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A Test Bed to Evaluate Advanced Distribution Management Systems for Modern Power Systems

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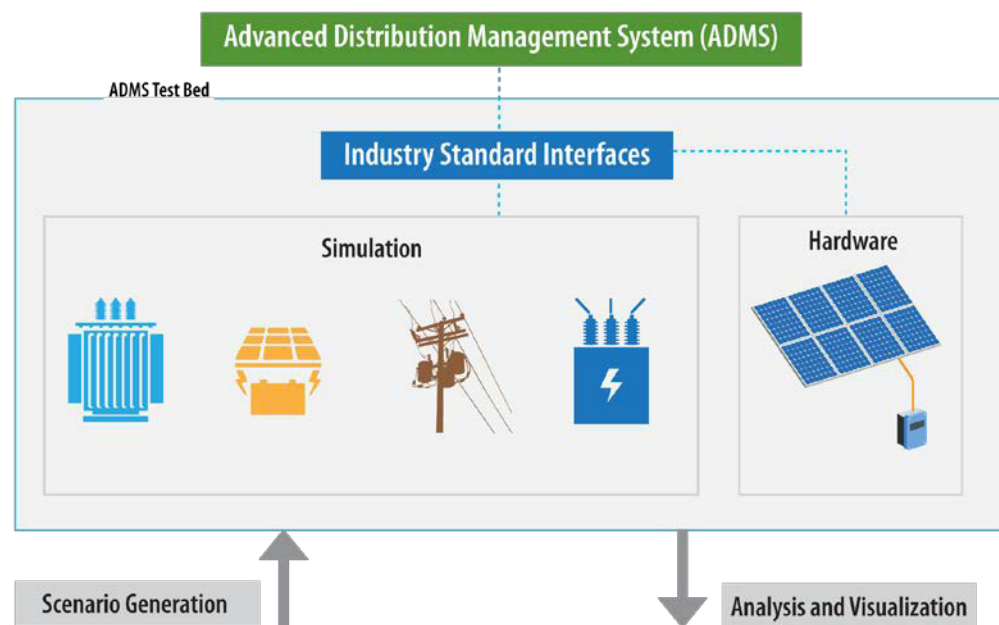
Introduction

- ▶ Penetration level of DERs is increasing
 - Especially intermittent sources such as PV
- ▶ Requires distribution management system (DMS) updates
 - Visibility of DERs
 - Interfaces with DERMS and microgrid controllers
 - Expanded FLISR capabilities
 - Advanced VVO, etc.
- ▶ Advanced DMS (ADMS) adoption rate still very low



The ADMS Test Bed

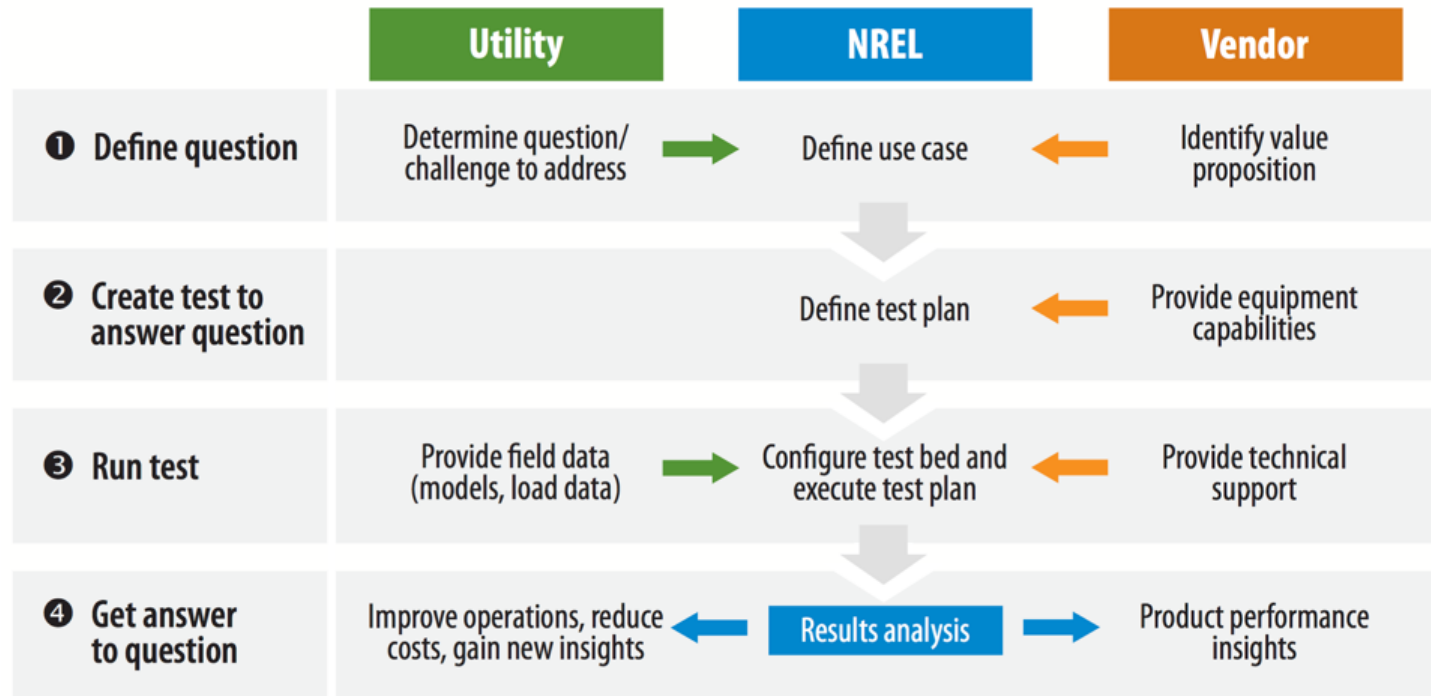
- Objective: Accelerate ADMS adoption by providing a laboratory test platform for existing and emerging ADMS applications
- Realistic laboratory testing
 - Power system modeling
 - Controller/power hardware
 - Industry-standard communication protocols
- Can model future scenarios with more DERs
- For use by utilities, vendors, and researchers



