

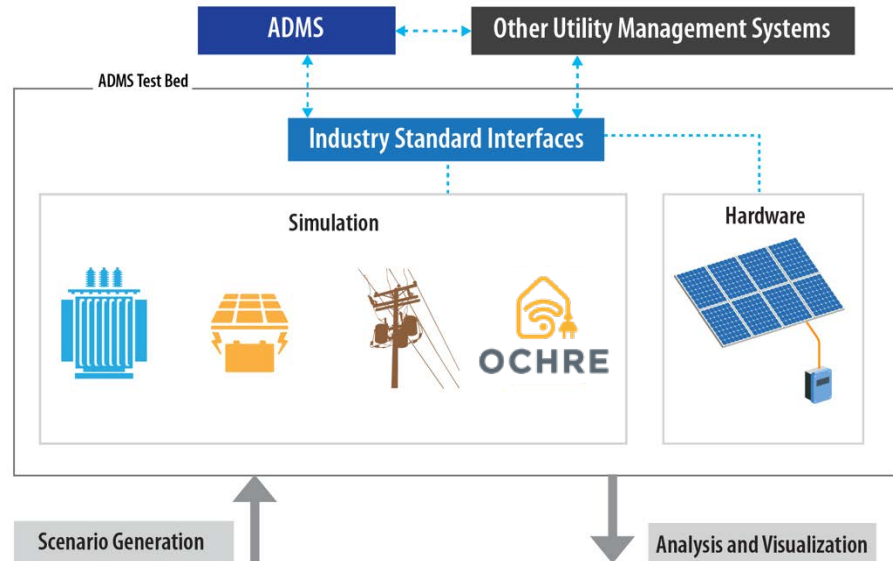
ARIES and ADMS Test Bed Overview and Updates

Annabelle Pratt, Chief Engineer, NREL
December 12, 2024
ADMS Test Bed and FAST-DERMS Workshop

ADMS Test Bed Capabilities



U.S. Department of Energy (DOE) Office of Electricity (OE) goal: Transform utility electric distribution management systems to enable the integration and management of all assets and functions across the utility enterprise regardless of vendor or technology.



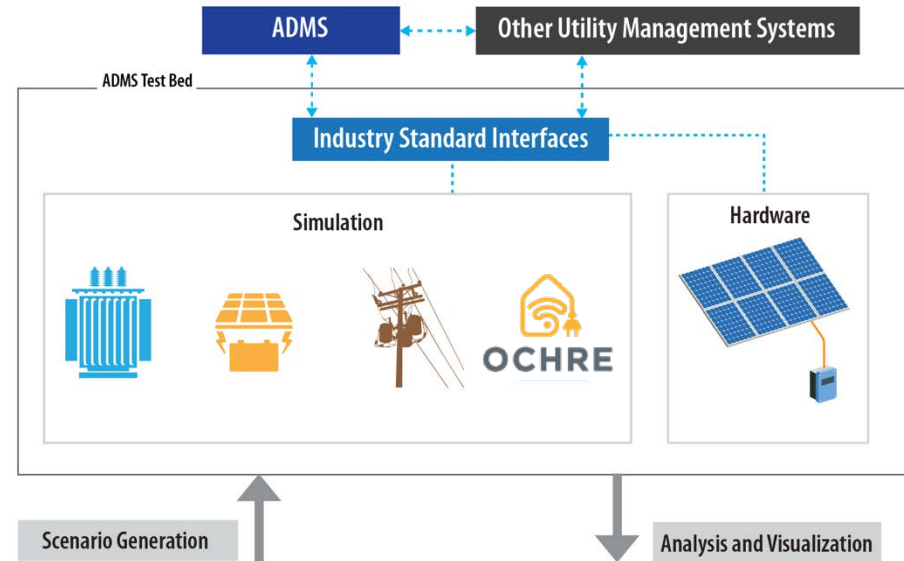
ADMS Test Bed Capabilities



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- Real-time cosimulation using HELICS:
 - Real or representative power system
 - Either quasi-static time-series (QSTS) (OpenDSS) or electromagnetic transient (RTDS or OPAL-RT) power system simulation
 - Current or future distributed energy resource (DER) levels
 - Normal or abnormal grid conditions
 - OCHRE™ for residential buildings (QSTS), <https://www.nrel.gov/grid/ochre.html>.
- Hardware integration:
 - Power or controller hardware, e.g., inverters, capacitor bank controllers.
- Communications interfaces:
 - Mostly DNP3, some Modbus, IEEE 2030.5.



