Utility and Grid Operator Resources for Future Power Systems Webinar Series
Advance Distribution Management System (ADMS)

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National Renewable Energy Laboratory (NREL)

NREL Webinar Series

June 5, 2025

Content credit: Annabelle Pratt, Murali Baggu

Agenda

1. Distribution Operation and Management System
2. Advanced Distribution Management System: The Roadmap to a Smart-Grid
3. Advantages of an ADMS System
4. Challenges of Implementing an ADMS
5. Future of ADMS
6. Key Takeaways
7. Discussion

Distribution Operation and Management System

Distribution system operators manage and operate the medium- (typically <35 kV) and low-voltage electrical network for an electrical utility. They serve to:

- Manage the delivery of energy to the load
- Monitor the energy flow
- Control and coordinate field equipment
- Ensure reliability and protection.

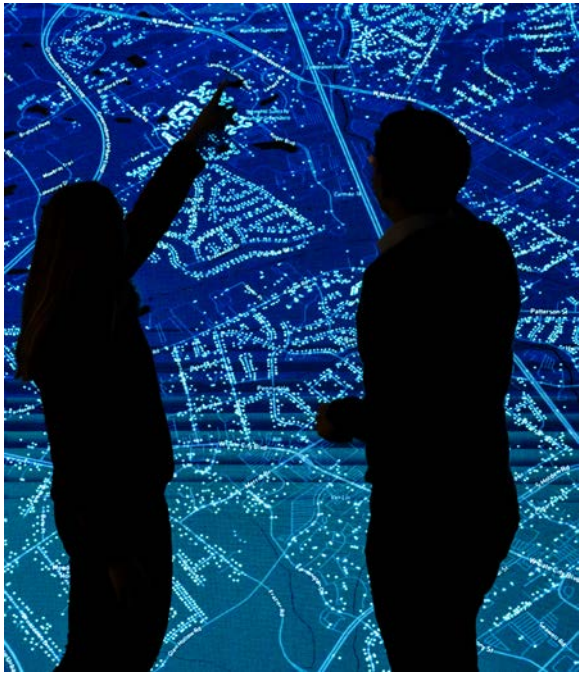
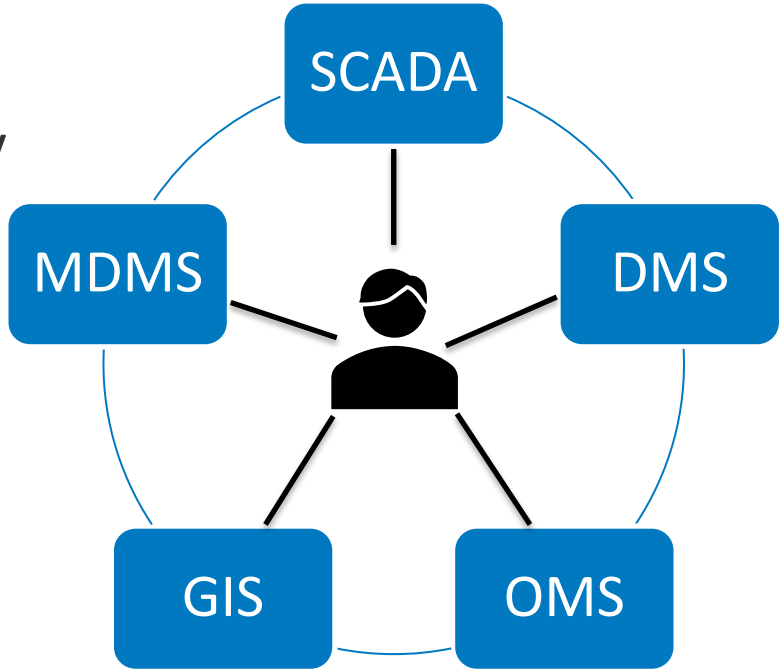


Photo by NREL (74758)

Utility Operations and Data Platforms

Historically, utilities implement a phased approach with their technology adoption.

- Supervisory control and data acquisition (SCADA)
- Outage management system (OMS)
- Geographical information system (GIS)
- Distribution management system (DMS)
- Meter data management system (MDMS)

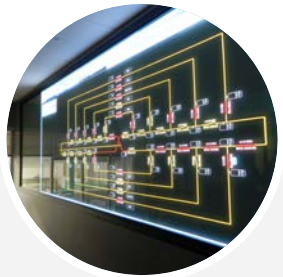


Advance Distribution Management System: The Roadmap to a Smart-Grid

The grid is changing and providing new challenges that drive the innovation for advance software solutions

GIS

Visualization
Interface



DMS

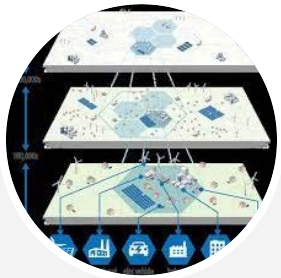
State estimations
System operations automation

OMS

Switching order management
AMI and call management

SCADA

Data acquisition
Monitoring



Applications Requiring GIS, DMS, OMS, & SCADA

Fault Location, isolation, and system Restoration (FLISR)
Volt/Var optimization (VVO)

Photo by NREL (52725;24927;84680;62246,62766)

Adoption of Advanced Distribution Management System

The American Recovery and Reinvestment Act of 2009 provided an initial funding opportunity that helped kick-start the industry.[1]