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ADMS Test Bed Use Case Development



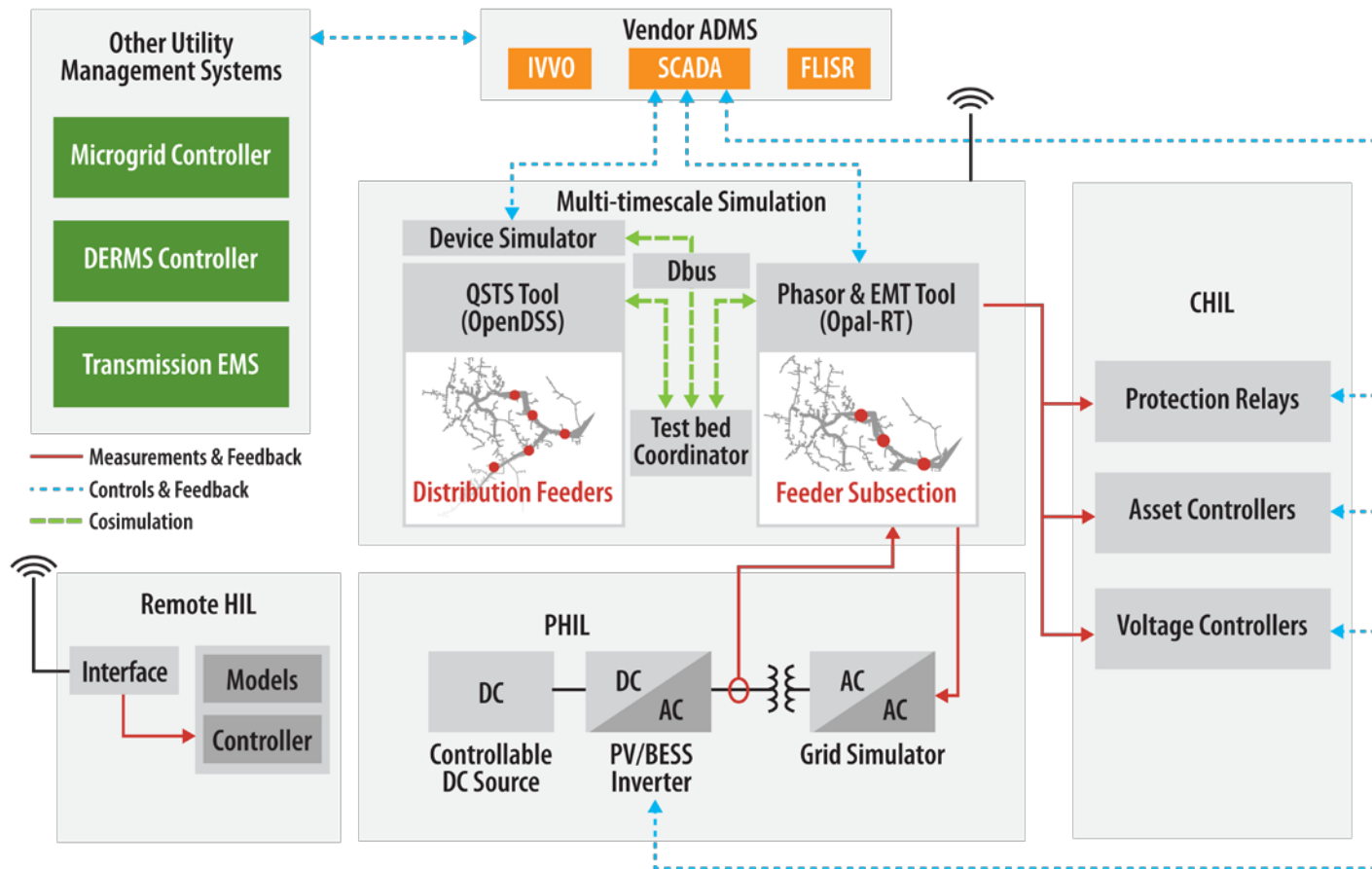
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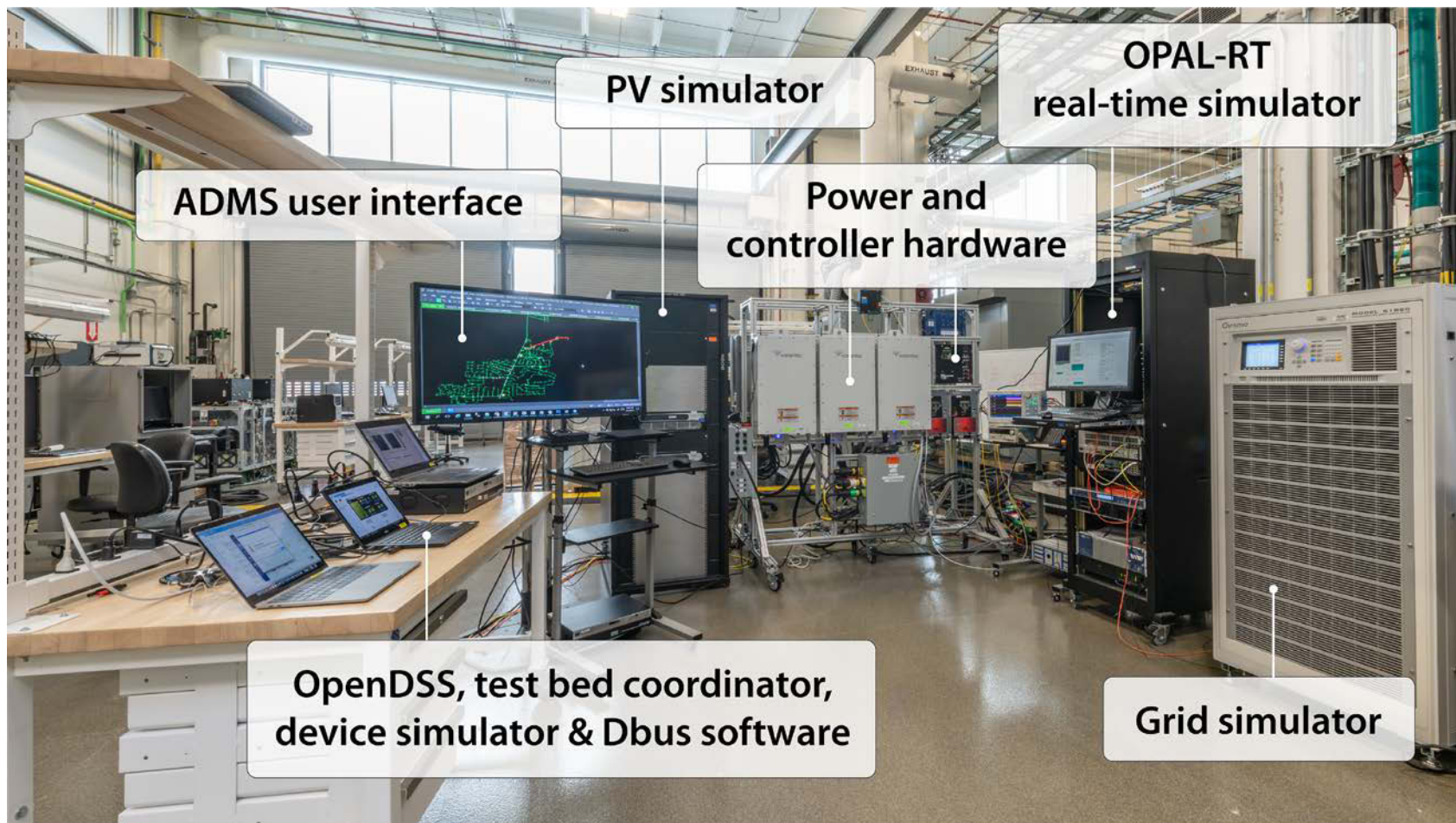
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ADMS Test Bed Overview