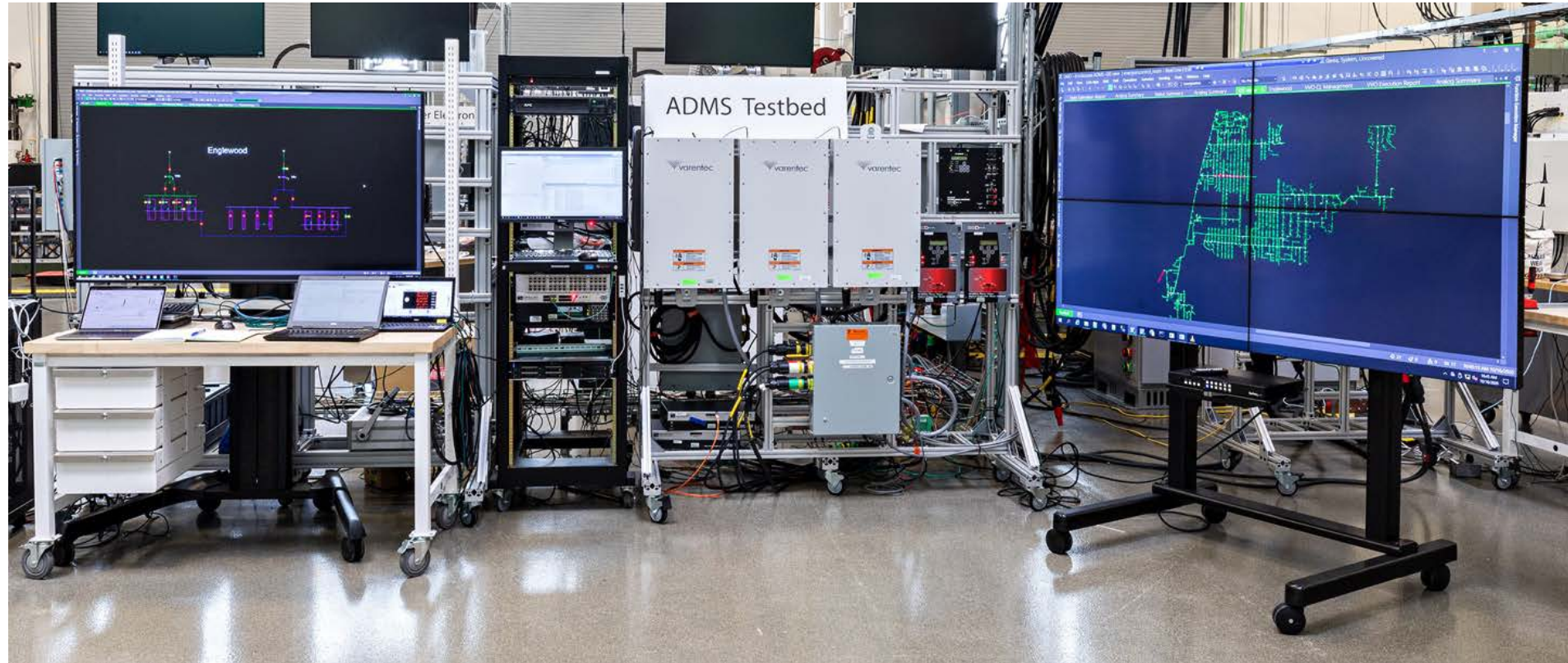
The National Renewable Energy Laboratory's (NREL's) ADMS Test Bed:
<https://www.nrel.gov/grid/advanced-distribution-management.html>

ADMS Test Bed



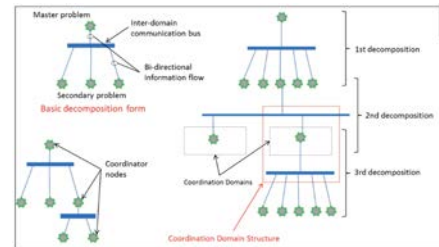
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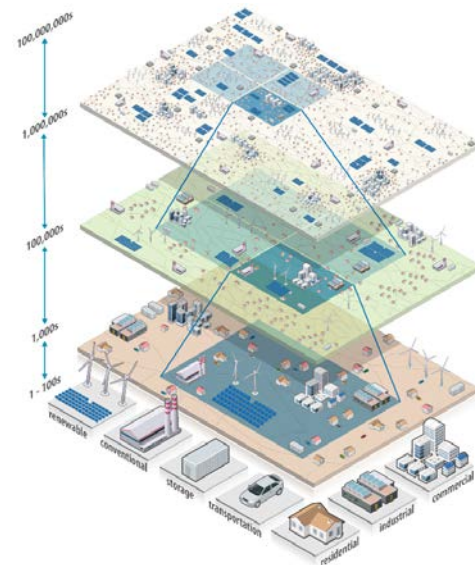


Where We Stand Today

- Higher DER penetrations challenge grid controls.
- Industry is responding with new products:
 - ADMS that are DER-aware
 - ADMS with DERMS modules
 - Stand-alone DERMS products
 - Virtual power plants (VPPs) and aggregators.
- Research and development (R&D) organizations (national laboratories, universities) are responding with new grid control architectures:
 - FAST-DERMS
 - NREL's Autonomous Energy Systems.