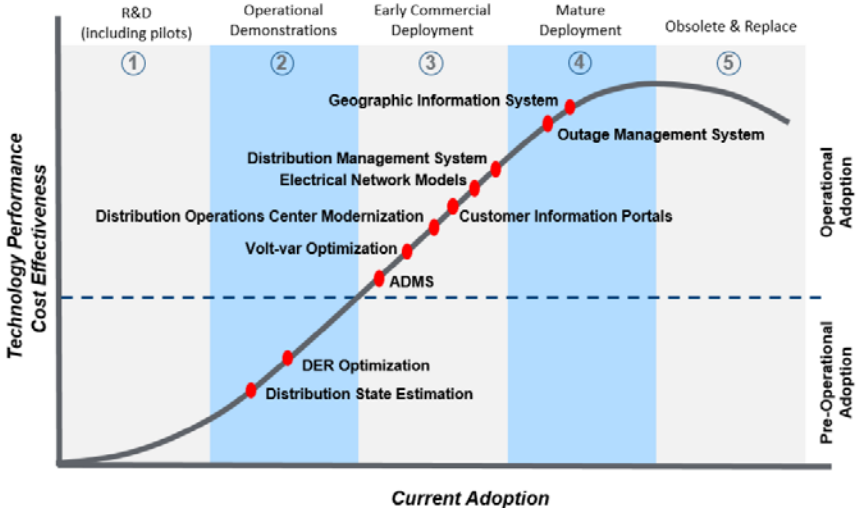
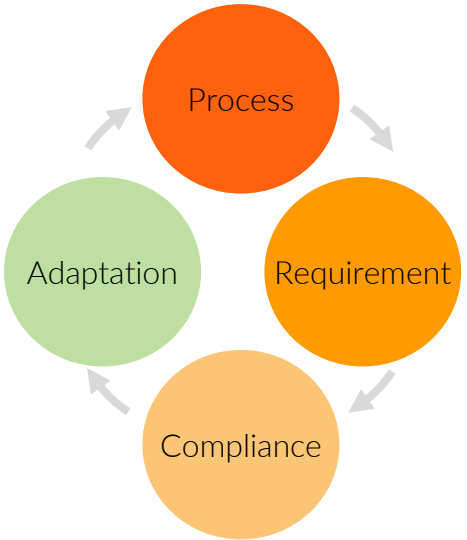
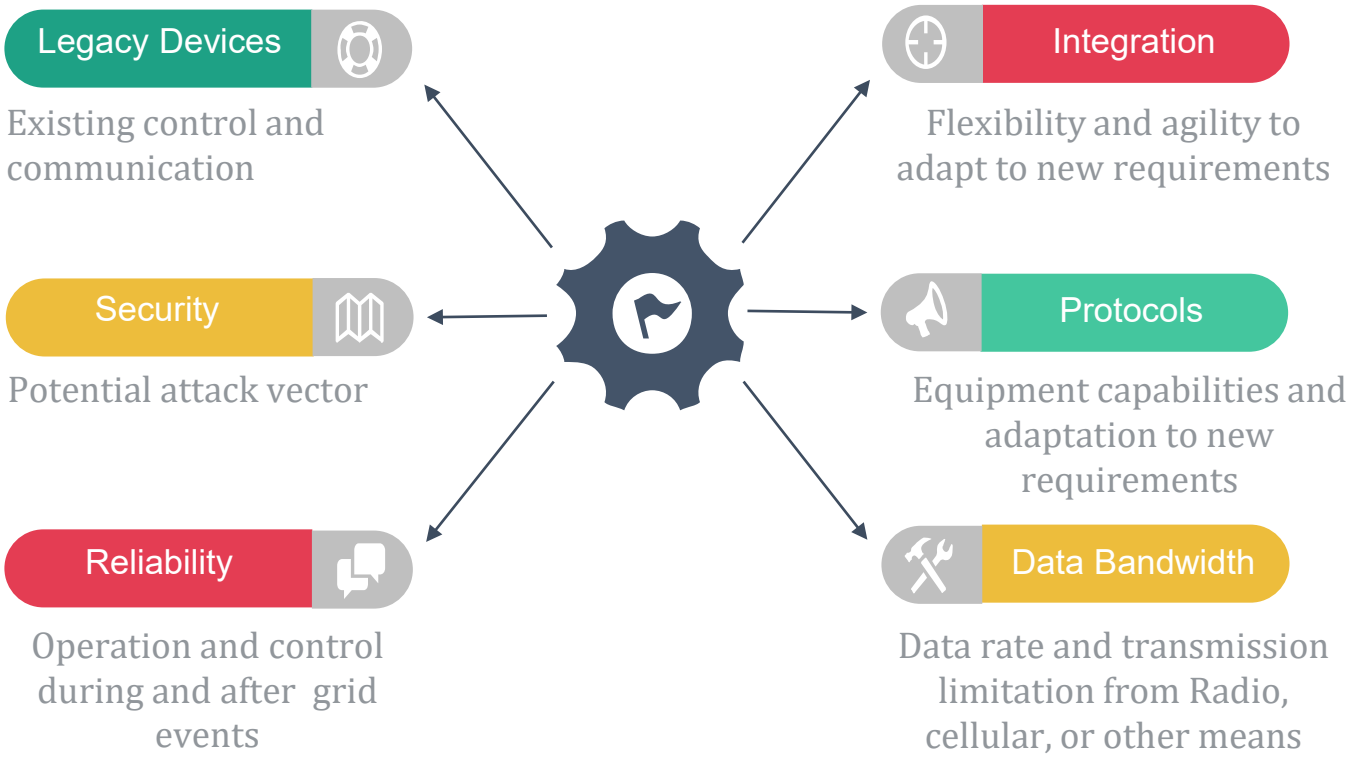


Figure: Technology Adoption Cycle[2]



1. U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability. *Voices of Experience: Insights into Advanced Distribution Management Systems.* Washington, DC, USA, 2015. https://www.energy.gov/oe/articles/voices-experience-insights-advanced-distribution-management-systems-february-2015
2. U.S. Department of Energy. 2019. *Modern Distribution Grid Project Volume II: Advanced Technology Assessment.* Washington, DC: U.S. Department of Energy. https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_II_v2_0.pdf

Integration Challenges



Advantages of an ADMS system

- **Reliability:** Faster restoration times and fewer outages
- **Efficiency:** Optimized energy flow reducing losses and operational costs
- **Resilience:** Enhanced ability to adapt to unexpected events such as storms or equipment failures
- **Grid Modernization:** Enables the integration of advanced technologies including electric vehicles, microgrids, and distributed energy resources
- **Safety:** Reduces risks for utility workers and the public through better monitoring, control, and public communications

