NATIONAL LABORATORY OF THE ROCKIES

Distributed Energy Resource Management Systems (DERMS)

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The Changing Grid

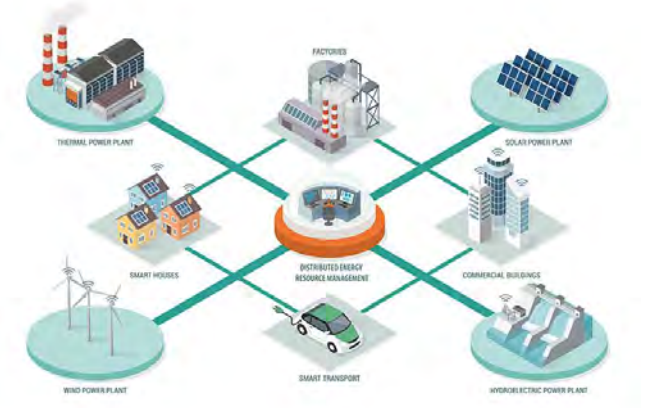
- New Technology
- Government incentives
- Changing workforce

- Extreme weather
- Aging infrastructure

Distributed Energy Resources Management

A software platform to assist utilities in managing the grid operation with the support of distributed energy resource assets

- Device management and control
- Grid reliability
- DER optimization
- DER Grid Integration

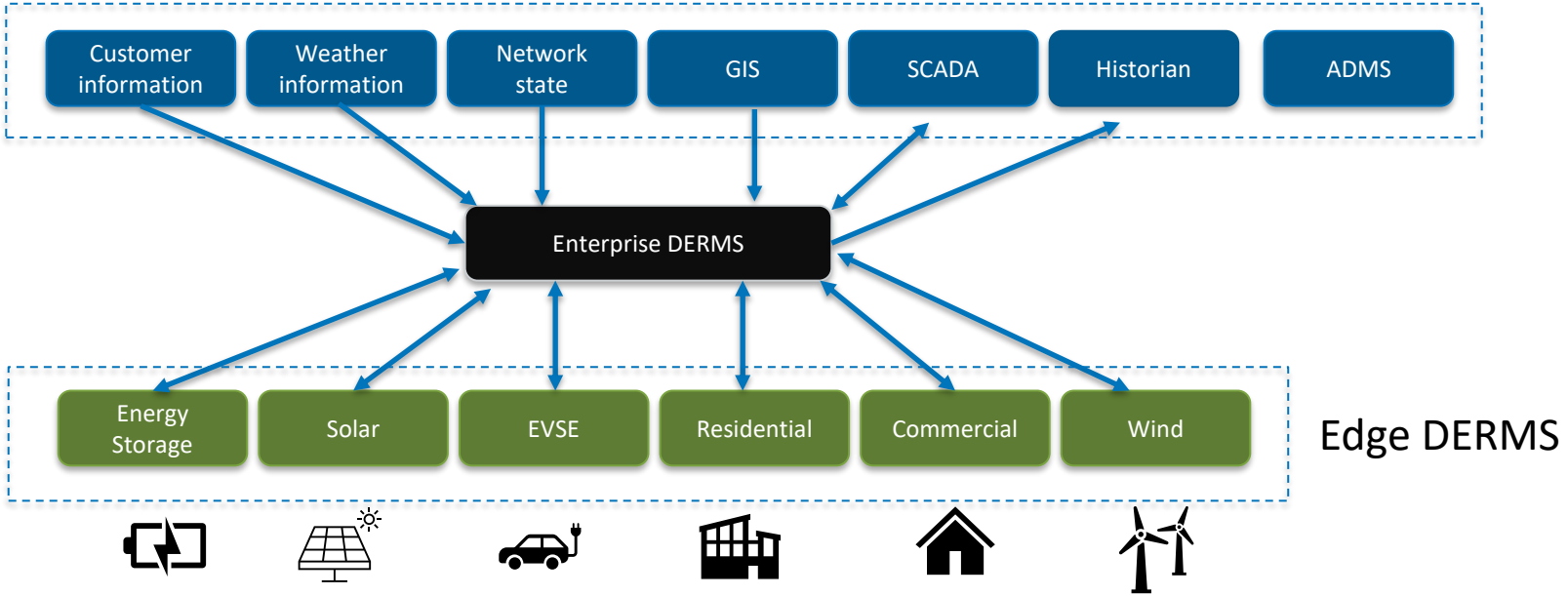


- Distributed Energy Resources (DERs):
  - Utility-scale **battery energy storage system (BESS)**, photovoltaic (PV), flexible commercial and industrial loads, etc.
  - Behind-the-meter: Residential electric vehicle (EV), battery energy storage system, electric water heaters, HVAC controls, smart buildings, etc.
  - Can be grouped into demand, generation, and storage