Source: PNNL



Source: NREL

Why We Need Laboratory Evaluation

Realistic laboratory environments support three types of research that are critical for developing new grid control products (and synergies among products) and architectures:

1. **De-risking**—making field demonstration projects (pilots) more successful
2. **Evaluating claims**—proving out the promise of new controls
3. **Future-proofing**—performing evaluations on models of future power systems with even higher DER penetrations.

For this, we need a flexible combination of laboratory hardware and simulation tools to allow for a wide range of experiments.



The ESIF is
NREL's largest
R&D facility
(182,500 ft²)

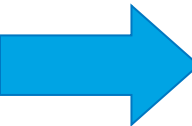


From ADMS to Grid Controls Evaluation



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The ADMS Test Bed was developed through GMLC/OE funding in 2016. It was originally focused on the evaluation of ADMS.



However, the foundational capabilities are:

1. Realistic, real-time (hardware-in-the-loop) simulations of a real or representative distribution power system in a laboratory that includes behind-the-meter and utility-scale DERs
2. Ability to interface the laboratory system with commercial or precommercial grid management software through industry-standard communications protocols
3. Ability to evaluate the performance of grid controls using metrics and visualizations.

ARIES

Advanced Research on Integrated Energy Systems (ARIES) is a unique research platform developed by NREL and DOE's Office of Energy Efficiency and Renewable Energy.



Energy Systems Integration Facility (ESIF)



