- RES TOWN NON-ALL EL
- GS-LG DMD OPTIONAL TURTLE
- GEN SERV SMALL INDEX
- GEN SERV SMALL
- RURAL RESIDENTIAL
- RES TOWN NON-ALL EL
- GS-LG DMD OPTIONAL
- RURAL ALL ELECTRIC
- CUSTOMER OWNED METER
- RURAL DEMAND
- GEN SERV SMALL - SNOWMASS DIST
- RURAL OFF PEAK TOD
- RES HEAT ONLY
- RURAL RES UNDER 50 KW
- RES TOWN < 50KW
- GEN SERV < 50KW
- IRRIG < 50KW
- RES TOWN NON-ALL EL

- 163 all-electric residential loads selected (peak <15 kW)
- House model:
  - HVAC
  - EWH
  - Base load
  - PV
  - ESS
  - EV.

Coordination Between ADMS and Grid-Edge Control



Visibility of the grid

Coordinator

Coordinates local DERs to achieve system-level benefit based on real-time measurement (distribution optimal power flow)

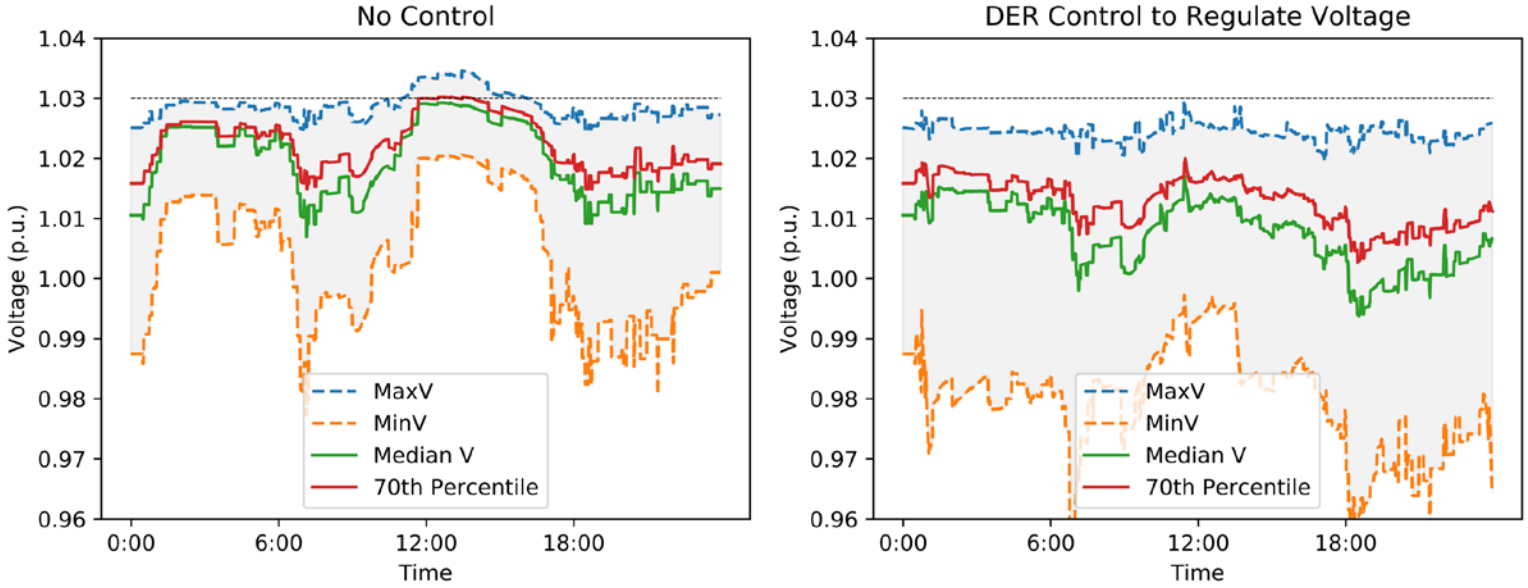
Control signal only related to each home itself