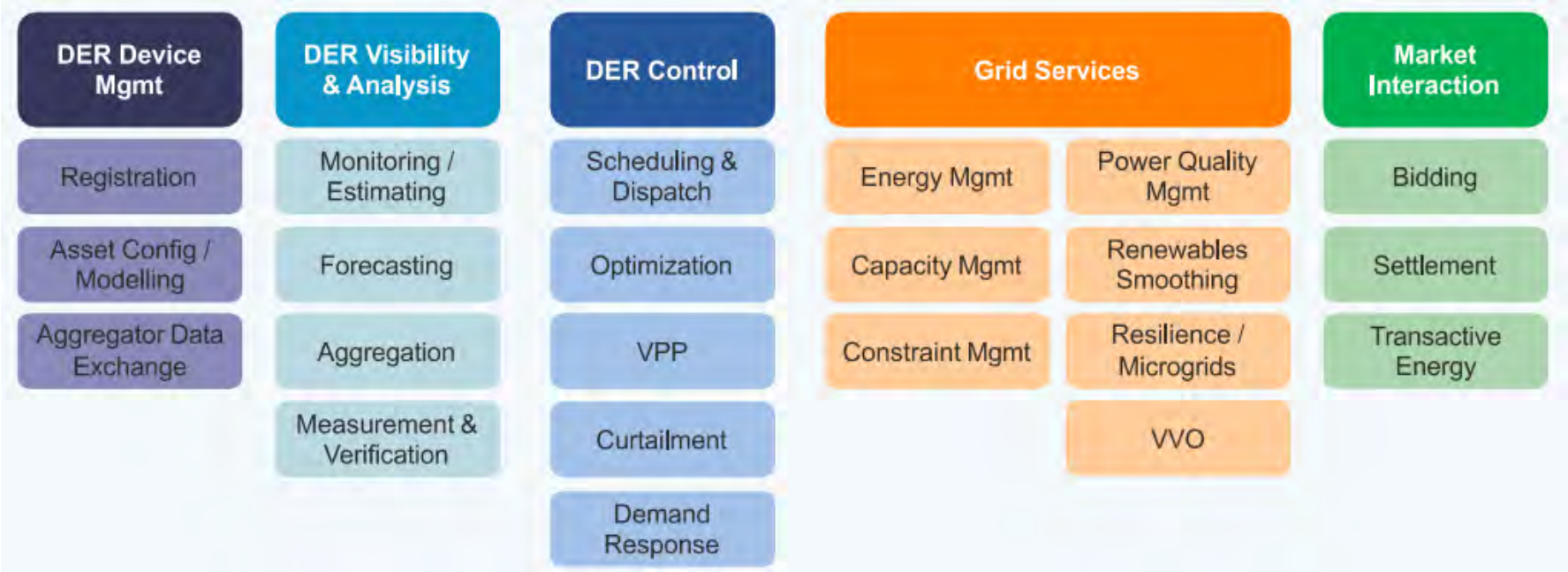
Benefit	Value
Augment visibility and enhance planning capabilities.	Augmented situational awareness helps utilities reach their renewable energy goals more quickly and provide flexibility.
Implement non-wires solution	Defer costly grid reinforcement needs that could impact the cost of energy.
Leverage DER control as a tool to resolve network issues and enhance operational flexibility	Coordination schemes to increase the system reliability

Architecture

Enterprise DERMS and Edge DERMS



DERMS Capabilities

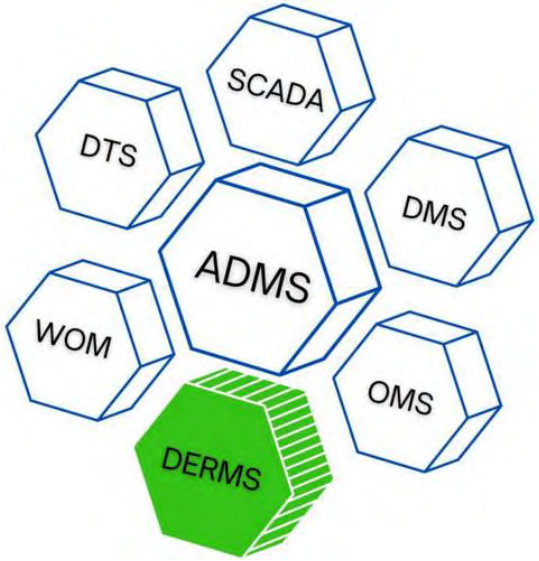


Source: https://sepapower.org/resource/encyclopedia-ofderms-functionalities/

Implementing DERMS

The DERMS are flexible and developing systems that require a strategy and clear objective.

- Reliability/Resilience
- Reverse power flow management
- Frequency and voltage stability
- Real and reactive power
- Constraint Management
- Capacity/peak shifting/Coordination/VPP



Strezoski, L., A.Pratt, H.Padullaparti, I.Mendoza, and M.Baggu. 2025. “Architectural Approaches for Integrating ADMS and DERMS: Challenges, Comparisons, and Real-World Use Cases.” Wiley Interdisciplinary Reviews: Energy and Environment14, no. 4: e70015. https://doi.org/10.1002/wene.70015.

NLR Advanced Research on Integrated Energy Systems

ARIES (Advanced Research on Integrated Energy Systems)

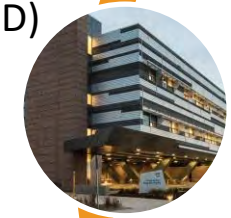
- Control Center operation

ARIES by NATIONAL LABORATORY OF THE ROCKIES

RTAG

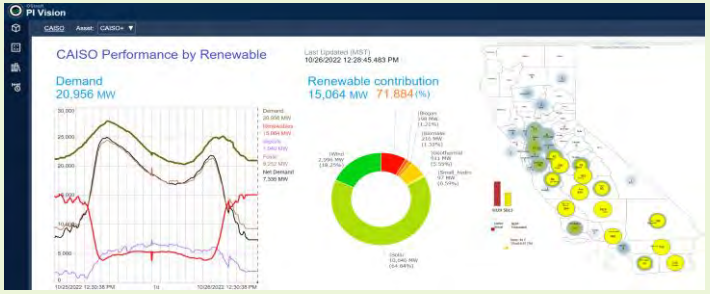
ADMS Test Bed (R&D)

- T-D integration
- Co-simulation



HELICS Historian AI/ML

PSS®E PowerWorld PowerTech



NREL AWS Private Cloud (External Collaboration)

- North American Energy Resilience Model (NAERM)
- National Transmission Planning (NTP)

Control Room of the Future Tool

Digital Twin, AI/ML, resiliency, cybersecurity, etc.