Flatirons Campus



Virtual Emulation Environment

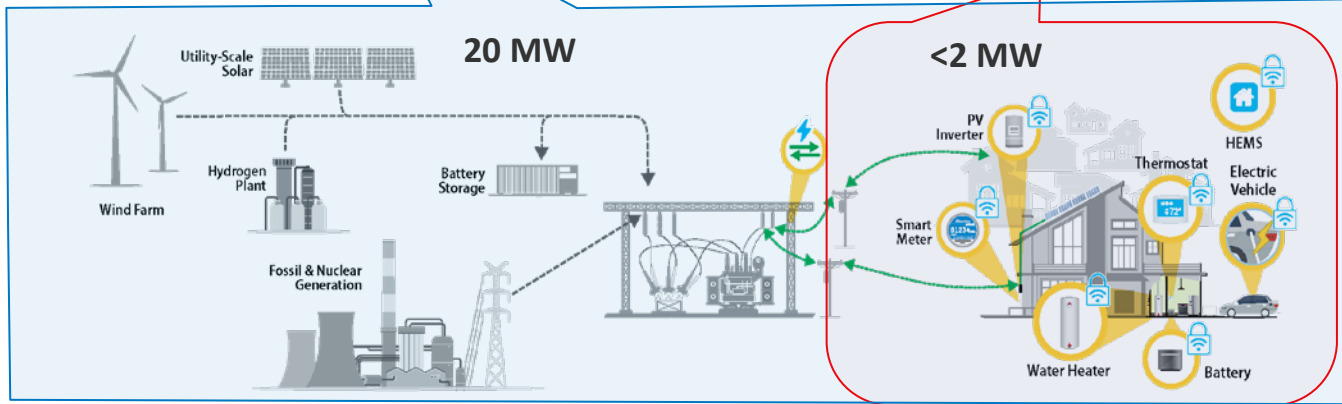


IESS

Photos by NREL



ESIF



Generation & Storage

Transmission/
Distribution & Storage

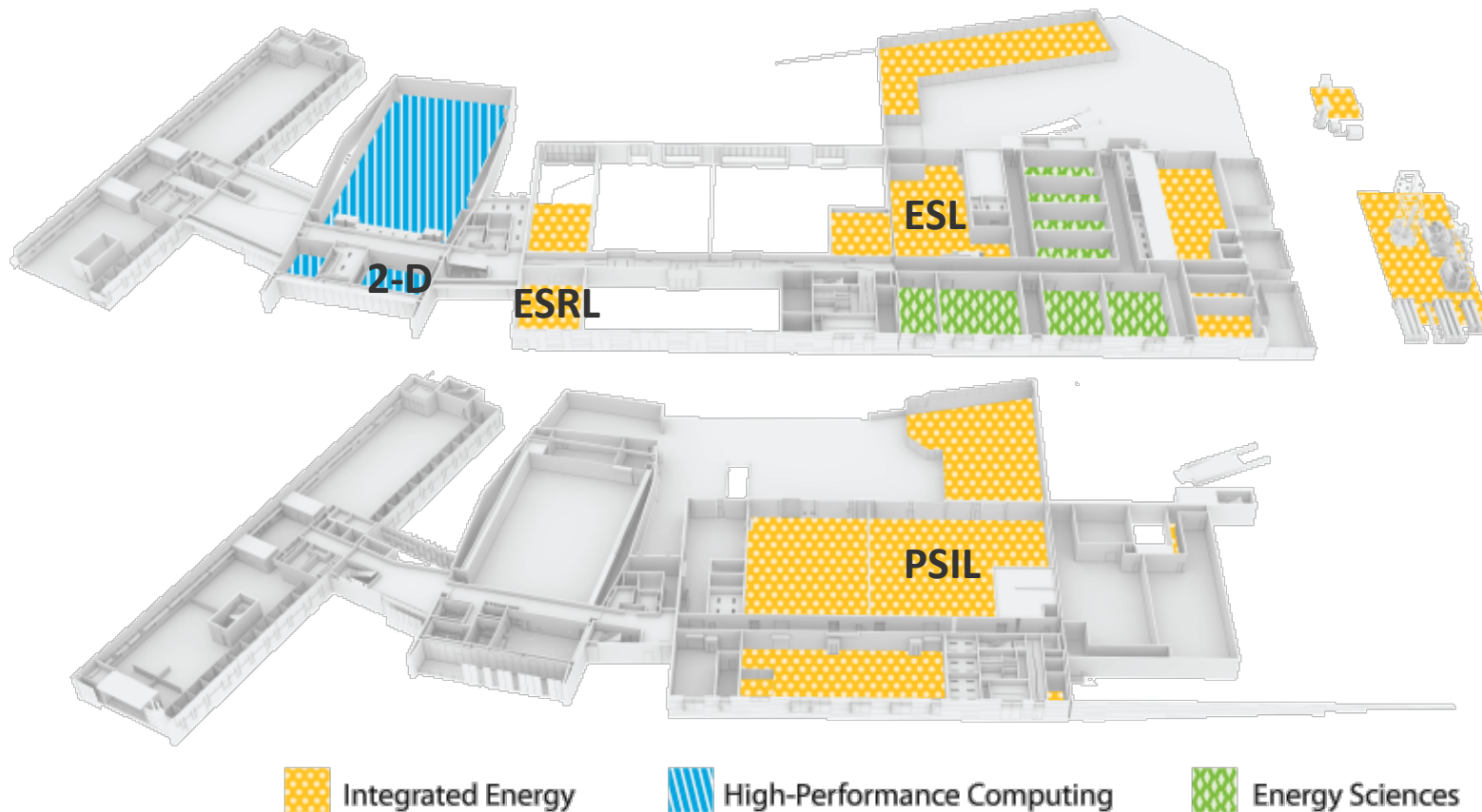
Loads & Storage

Virtual Emulation

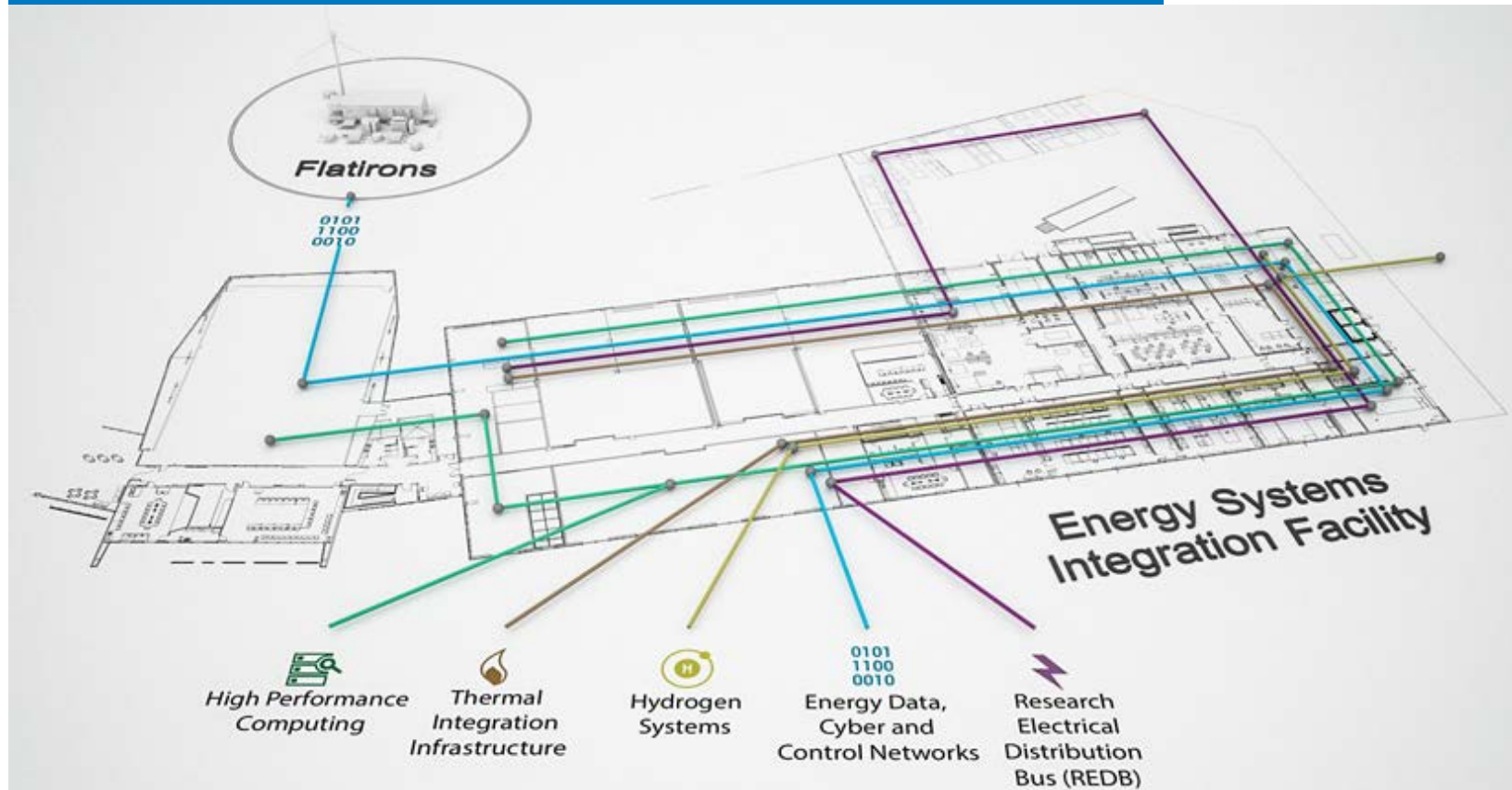
ARIES is a globally unique research capability that can be used to demonstrate that DERs can operate in real-time energy markets and provide reliable and resilient grid services.