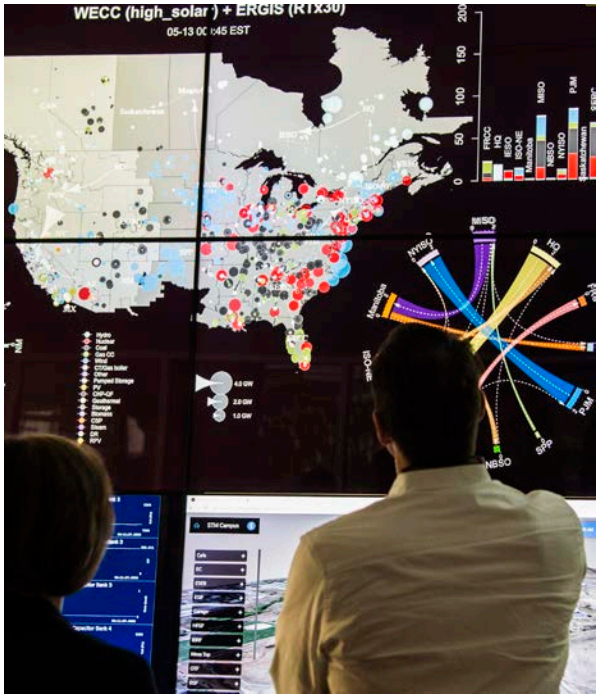


Photo by NREL (58306)

Advance Applications

- Volt-Var optimization/optimization
- Fault location, Isolation, Service Restoration
  - Fault location analysis
- Automation
- Power flow and load management
- Study/training mode

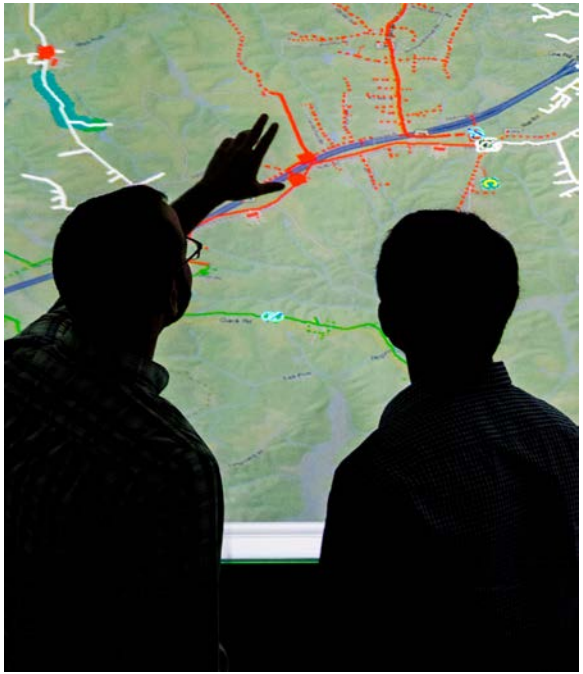
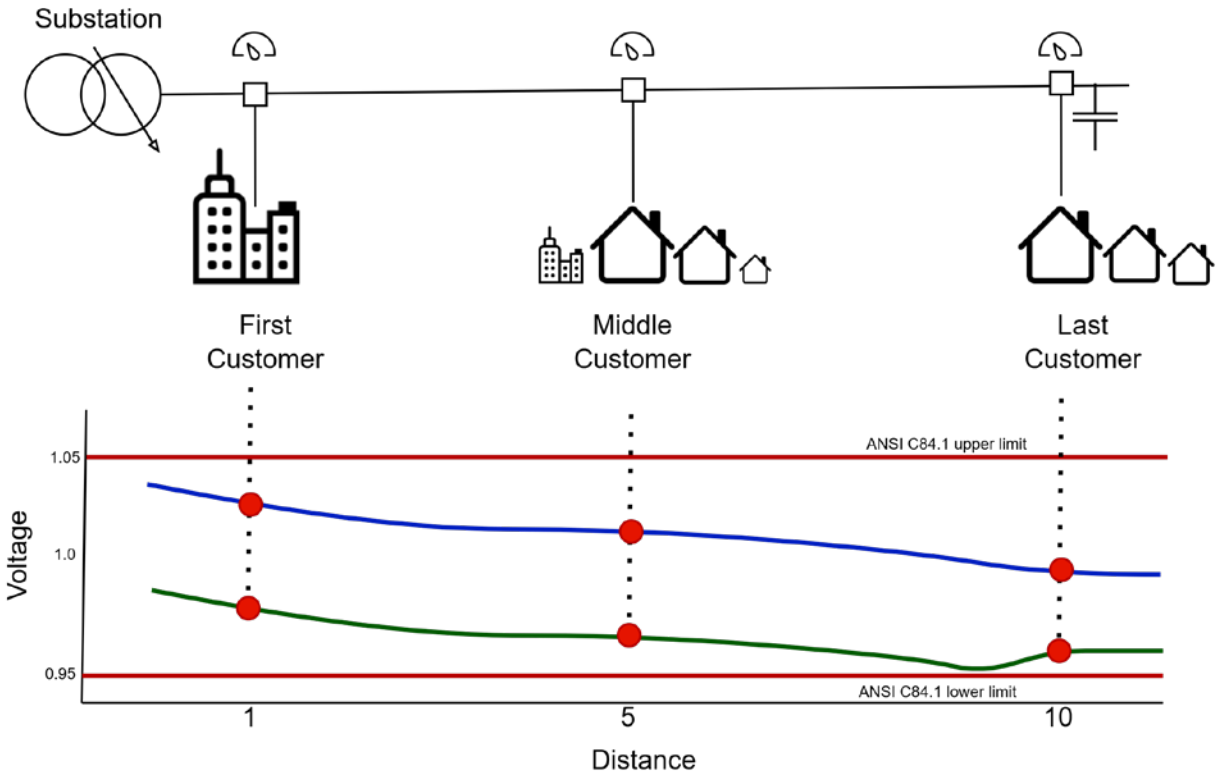