Dispatcher Training Simulator (DTS)

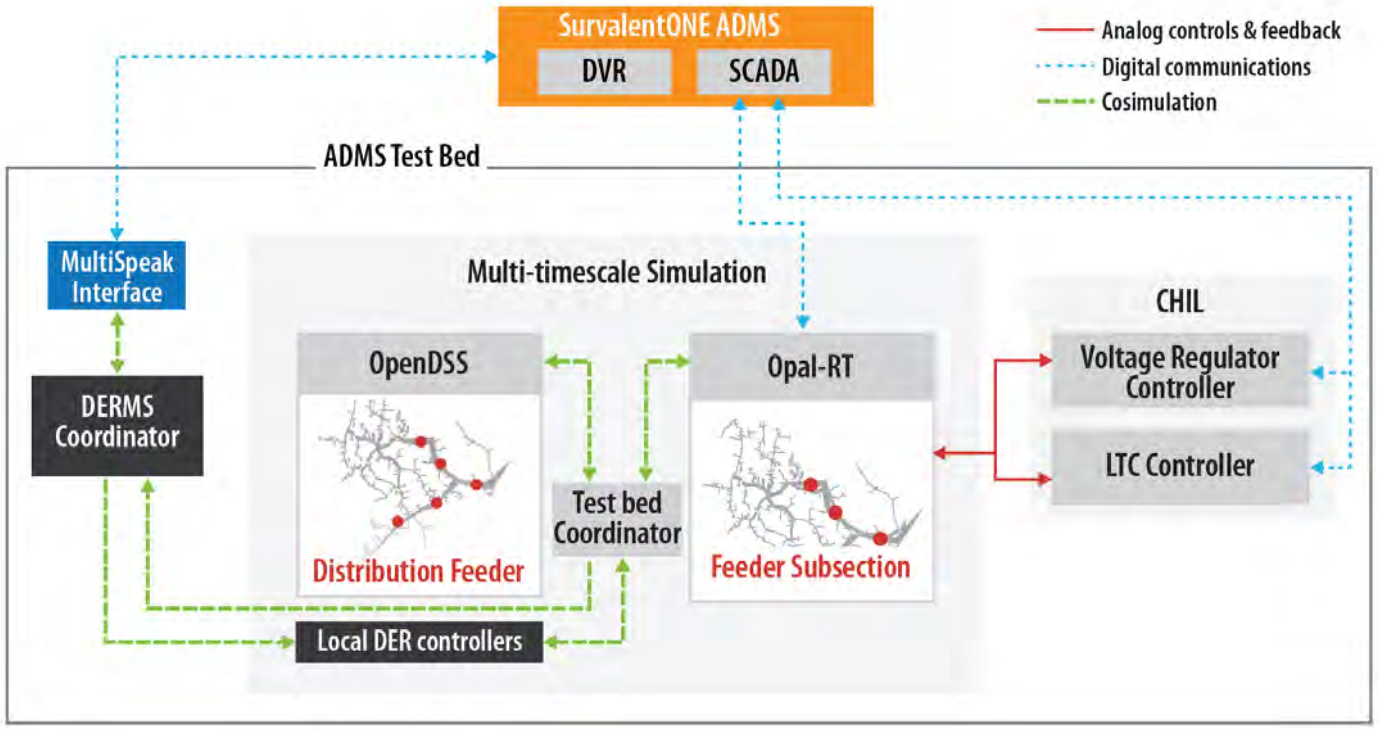
Simulation vs. replay

Power flow, prime movers, protective relays and events processor, etc.

Production-Grade Operational Models

Covers the entire Western Interconnection (WI).

Peak Load Management

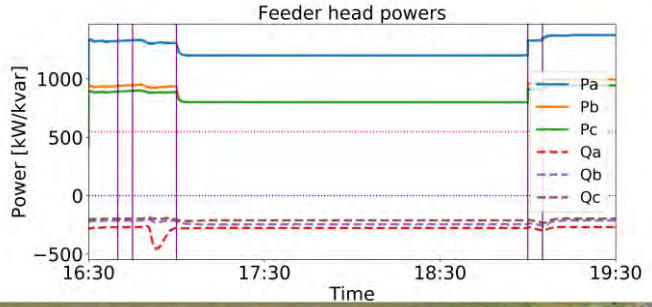


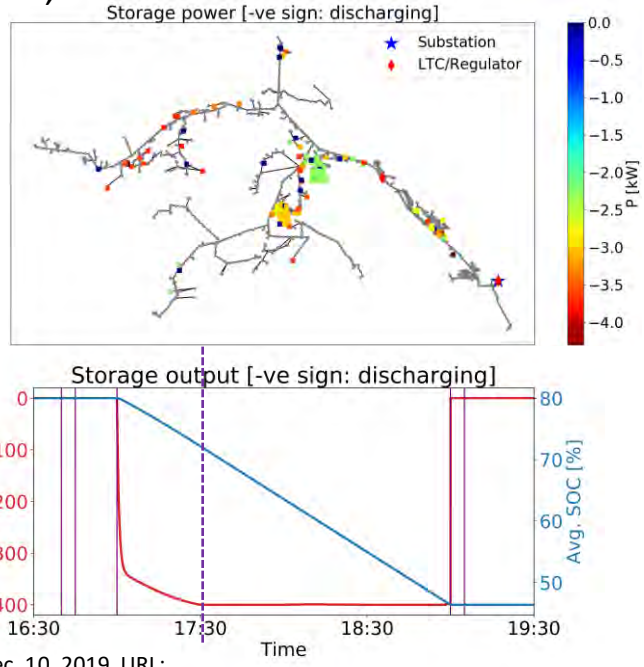
<u>Partners</u>
Holy Cross Energy
Survalent
NRECA
EPRI
PNNL