ESIF Layout

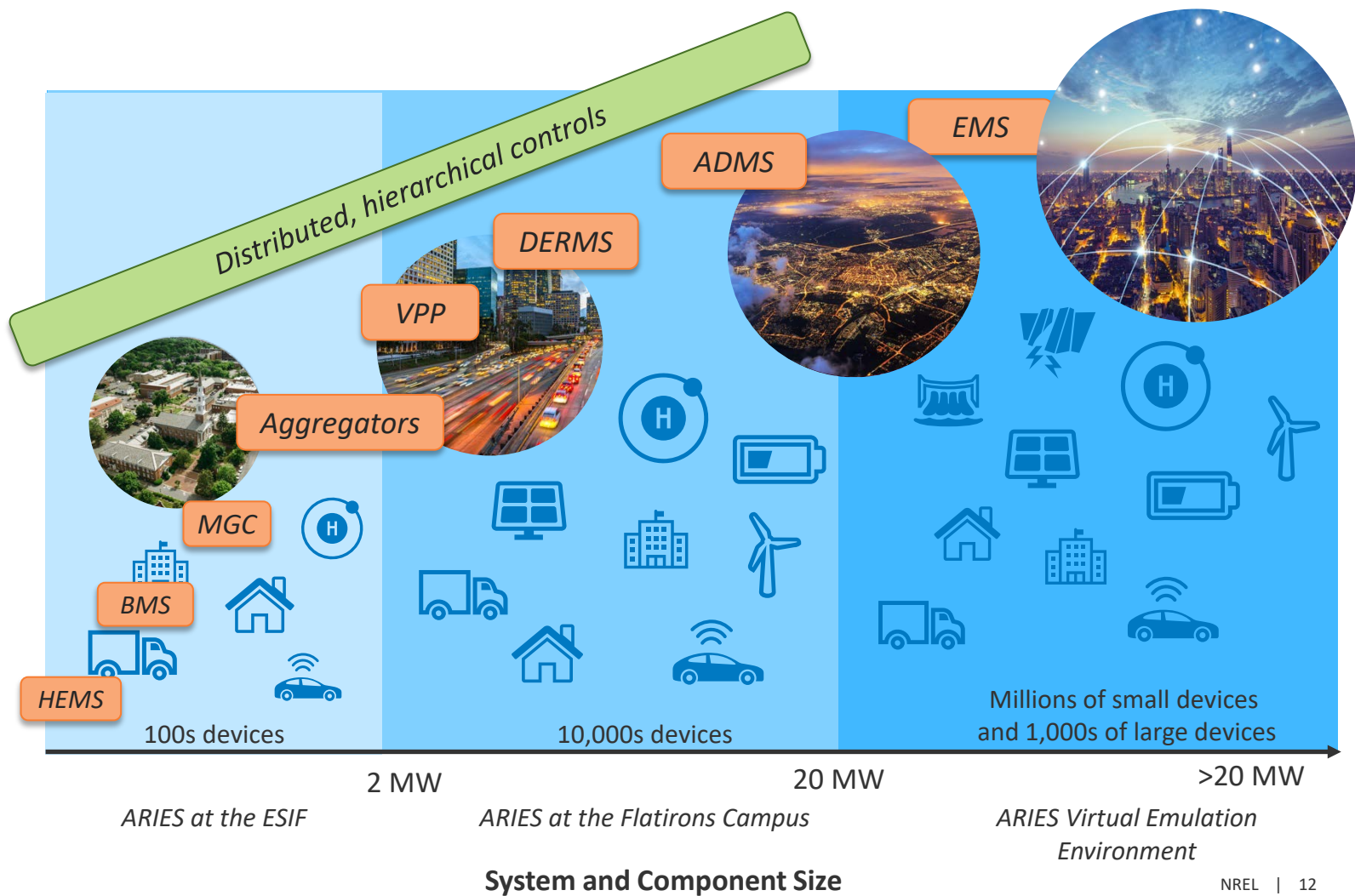
ARIES focuses on but is not limited to the Integrated Energy laboratories at ESIF. This presentation addresses ESIF Integrated Energy Laboratories' Research Capabilities.