ADMS Test Bed Physical Setup

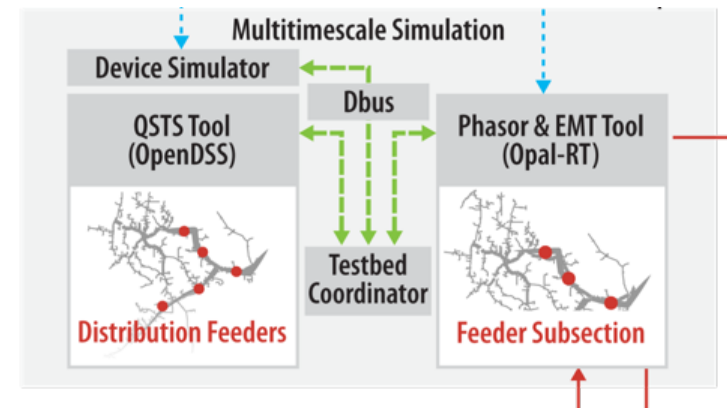


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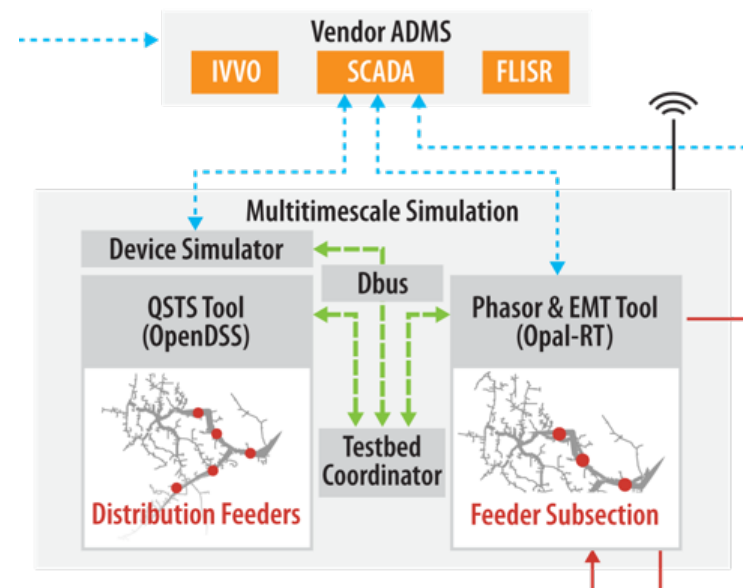
ADMS Test Bed Software