Local DER controller ..... **Local DER controller**

Solve the optimal set point for its DER

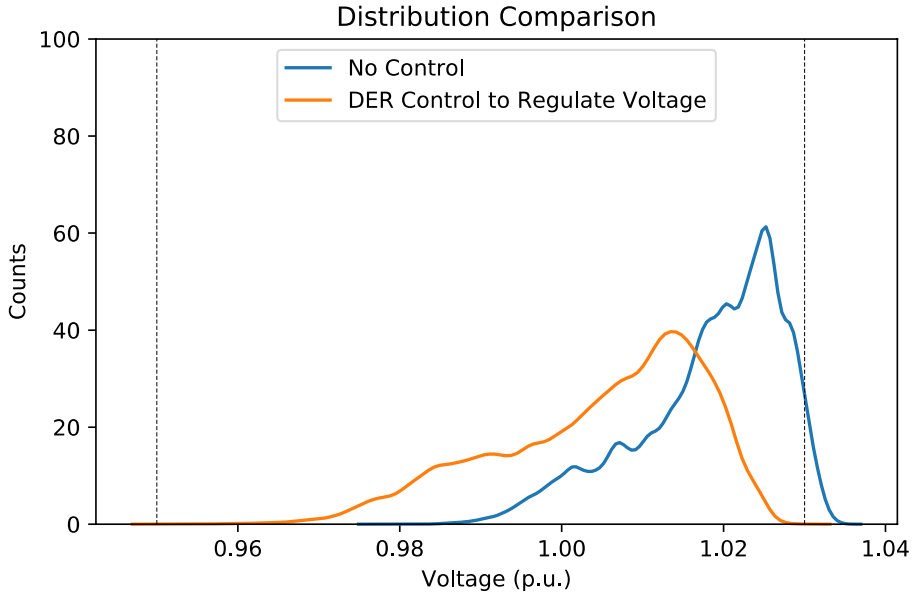
Device dispatch

Use Case: Voltage Regulation



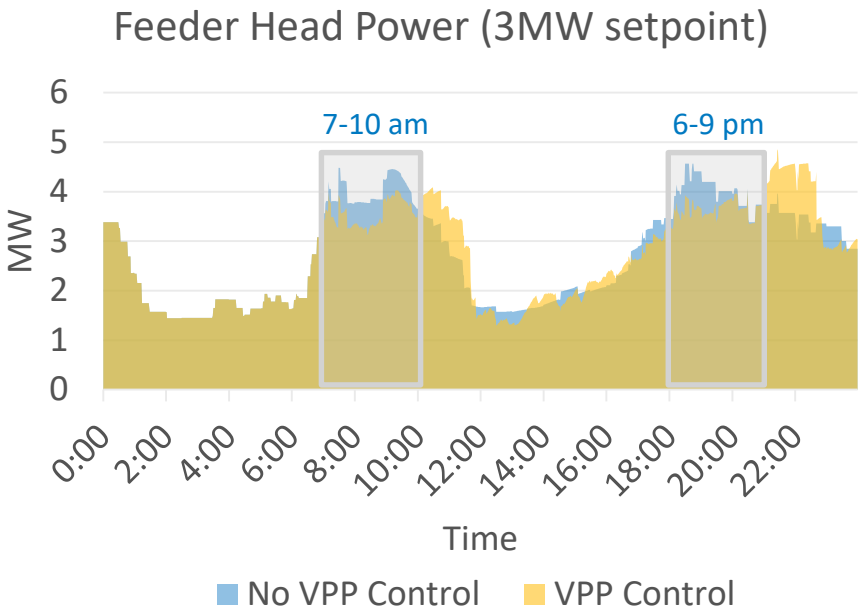
Use reactive power capability from smart inverters to regulate distribution voltage without curtailing PV generation

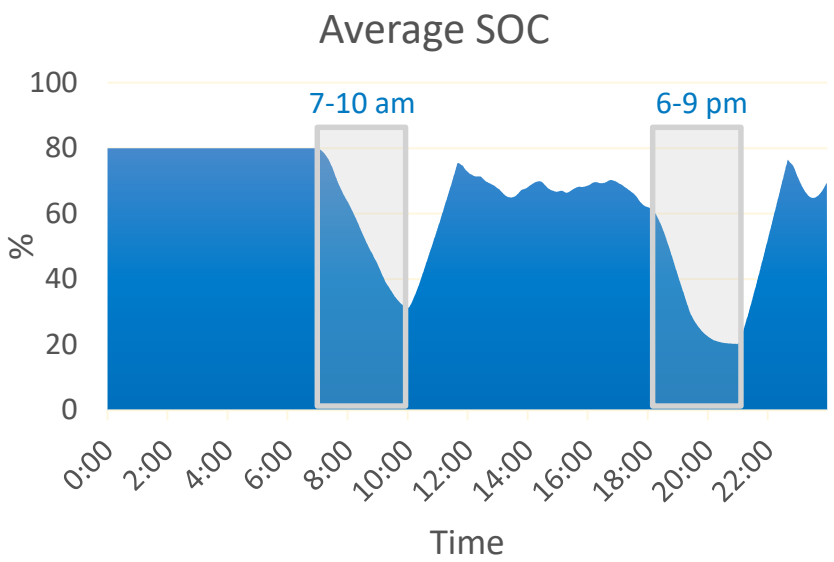
Use Case: Voltage Regulation



Use reactive power capability from smart inverters to regulate distribution voltage without curtailing PV generation

Use Case: Virtual Power Plant (VPP)