ESIF Major Research Systems



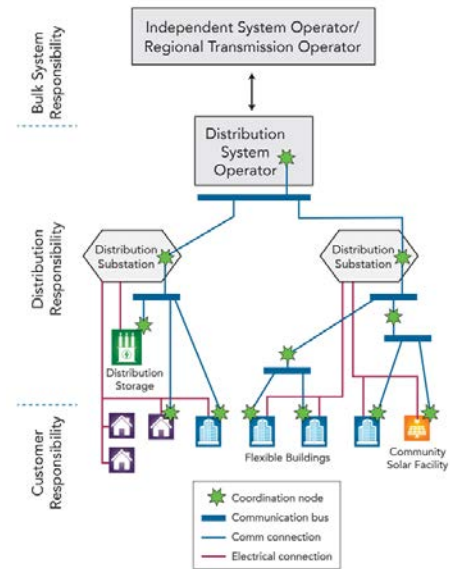
ARIES Scale



A Few Words About Scale



- The grid is a tightly coupled system, and therefore control should be developed and implemented with a holistic, end-to-end system view.
- Do we need to simulate the entire Western Interconnection, for example, to arrive at any conclusions about grid control solutions?
- No, because the electric grid infrastructure has a natural hierarchy with key aggregation points:
 - Transmission price nodes
 - Distribution substations.
- We consider the distribution substation service area an appropriate scale for the evaluation of DER management solutions.
 - Even with centralized ADMS and DERMS, key functions—such as voltage management—are implemented at the substation level.
- We can connect a small number of distribution substations to a transmission price node to evaluate data exchange.
- Only once a specific control is successfully demonstrated at the distribution substation level do larger-scale simulations make sense.



Source: *Interoperability Strategic Vision*,
March 2018

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 RTOFP
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

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 (**SDG&E, ComEd**)
 19. SALMON (**Portland General Electric**)
 20. AI-PhyX
 21. SensorMAP (**PGE; Duquesne Light Company**)
- Office of Clean Energy Demonstration Selected Awards:*
22. Prime Time VPP (**Xcel Energy**)
 23. GRID-FLEXER (**Dominion Energy Virginia**)
 24. Outer Cape Microgrid Optimization (**Eversource**)

11 Completed

7 Active

6 New

ARIES User Call for ADMS Test Bed Future Use Cases



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User Call Issued August 2023

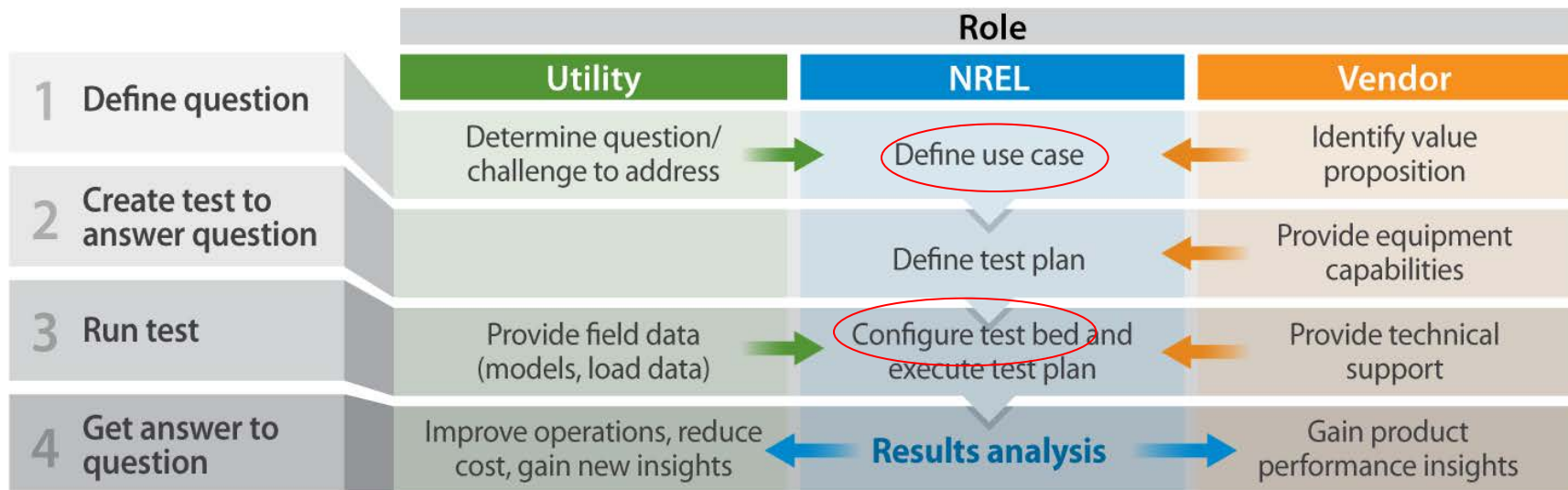


Advanced Research on Integrated Energy Systems (ARIES) User Call for Advanced Distribution Management System (ADMS) Test Bed Vehicle-Grid Integration Use Cases