Photo by NREL (34478)

Volt/Var Optimization

Automatic regulation of voltage

- Energy consumption reduction
- Optimization
- Savings for both utilities and customers



Graphic by NREL

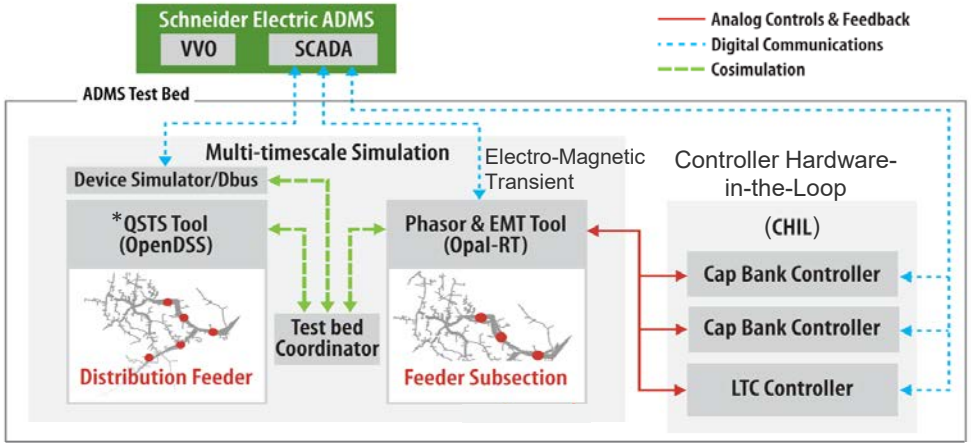
Photo by NREL (78768)

Data Remediation and Telemetry Impact on VVO performance

NREL project to evaluate the impact in the performance of the ADMS VVO application with various levels of data remediation and additional telemetry

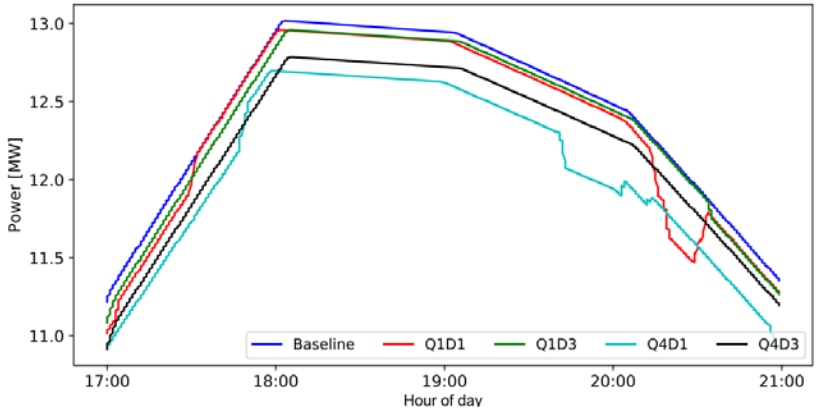
Mendoza, Ismael, Annabelle Pratt, Harsha V. Padullaparti, Soumya Tiwari, and Murali Baggu. 2024. Model Quality and Measurement Density Impact on Volt/Volt Ampere Reactive Optimization Performance. *Energies* 17(15): 3707. https://www.mdpi.com/1996-1073/17/15/3707

ADMS Test Bed Evaluation Results



QSTS: Quasi-Static Time Series
LTC: Load Tap Changer
VVO: Volt/VAR Optimization
SCADA: Supervisory Control and Data Acquisition
EMT: Electromagnetic Transient

Feeder head power demand curves for all scenarios



Summary of experiment metrics

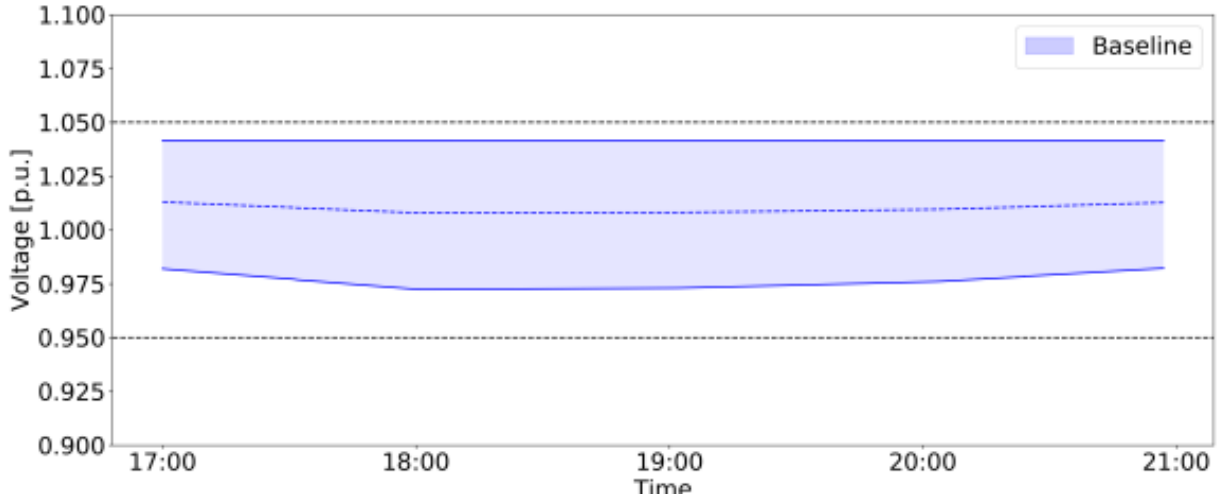
	Number of Capacitor Operations	Number of LTC Tap Operations	Energy Savings (%)	Number of Voltage Exceedances
Baseline	0	0	N/A	0
Q1D1	0	11	0.81	90
Q1D3	0	1	0.51	0
Q4D1	0	7	2.9	1014
Q4D3	0	0	1.8	0