H. Padullaparti, A. Pratt, I. Mendoza, S. Tiwari, M. Baggu, C. Bilby, and Y. Ngo, "Peak Load Management in Distribution Systems Using Legacy Utility Equipment and Distributed Energy Resources," IEEE GreenTech, 2021.

Peak Demand Management using DERMS

- DERMS implemented in Holy Cross Energy (HCE)'s distribution system
- DERMS Peak Load Management target powers: 1200 kW, 800 kW, and 800 kW

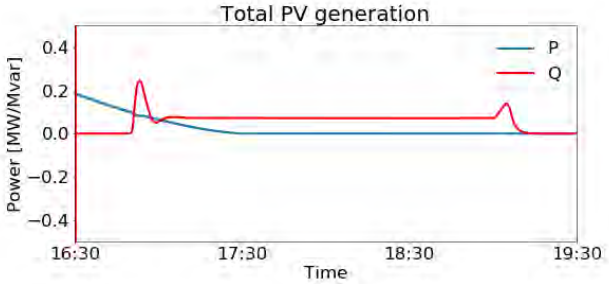


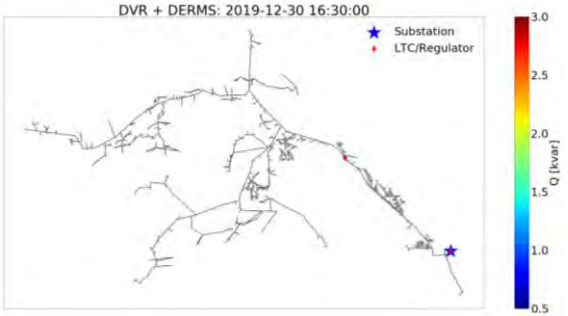


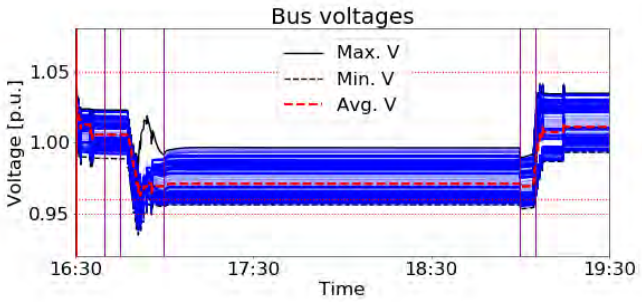
Connor O'Neil. 2019. "Small Colorado Utility Sets National Renewable Electricity Example Using NREL Algorithms." NREL. Dec. 10, 2019. URL: https://www.nrel.gov/news/features/2019/small-colorado-utility-sets-national-renewable-electricity-example-using-nrel-algorithms.html

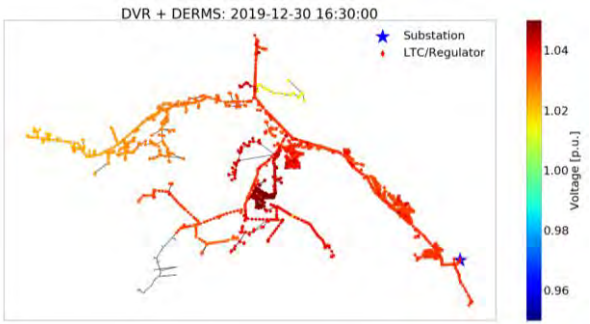
Padullaparti, Harsha, Annabelle Pratt, Ismael Mendoza, Soumya Tiwari, Murali Baggu, Chris Bilby, and Young Ngo. "Peak Demand Management and Voltage Regulation Using Coordinated Virtual Power Plant Controls." IEEE Access 11, 130674–130687. URL: https://www.nrel.gov/docs/fy24osti/81105.pdf

- Dynamic voltage regulation (DVR) performs conservation voltage reduction (CVR) by reducing voltages, DERMS voltage regulation ensures the bus voltages are above 0.95 p.u., DERMS dispatches BESS powers to ensure power tracking at the substation.
- The dynamic voltage regulation (DVR) is enabled at 16:45, DERMS voltage regulation enabled at 16:40, and the DERMS VPP is enabled at 17:00.
- At time 16:30, the system voltages are higher. No reactive power exchange between PVs and grid.