- Select one or more simulators to fit use case
 - Can run parts of feeder in different simulators
- Currently using:
 - OpenDSS by EPRI
 - Quasi-static time series (QSTS), sec - min
 - ePHASORSim by OPAL-RT
 - Dynamic phasor, 1- to 10-ms
 - Can incorporate other simulators, e.g., RTDS
- Orchestrated by test bed coordinator software
 - Written in Python, uses the Hierarchical Engine for Large-Scale Infrastructure Co-Simulation (HELICS) framework.
 - U.S. Department of Energy investment www.helics.org.



Communication Interfaces

- ▶ ADMS to OpenDSS
 - Device simulator developed to provide communications interface
 - Interfaces through Dbus
 - Low overhead data exchange based on TCP
- ▶ ADMS to Opal-RT
 - Drivers available
- ▶ Currently using DNP3
 - Can incorporate others, e.g., IEC 61850



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Current ADMS Test Bed Use Cases

- ▶ Use Case 0: Centralized and distributed VVO
 - Duke Energy and General Electric
 - *Completed in 2017 using ADMS power flow.*
- ▶ Use Case 1: Model quality impacts on VVO
 - Xcel Energy and Schneider Electric
 - *ADMS test bed currently set up for this use case.*
- ▶ Use Case 2: Peak load management with DERMS
 - Holy Cross Energy and Survalent
 - *To be completed in 2019.*



Use Case 1

- Evaluate performance of the ADMS VVO application for different levels of model quality and different levels of measurement density
- Phase 1: evaluate using ADMS training simulator
 - Six Xcel Energy feeders with different characteristics
 - (4 model-quality levels) X (4 meter-density levels)
- Phase 2: evaluate using the ADMS test bed
 - Simulate two or three combinations for one feeder.

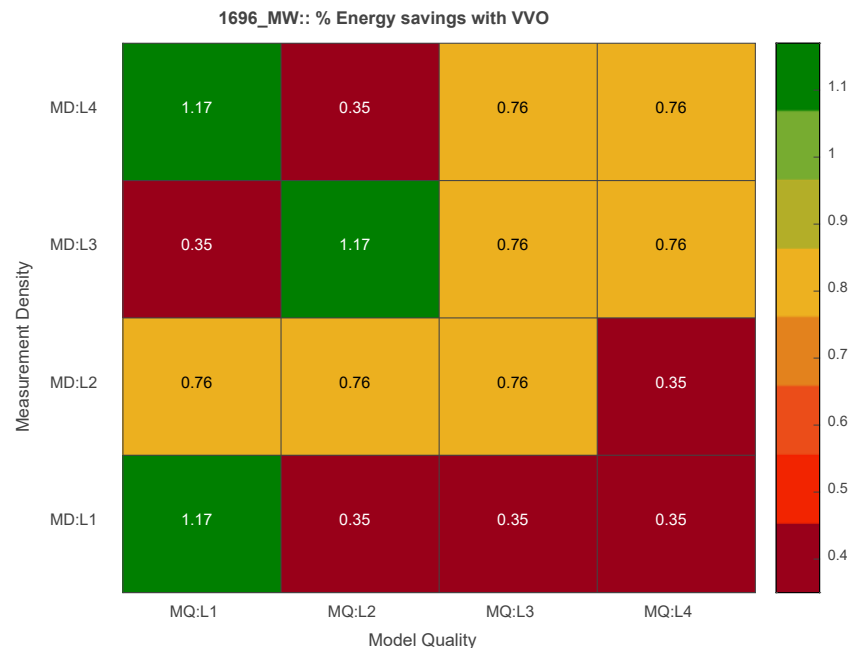
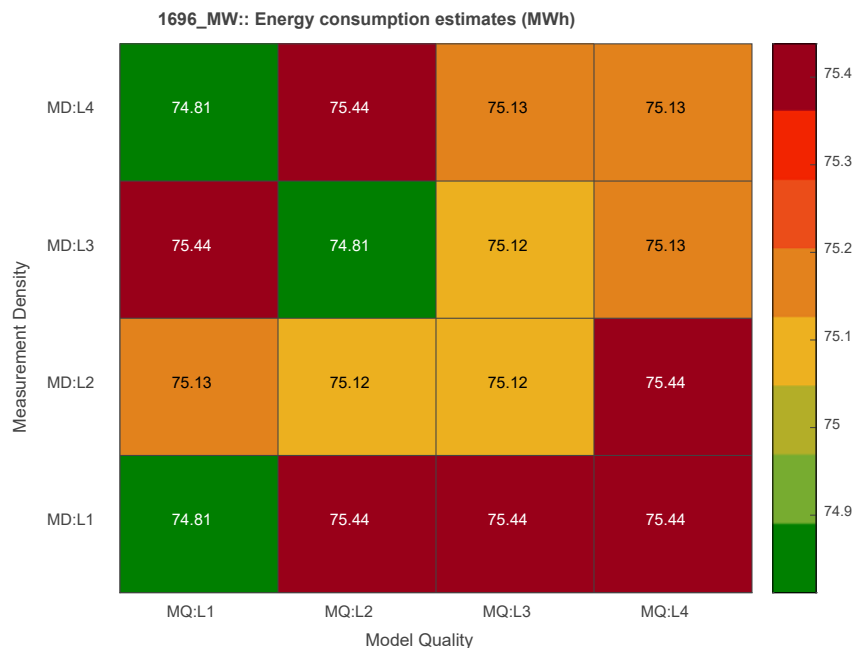