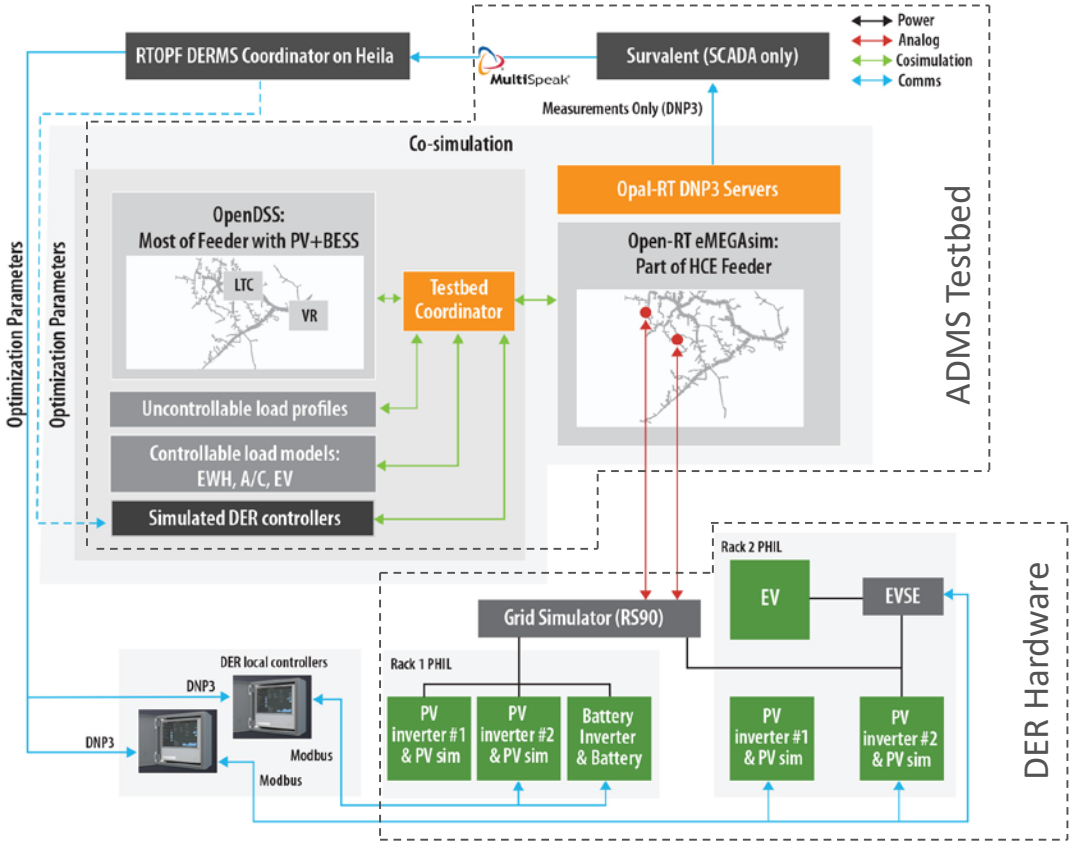




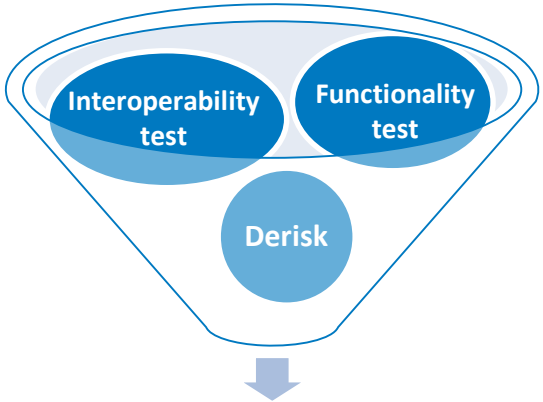
Use the flexibility provided by DERs to enable the distribution feeder to work as a VPP

Laboratory Validation

Laboratory Validation



- Distributed energy resource management system (DERMS) algorithm in Heila Edge
- Six power hardware devices
- Standard-based communication: Multispeak, DNP3



A fully playable platform replicating utility control room

Distributed Energy Resource Control

Photos by NREL

Application to the Real World

Live Learning Lab

Basalt Vista affordable housing project:

- Habitat for Humanity, Pitkin County, Basalt School District
- 27 homes for teachers and local workforces
- 4 selected for field deployment
- Designed to zero energy building with all-electric construction
- Adjacent to Basalt High School.

HCE will manage DERs and obtain grid flexibility by controlling:

- Rooftop solar
- Energy storage
- Mobility charging (EV supply equipment)
- Comfort (hot water + heating, ventilating, and air conditioning [HVAC]).

Distributed Control of Distributed Energy Resources

Heila Edge

Figure 8. Field System Details

Holy Cross Energy slide and photos published with permission

Social Media Attention

- PV Magazine “A household-scale virtual power plant has arrived”, https://pv-magazine-usa.com/2019/08/15/a-household-scale-virtual-power-plant-has-arrived/
- Energy News Network, “All-electric homes offer a prototype for low-carbon housing in Colorado”, https://energynews.us/2019/10/17/west/all-electric-homes-offer-a-prototype-for-low-carbon-housing-in-colorado/
- Builder, “Optimizing net zero homes for the grid,” https://www.builderonline.com/design/technology/optimizing-net-zero-homes-for-the-grid_o?utm_source=newsletter&utm_content=Article&utm_medium=email&utm_campaign=BP_101719&
- Colorado Governor visited Basalt Vista on Oct. 14, 2019.

Thank you

www.nrel.gov

Fei.Ding@nrel.gov

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Advanced Grid Research
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US DEPARTMENT OF ENERGY

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