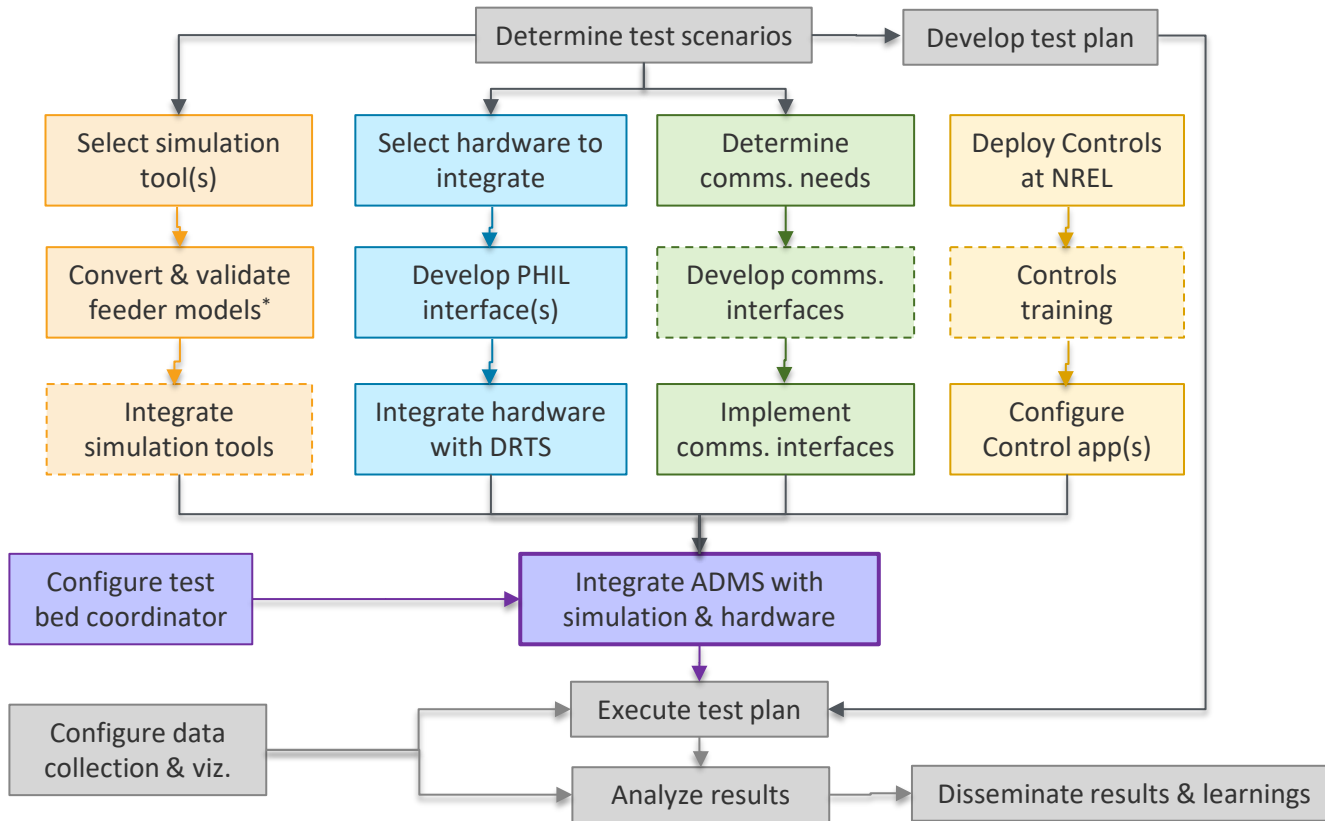
Vehicle-grid integration research areas:

- **Control architectures**—addresses control architectures and/or algorithms for systems with high levels of electric vehicles (EVs) and other DERs
- **Role of DERMS and aggregators**—addresses ways to coordinate the operation of an ADMS with a DERMS and/or aggregators to manage high levels of EVs and other DERs
- **Integration with buildings**—addresses the evaluation of control and management solutions that specifically include vehicle integration with buildings (residential or commercial)
- **Communications architectures and cyber-secure data**—addresses the evaluation of solutions that specifically include different communications architectures, protocols, and/or cyber-secure solutions
- Projects selected in spring of 2024.