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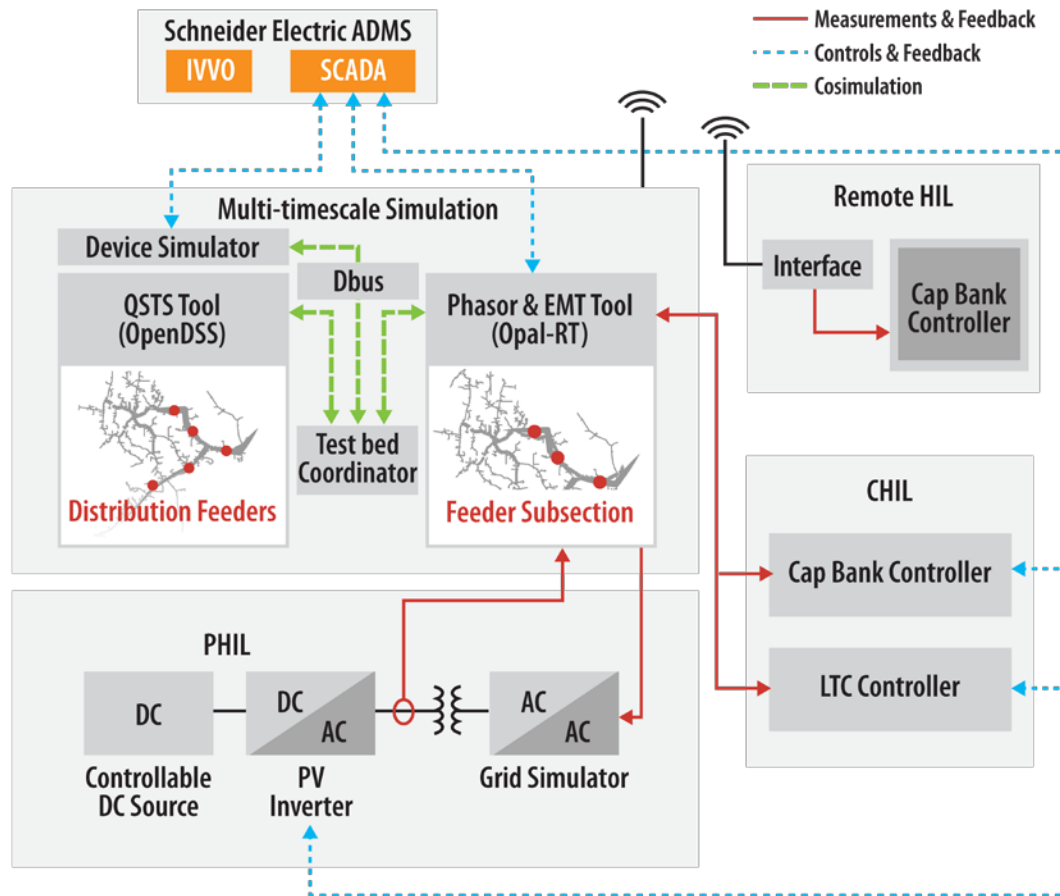
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Use Case 1 Phase 1 Simulation Results

- No significant impact for this feeder
- Other Xcel Energy feeders show more change