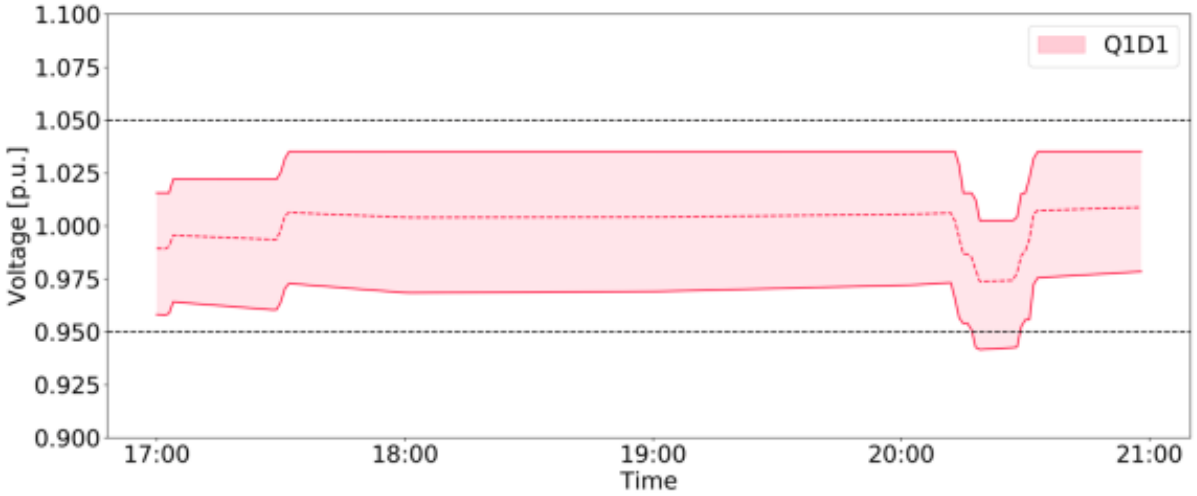
Q: Model quality level
D: Measurement density level

Q4: Highest level of model quality
D1: Lowest level of measurement density

End-of-line measurements

Baseline end-of-line Measurements

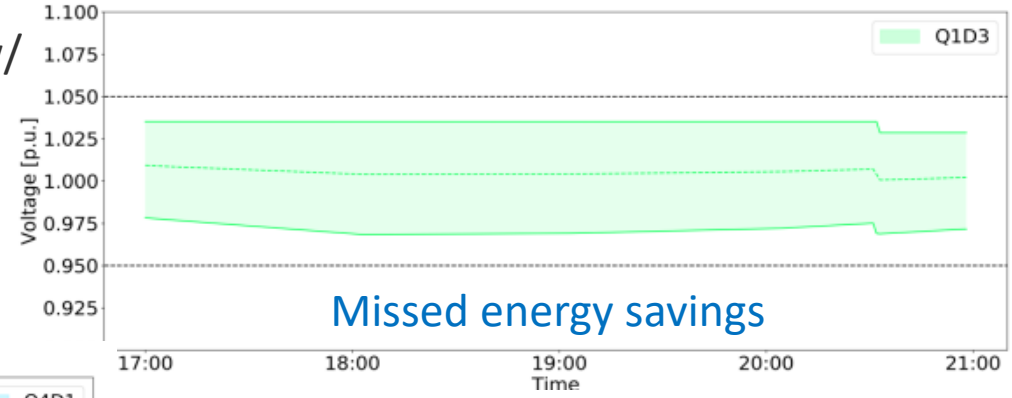


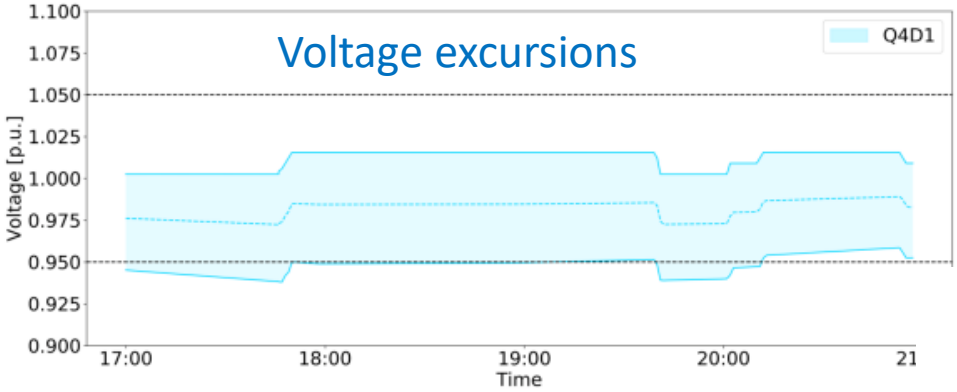


VVO enabled w/ no improvements

End-of-line measurements

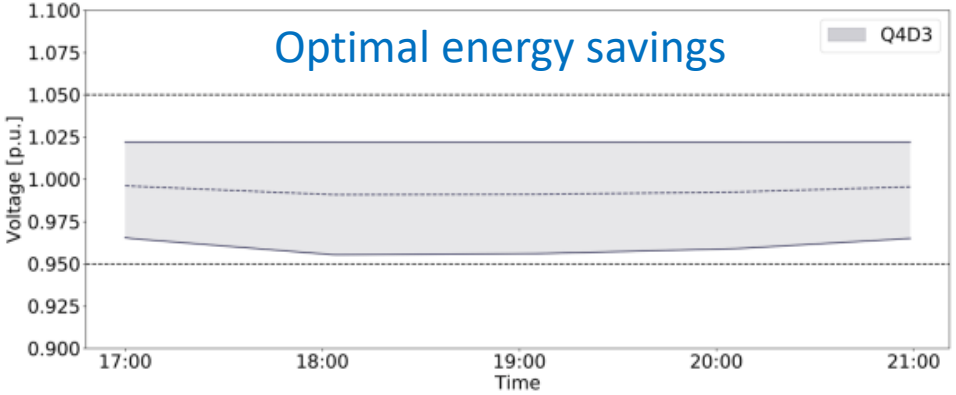
VVO enabled w/ Only telemetry improvements