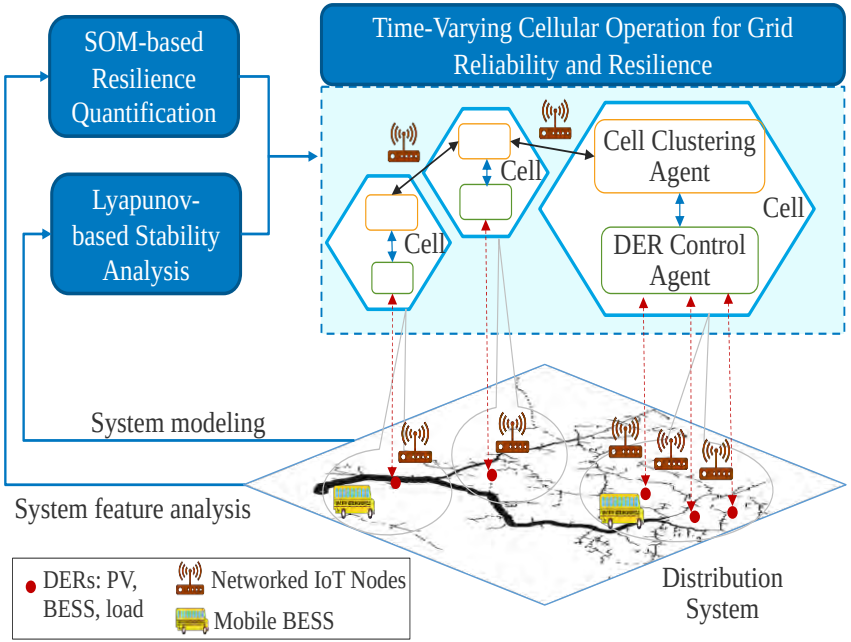




Padullaparti, Harsha, Annabelle Pratt, Ismael Mendoza, Soumya Tiwari, Murali Baggu, Chris Bilby, and Young Ngo. "Peak Demand Management and Voltage Regulation Using Coordinated Virtual Power Plant Controls." IEEE Access 11, 130674–130687. URL: https://www.nrel.gov/docs/fy24osti/81105.pdf

Resilience and Stability Oriented Cellular Grid Formation and Optimizations for Communities with Solar PVs and Mobile Energy Storage (REORG)

Objectives: Develop, validate, and demonstrate a cellular community microgrid formation and optimization approach to achieve resilient, stable, scalable operations for distribution feeders with PVs and mobile BESSs.



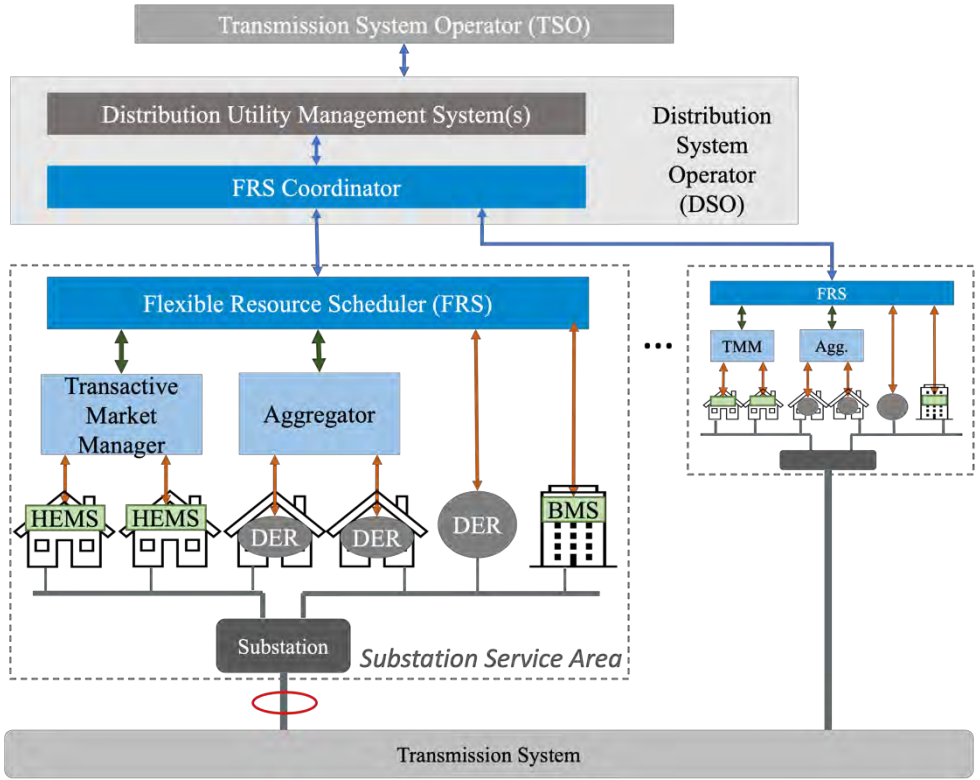
- **Innovation**
  - Resilient and stable cell microgrid organization scheme using machine learning and advanced stability designs
  - Distributed and adaptable cell management system realized using modern IoT platforms
- **Impact**
  - Solution that addresses an electric co-op's wildfire mitigation requirements
  - National scalable approach for operating multiple microgrids and increase system-level resilience

Ding, Fei. "REORG: Resilience and Stability Oriented Cellular Grid Formation and Optimizations for Communities with Solar PVs and Mobile Energy Storage: NREL ADMS Test Bed IAB Meetings." , Jan. 2022. https://docs.nlr.gov/docs/fy22osti/81848.pdf

Federated Architecture for Secure and Transactive Distributed Energy Resource Management Solutions (FAST-DERMS)

- Employ **"Total DSO" architecture** model such that the DSO represents the aggregated resource response in the bulk transmission system.
- Perform **network-aware optimization** to maintain distribution health while simultaneously providing bulk service.
- Demonstrate **distributed intelligence** by managing aggregations at the distribution substation through our Flexible Resource Scheduler (FRS).
- **Simplify T&D interaction** by defining and measuring transmission services provided at the distribution substation.

The goal is to make multiple substations connected to a transmission load bus (unmanaged load + DER) have the controllability of a conventional generator.