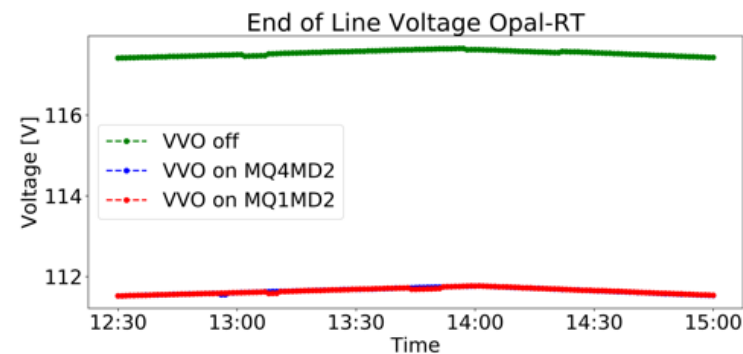
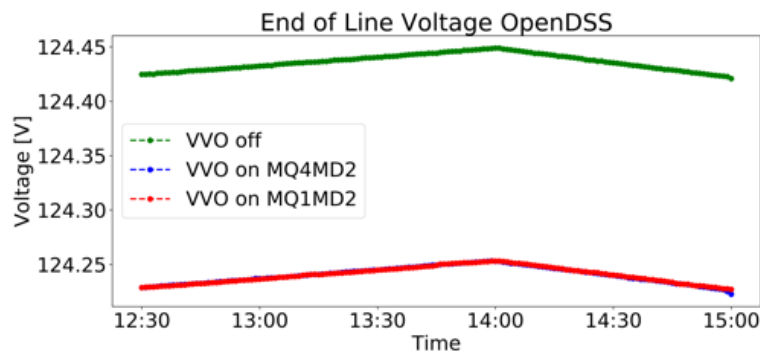
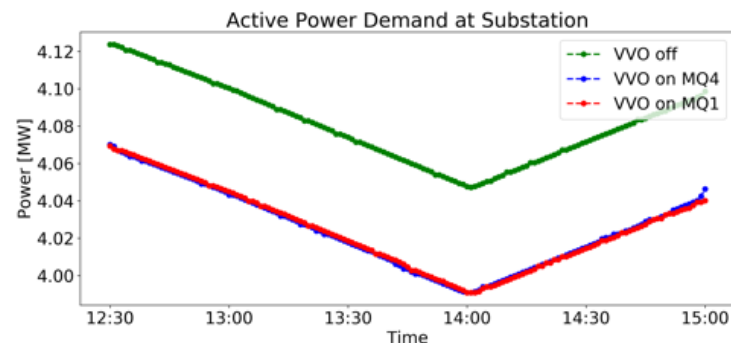
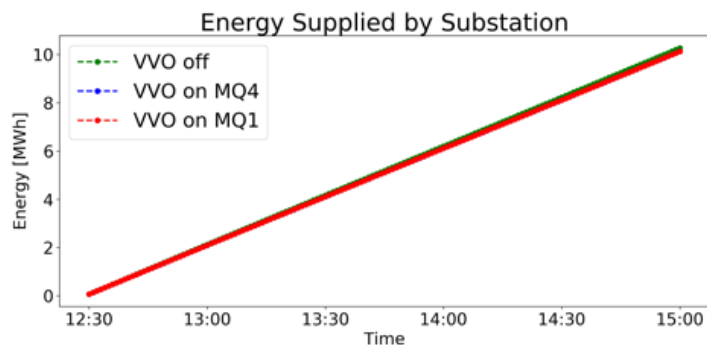


ADMS Test Bed Setup for Use Case 1



Use Case 1 Phase 2 Preliminary Results

- Consistent with Phase 1 results
- Currently working on 24-hour simulations



Use Case 2

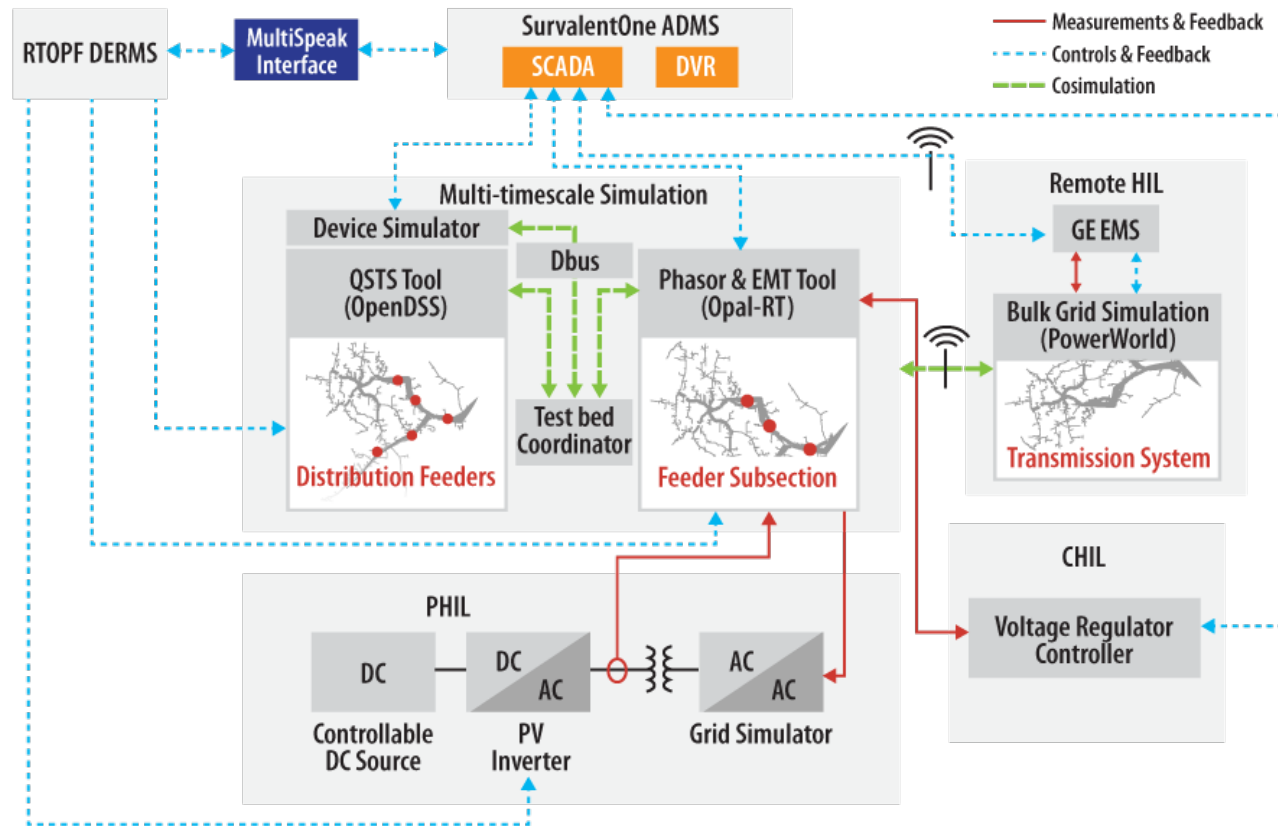
- ▶ Evaluate performance of peak load management coordinated across ADMS, DERMS and EMS
 - Holy Cross Energy rural feeder with
 - high rooftop PV penetration
 - some BESS
 - flexible load (water heaters, air conditioners and EVs)
 - DERMS complements ADMS operations
 - Builds on project focused only on DERMS
 - MultiSpeak communications interface from ADMS to DERMS