VVO enabled w/ improved model quality

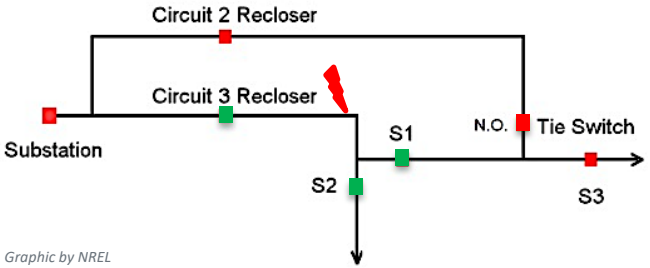
VVO enabled w/ improved model quality and telemetry improvements



Fault Location, Isolation, System Restoration (FLISR)

- Leverage real-time information to locate fault
- Automatically isolate the affected section
- Provide system restoration strategy

Photo by NREL (62246)



Graphic by NREL

Standards

- IEC 61968 Common Information Model
  - Information exchange architecture
- IEEE 2030
  - Guide for smart grid interoperability of energy technology
- IEEE 1547
  - Interconnection requirements for distributed generation
- North American Electric Reliability Corporation Critical Infrastructure Protection
  - Cybersecurity standard

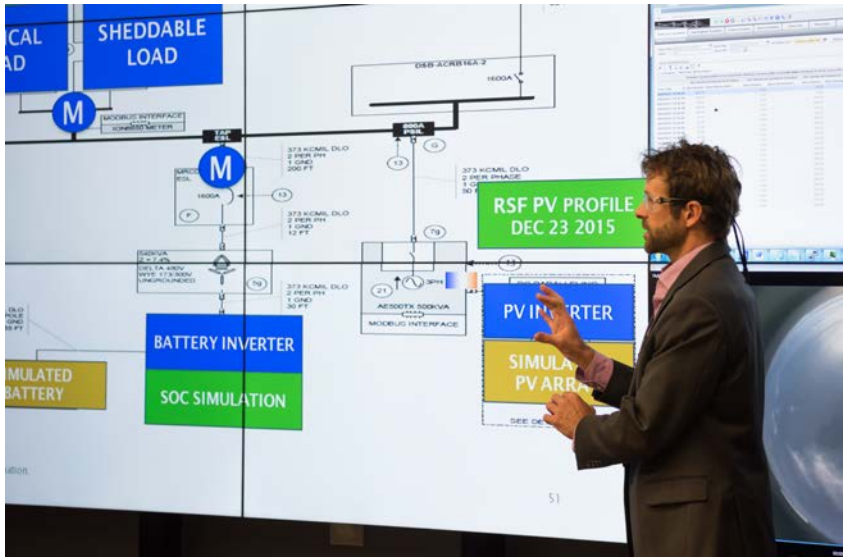
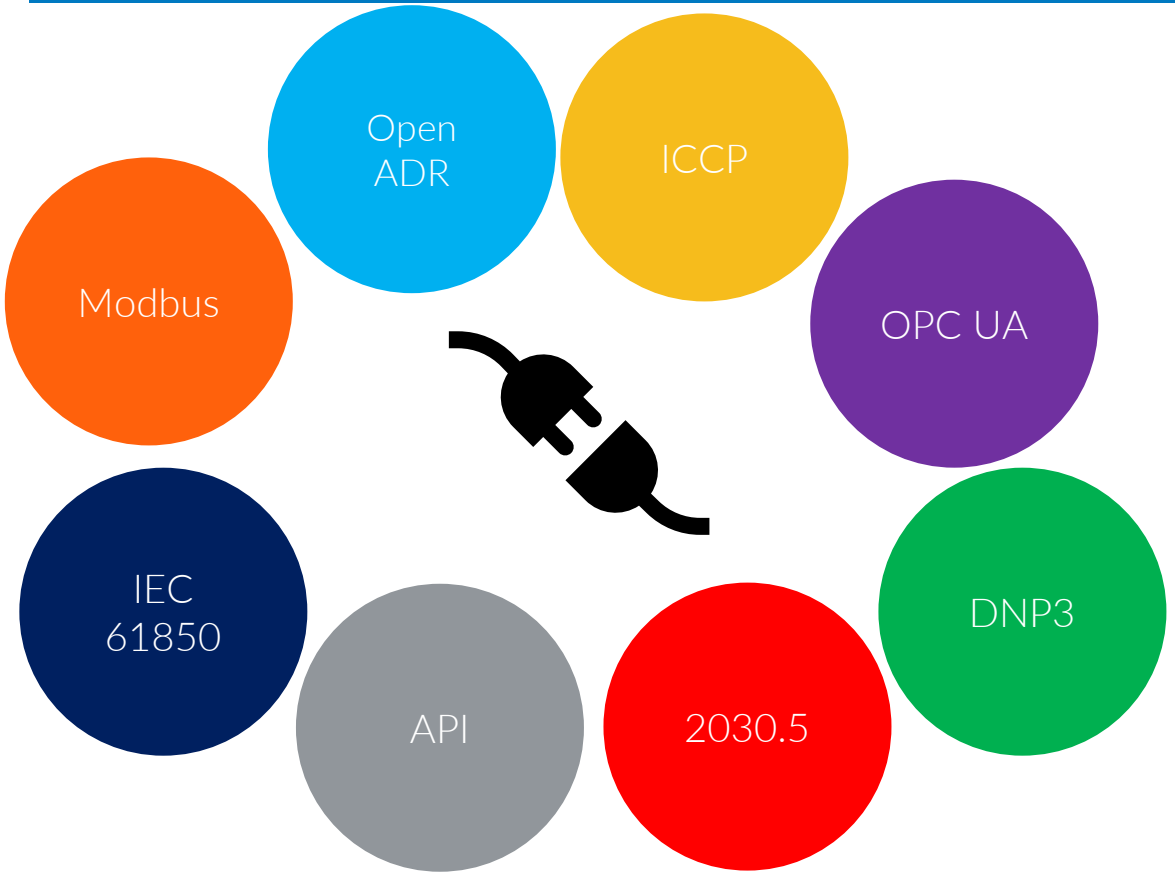


Photo by NREL (42840)

Communication Protocols



Each protocol offers a unique level of flexibility and security. However, it can hinder interoperability.