Ding, Fei. "Federated Architecture for Secure and Transactive Distributed Energy Resource Management Solutions (FAST-DERMS)" https://docs.nlr.gov/docs/fy22osti/81566.pdf

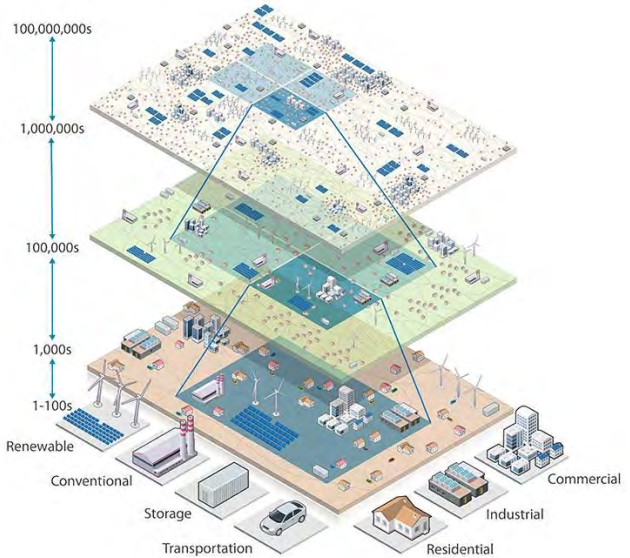
Challenges and Opportunities

Opportunities

- Integration of DERMs for better management of intermittent energy sources
- Reduce peak demand and system congestion
- Improve system reliability at the grid edge
- Defer costly infrastructure upgrades
- Increase customer participation and engagement

Challenges

- Development of cross-functional teams
- The power system is changing at a rapid pace
- Accurate maintenance of the network model
- Each feeder requires an iterative tunning process for optimal performance
- Cybersecurity and integration into the control room



Thank you

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Backup slides

NLR ADMS Test Bed

The **advanced distribution management system (ADMS)** is a utility-operated platform focusing on grid operations and reliability. The **DERMS** manages DERs, and **VPPs** aggregate DERs to participate in energy markets.

ADMS test bed capabilities for VPP evaluations:

- Multi-time scale cosimulation using Hierarchical Engine for Large-scale Infrastructure Co-Simulation (Open Distribution System Simulator/OPAL-RT/Real-Time Digital Simulator)
- Hardware integration
- Communications interfaces
- Data collection and visualization

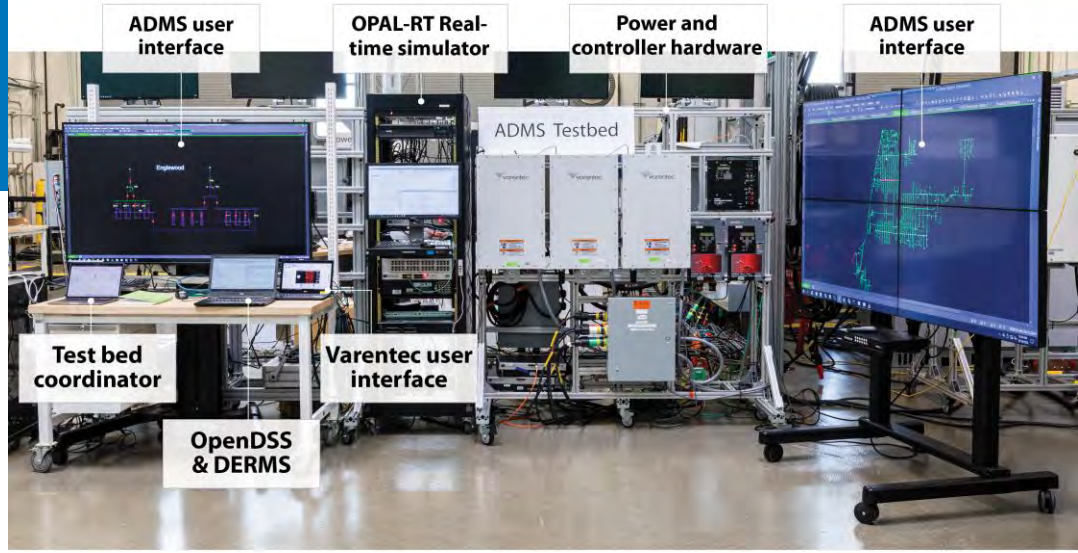
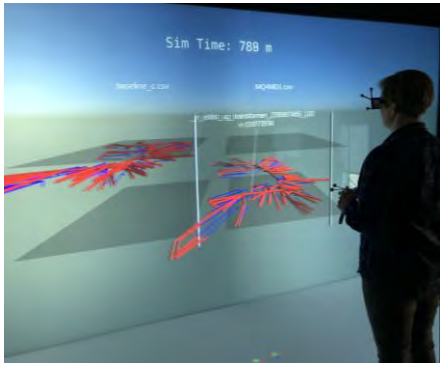