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ADMS Test Bed Setup for Use Case 2



Future Use Cases

- ▶ Non-wires alternatives to grid modernization
 - ADMS + DERMS for behind-the-meter resources.
- ▶ Enabling Extreme Real-Time Grid Integration of Solar Energy (ENERGISE) ECO-IDEA
 - ADMS + Varentec devices + DERMS for photovoltaics
- ▶ Evaluating a wireless communications system for utility applications
- ▶ Controls coordination between centralized and distributed FLISR

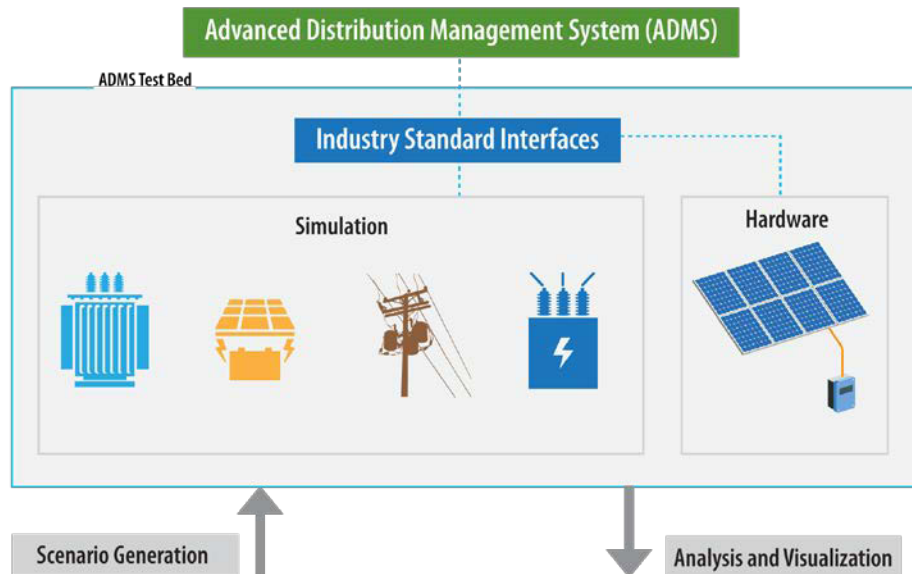


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Conclusion

- ▶ The ADMS test bed is a tool to evaluate existing and emerging management systems as power distribution systems change
 - Due to increased penetration of PV, BESS and EVs, and more flexible loads
- ▶ Results from laboratory experiments can inform field deployment decisions to ensure reliable operation of modern power systems