ADMS Test Bed Use Case Development



Configuring the Test Bed



* NREL's Distribution Transformation Tool (DiTTo): <https://github.com/NREL/ditto>

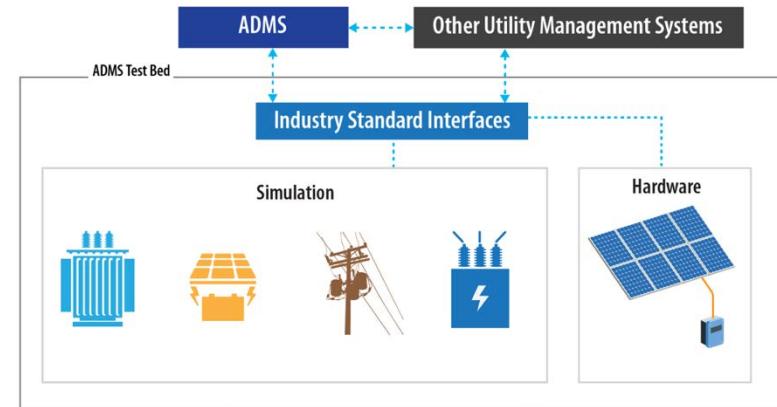
ADMS and Controls Interfaced



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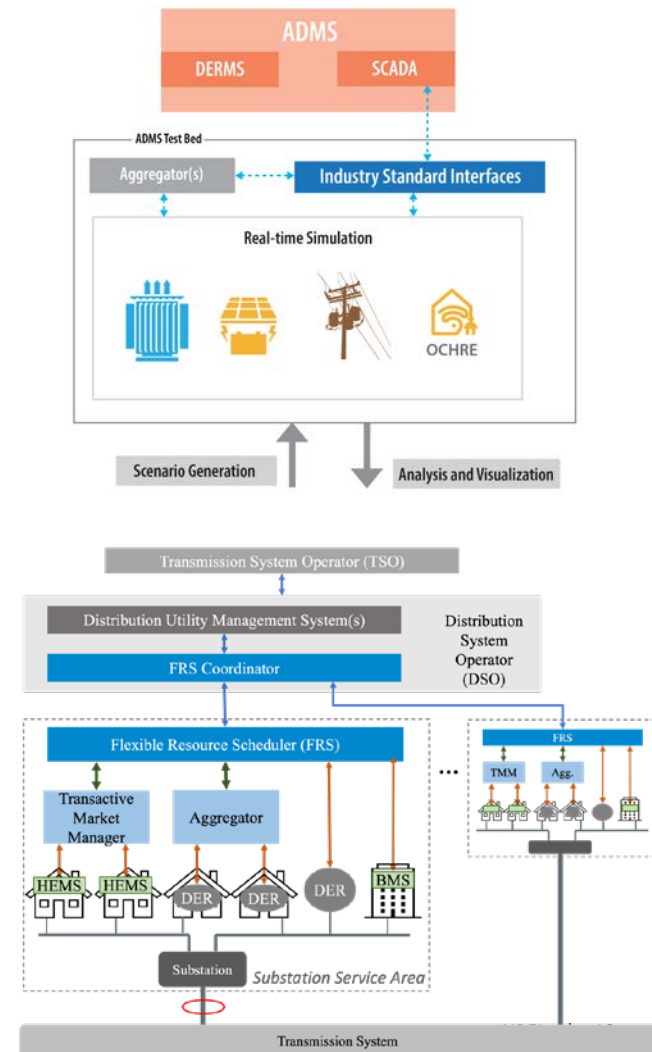
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- Commercial ADMS by:
 - General Electric
 - Schneider Electric
 - Survalent
 - Oracle (current)
 - OSI (in progress).
- Other utility management systems:
 - Varentec GEMS (now Sentient Energy).
- Research control algorithms:
 - Applications on GridAPPS-D, <https://www.gridapps-d.org/>
 - Python code, such as NREL's real-time optimal power flow (RTOFP) DERMS algorithms.



What About DERMS?

- One active project that uses the test bed (SALMON) will include a DERMS:
 - Module of OSI DERMS.
- The ESIF has invested in a Smarter Grid Solutions (SGS) DERMS:
 - A representative, state-of-the-art solution.
- Research “DERMS” solutions have been/will be interfaced:
 - NREL’s RTO PF
 - Flexible resource scheduler (FRS) from FAST-
DERMS.



Summary and Next Steps



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- NREL's ADMS Test Bed provides a realistic laboratory evaluation environment for grid controls (ADMS, DERMS, etc.) at the substation scale:
 - Real-time power system and building models
 - Hardware-in-the-loop capability
 - Can evaluate commercial and research grid controls.
- Mature capability, so OE programmatic funding is ending in Fiscal Year 2025.
 - Shifting strategy to pursue funding opportunities that have laboratory evaluation requirements/opportunities:
 - All three Office of Clean Energy Demonstrations awards selected for negotiations will use the ADMS Test Bed.
 - Capability enhancements are challenging to support without programmatic funding, e.g.:
 - Scaling beyond a substation for commercial controls is limited by the time to configure communications → need to automate.

Thank You

www.nrel.gov

NREL/PR-5D00-92384

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For Further Reading



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