ICCP: Inter-Control Center Communications Protocol
OPC: Open Platform Communications Unified Architecture
DNP: Distributed Network Protocol 3
API: Application Programming Interface
IEC: International Electrotechnical Commission
OpenADR: Open Automated Demand Response

Future of ADMS

- Integration with emerging technologies
  - Distributed Energy Resource Management System (DERMS)
  - Virtual power plant
  - Microgrids
  - Electric vehicles charging
  - Artificial intelligence/machine learning

Graphic by Pacific Northwest National Laboratory (PNNL)

SmartGrid Advanced Load Management and Optimized Neighborhood

- Full deployment of an ADMS and DERMS to evaluate the control of up to 1.4MW of flexible loads to provide grid services
  - Leverage:
    - Rooftop solar
    - Residential batteries
    - Heat pump water heaters
    - Smart thermostats
    - Electric vehicle charging

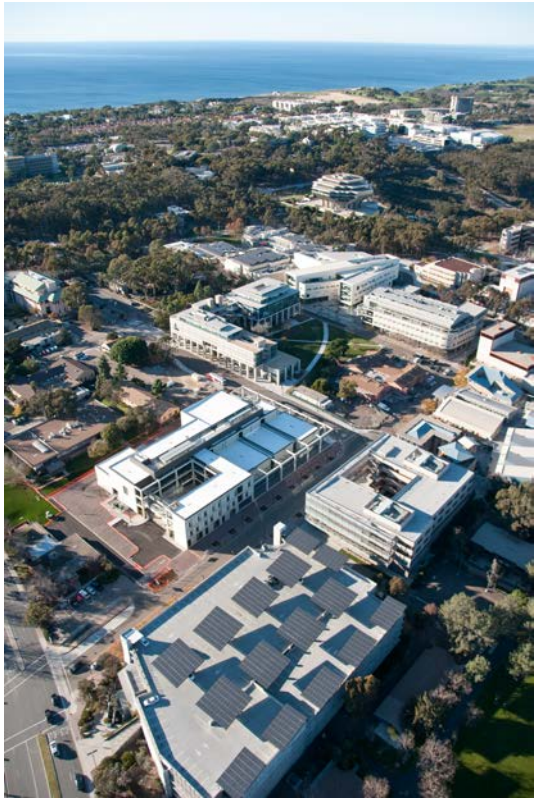


Photo by NREL(18834)

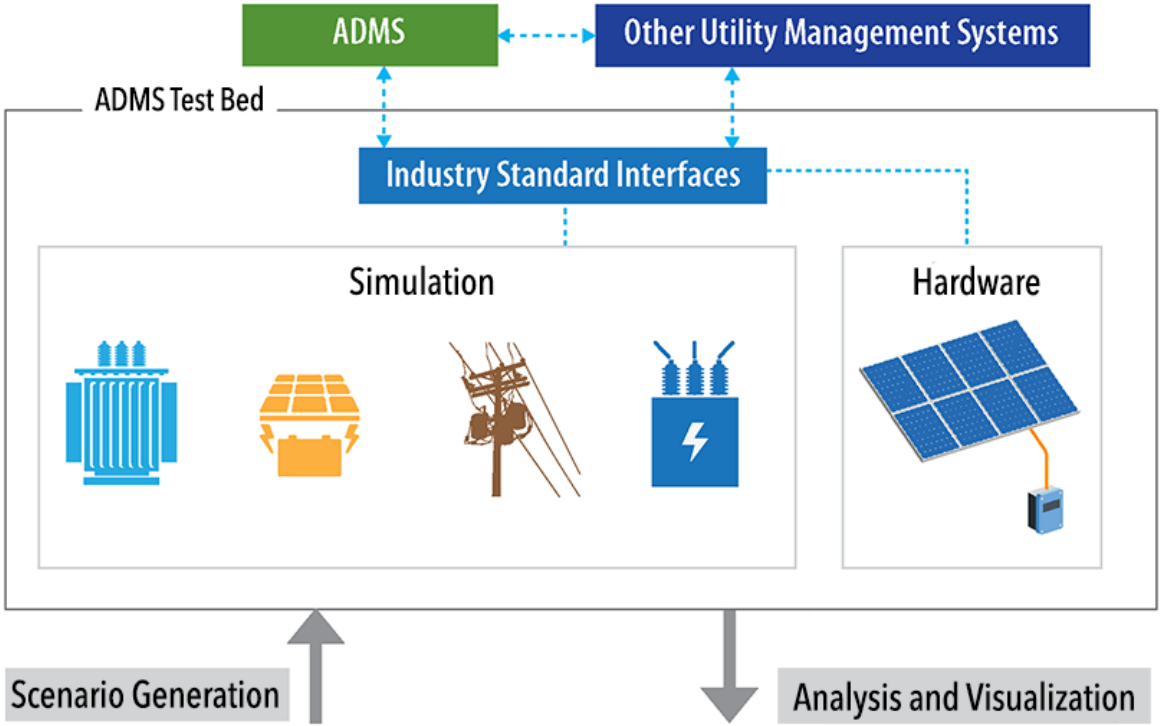
DERMS: Distributed Energy Resource Management Systems