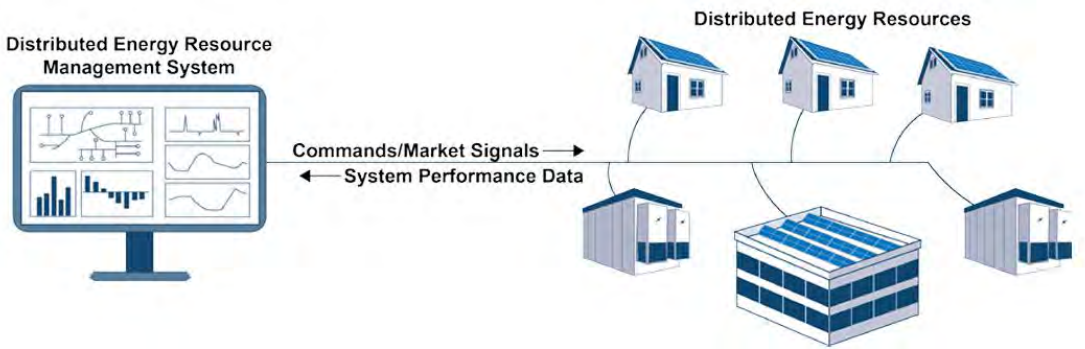
Image Sources: NREL

2D real-time visualization



3D visualization

Guides and Standards



- IEEE 2030.11-2021

Guide for Distributed Energy Resources Management System (DERMS) Functional Specification

- IEEE 2030.4-2023

Guide for Control and Automation Installations Applied to the Electric Power Infrastructure (Smart Grid Interoperability Reference Model)

- IEEE P2030.14

Draft Guide for Virtual Power Plant Functional specification for Alternate and Multi-Source Generation

- Other

IEEE 2030.5-2023: IEEE Standard for Smart Energy Profile Application Protocol

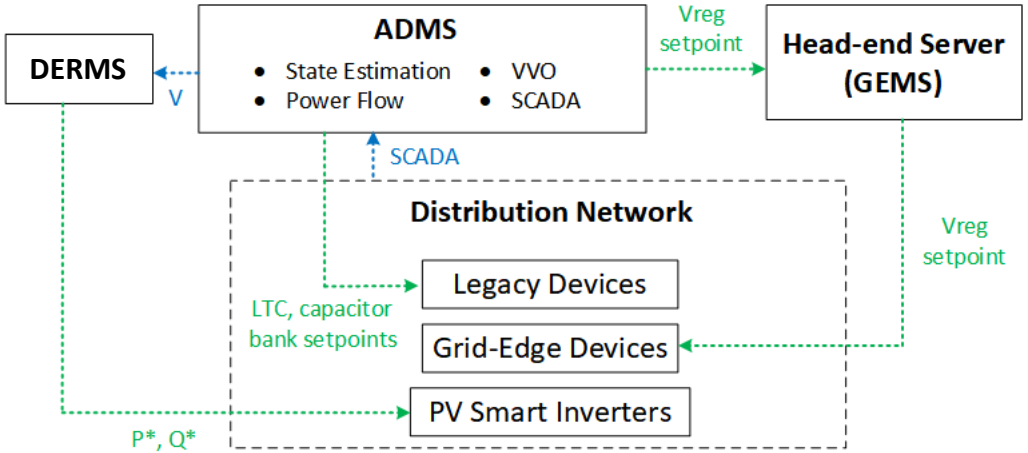
- IEEE 1815, 1815.1 & P1815.2 (DNP3)
- IEEE 1547 series
- Open Automated Demand Response

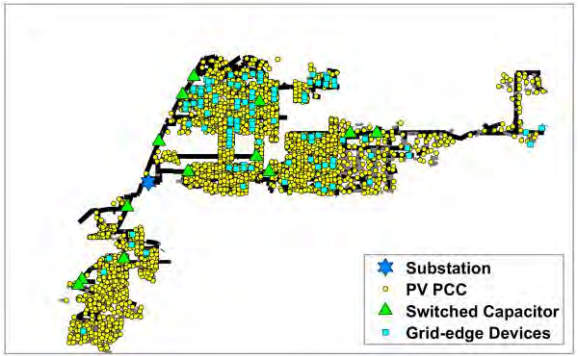
  Communication Specification (OpenADR 2.0), to be adopted by IEC
- Open Field Message Bus (OpenFMB) interoperability framework, ratified by NAESB
- IEC 61970: Common Information Model
- IEC 61968-5:2020 and IEC 61850-7-420

SEPA DERMS reference specifications

https://sepapower.org/resource/distributedenergy-resource-management-system-dermsrequirements/

Grid Management with ADMS, DERMS, and Grid-Edge Controls





Distribution grid with high-PV

VVO: Volt/VAR Optimization
SCADA: Supervisory Control and Data Acquisition
GEMS: Grid Energy Management Systems
LTC: Load Tap Changer

- Padullaparti, Harsha, Jing Wang, Santosh Veda, Murali Baggu, and Anastasios Golnas. 2022. "Evaluation of Data-Enhanced Hierarchical Control for Distribution Feeders With High PV Penetration." *IEEE Access* 10: 42860–42872. URL: https://doi.org/10.1109/ACCESS.2022.3168131.
- Strezoski, Luka, Harsha Padullaparti, Fei Ding, and M. Baggu. 2022. "Integration of Utility Distributed Energy Resource Management System and Aggregators for Evolving Distribution System Operators." *Journal of Modern Power Systems and Clean Energy* 10(2): 277-285. URL: https://doi.org/10.35833/MPCE.2021.000667.
- Wang, Jing, Harhsa Padullaparti, Fei Ding, Murali Baggu, and Martha Symko-Davies. 2021. "Voltage Regulation Performance Evaluation of Distributed Energy Resource Management via Advanced Hardware-in-the-Loop Simulation." MDPI Energies 14(20): 17–20. URL: https://doi.org/10.3390/en14206734.

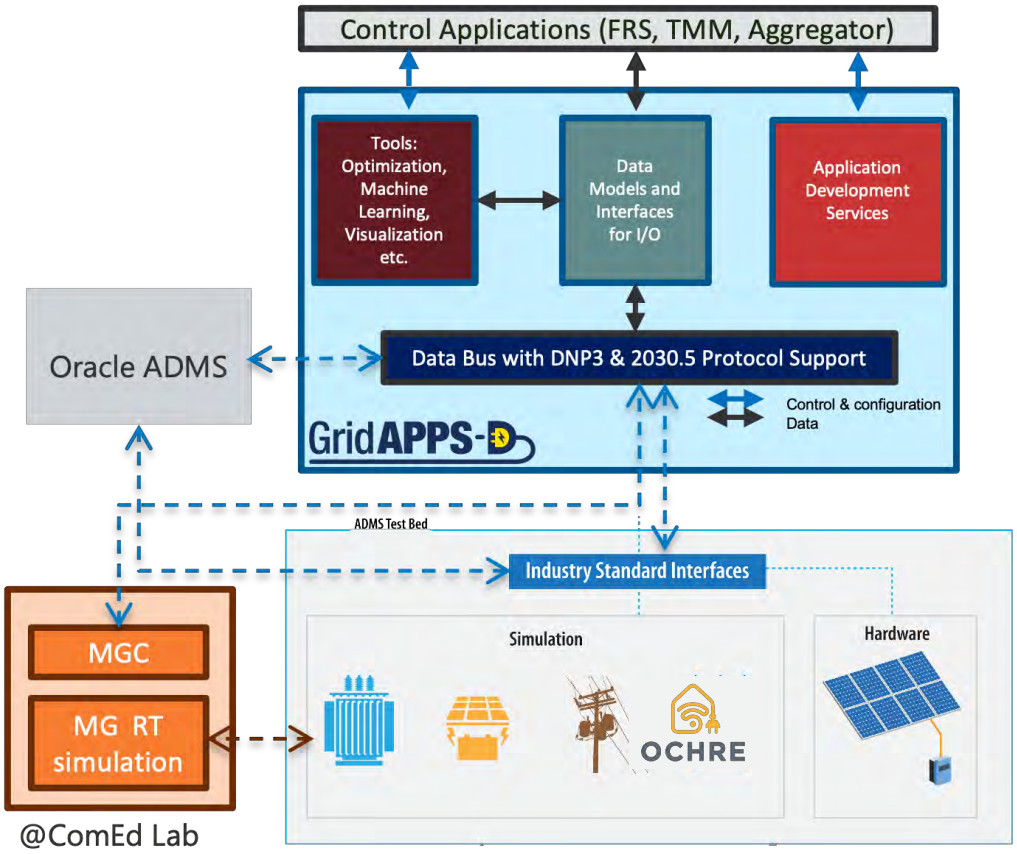
FAST-DERMS Project: Lab Setup

U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

- GridAPPS-D platform: https://www.gridapps-d.org/
  - Research control applications
- Oracle commercial ADMS
- Remote cosimulation with ComEd
  - Siemens microgrid controller
- ADMS Test Bed:
  - NREL's OCHRE residential building simulator
  - High-performance computer
  - 2030.5 communications.

Partners:

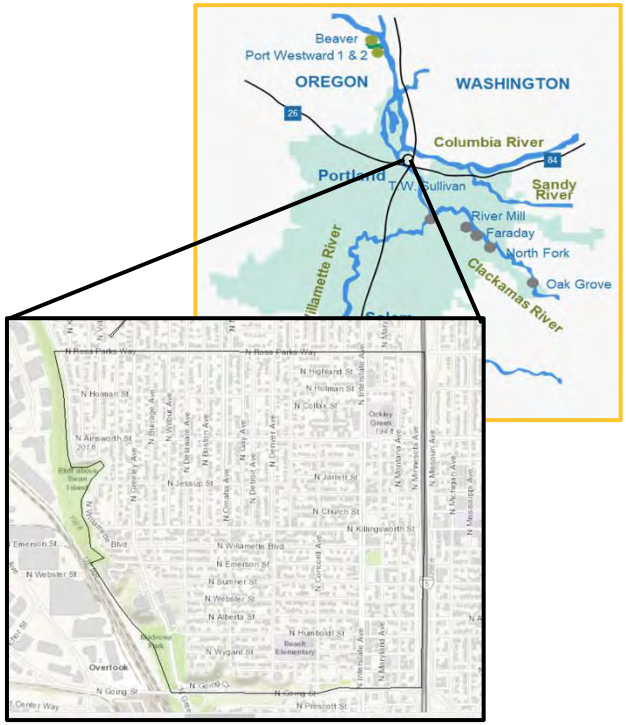
- SDG&E, Southern Company, ComEd, New York Power Authority, Oracle, GridBright, EPRI, LBNL, PNNL, ORNL, ISU, UNCC.



Smart Grid Asset Load Management & Optimized Neighborhood (SALMON)

- Smart Grid Test Bed Collaboration

- 5-year timeline (June 2022–June 2027)
- $11.667M budget ($6.65M federal,* $5.017M match)
- Retrofit 580 of 2,800 buildings (~21%)
- Build 1.4 MW flexible load resource
- 10% efficiency improvement across treated buildings



* Funded by DOE Connected Communities Program

SALMON test bed setup

Partners (on test bed task):

- Utility: Portland General Electric
- ADMS: OSI
- DERMS: OSI

- Developed digital twin of PGE's study area in ADMS Test Bed
  - Two feeders in OpenDSS
  - ~4,100 homes in OCHRE
  - Run on HPC
- Integrate with controls
  1. NREL's research DERMS and aggregator controls
  2. Commercial ADMS and DERMS and NREL's aggregators