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Thank you

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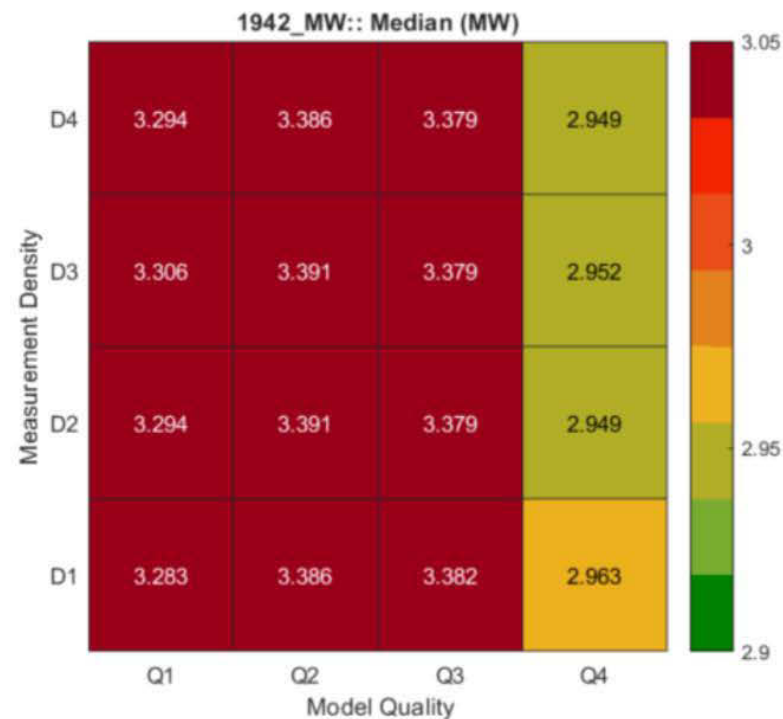
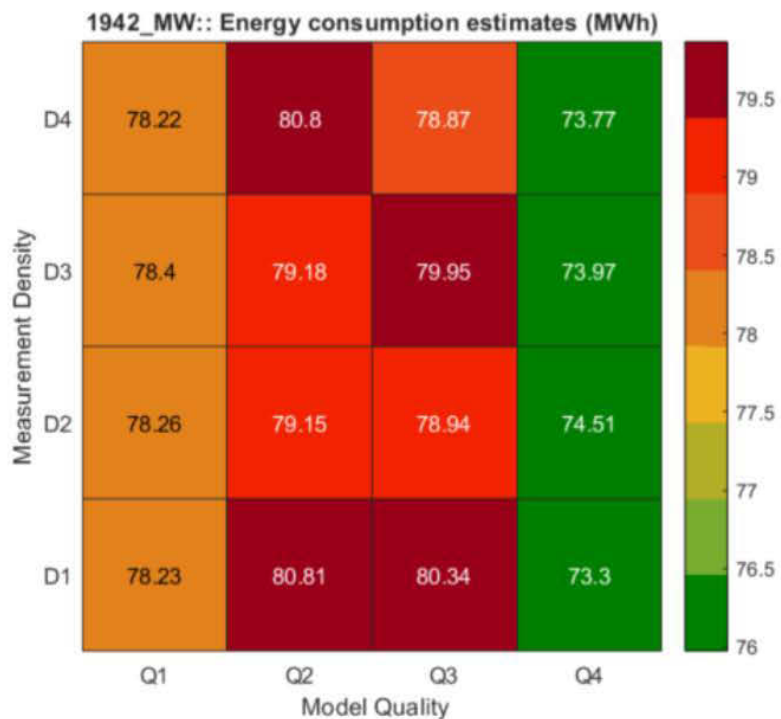


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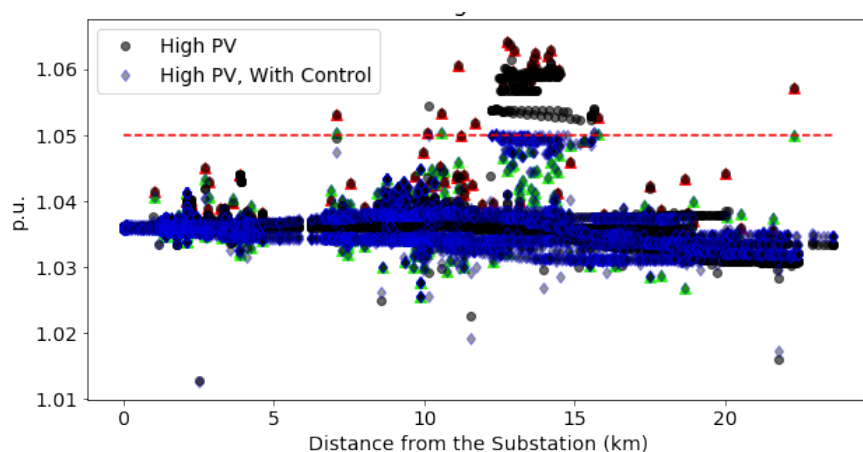
Use Case 1 Phase 1 Simulation Results

Results for another Xcel Energy feeder

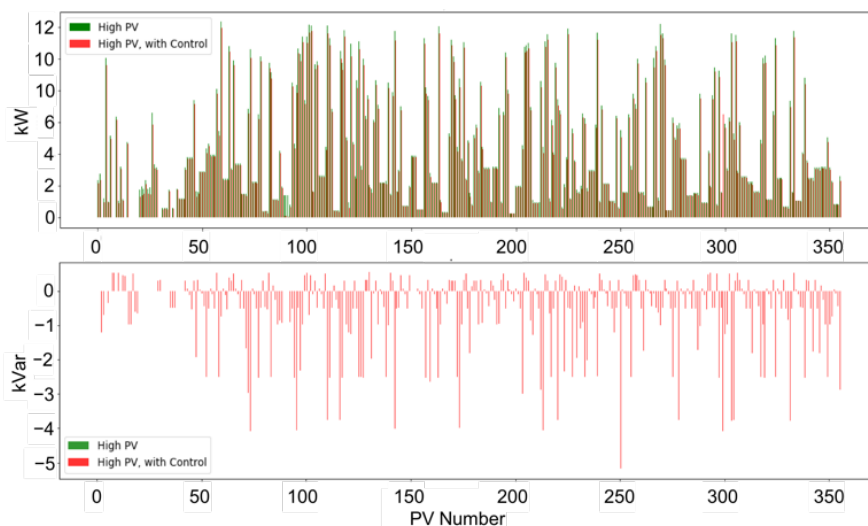


Use Case 2 Preliminary simulation results

- ▶ This from precursor project looking only at DERMS



Comparison of voltage profiles between no DERMS (black circles) and with DERMS (blue diamonds). The voltages at the nodes with PV are highlighted using red triangles (no DERMS) and green triangles (with DERMS).



Active power (top) and reactive power (bottom) output from each PV inverter.