Preliminary NREL Analysis

Key Takeaways

- The ADMS implementation is a multiyear process.
- The model accuracy is an essential piece to the effectiveness of the ADMS.
- Improve sensing strategy
- Workforce development
- Scalability and flexibility

NREL's ADMS Test Bed Capabilities



National Renewable Energy Laboratory. "Advanced Distribution Management System Test Bed." https://www.nrel.gov/grid/adms-test-bed

2016 - Present — 15 Utilities — 24 Projects — 9 vendors

ADMS Test Bed use cases:

1. ADMS network model quality impact on VVO
   - **Xcel Energy** + Schneider Electric
2. Peak load management with ADMS and DERMS
   - **Holy Cross Energy** + Survalent & NREL's RTOPF
3. AMI-based, data-centric grid operations
   - **SDG&E** + GridAPPS-D
4. FLISR in the presence of DERs
   - **Central Georgia EMC** + Survalent
5. DER controls strategies for T&D grid services
   - **Xcel Energy** + GridAPPS-D
6. Federated DERMS for high PV systems
   - **Southern Company** + Oracle & GridAPPS-D
7. Co-optimizing grid and facility operations
   - ***Shell*** + Spirae
8. System restoration with improved fault tracking
   - **Israel Electric Company** + EGM
9. Microgrid and EV Managed Charging Demonstration
   - **Colorado Springs Utilities** + SGS
10. DER-Augmented Grid Operations
    - **Dominion Energy** + Generac

11 Completed

7 Active

6 New

ADMS Test Bed capabilities used by:

11. Non-wires alternatives (**Holy Cross Energy**)
12. ECO-IDEA (**Xcel Energy**)
13. GO-SOLAR (**HECO**)
14. SolarExpert (**Duke**)
15. RONM (**Cobb EMC**)
16. PIVA (**SDG&E**)
17. REORG (**Holy Cross Energy**)
18. FAST-DERMS (**Southern Company, ComEd**)
19. SALMON (**Portland General Electric**)
20. AI-PhyX
21. SensorMAP (**PGE; Duquesne Light Company**)

- *OCED Awards:*

22. Prime Time virtual power plant (**Xcel Energy**)
23. GRID-FLEXER (**Dominion Energy Virginia**)
24. Outer Cape Microgrid Optimization (**Eversource**)

Thank You

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NREL/PR-5D00-93716

This work was authored by NREL for the U.S. Department of Energy (DOE), operated under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Policy. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

For Further Reading

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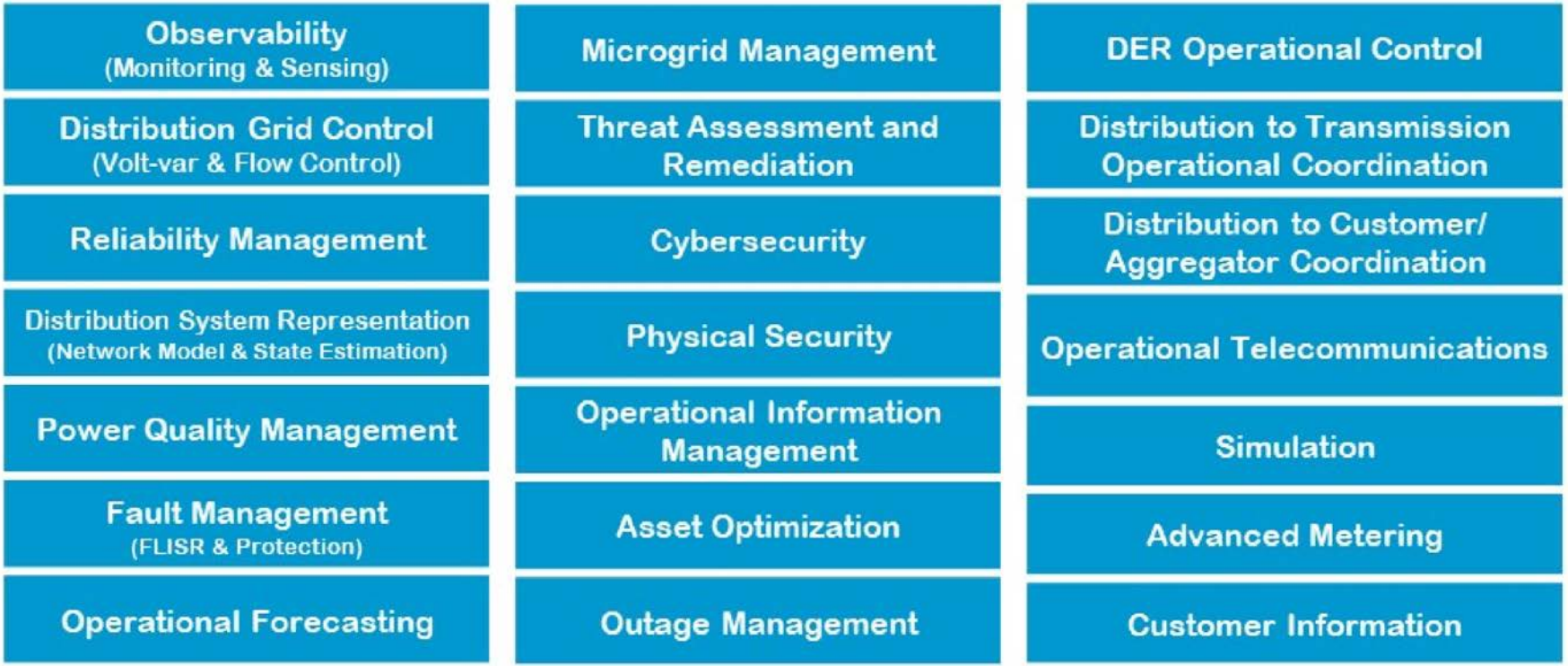
Distribution Grid Operations Functions



"Modern Distribution Grid: DSPx Next-Generation Distribution System Platform. Strategy & Implementation Planning Guidebook." U.S. Department of Energy Office of Electricity. https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf.