GRID STORAGE LAUNCHPAD

Interoperability and Reliable Operation of Energy Storage

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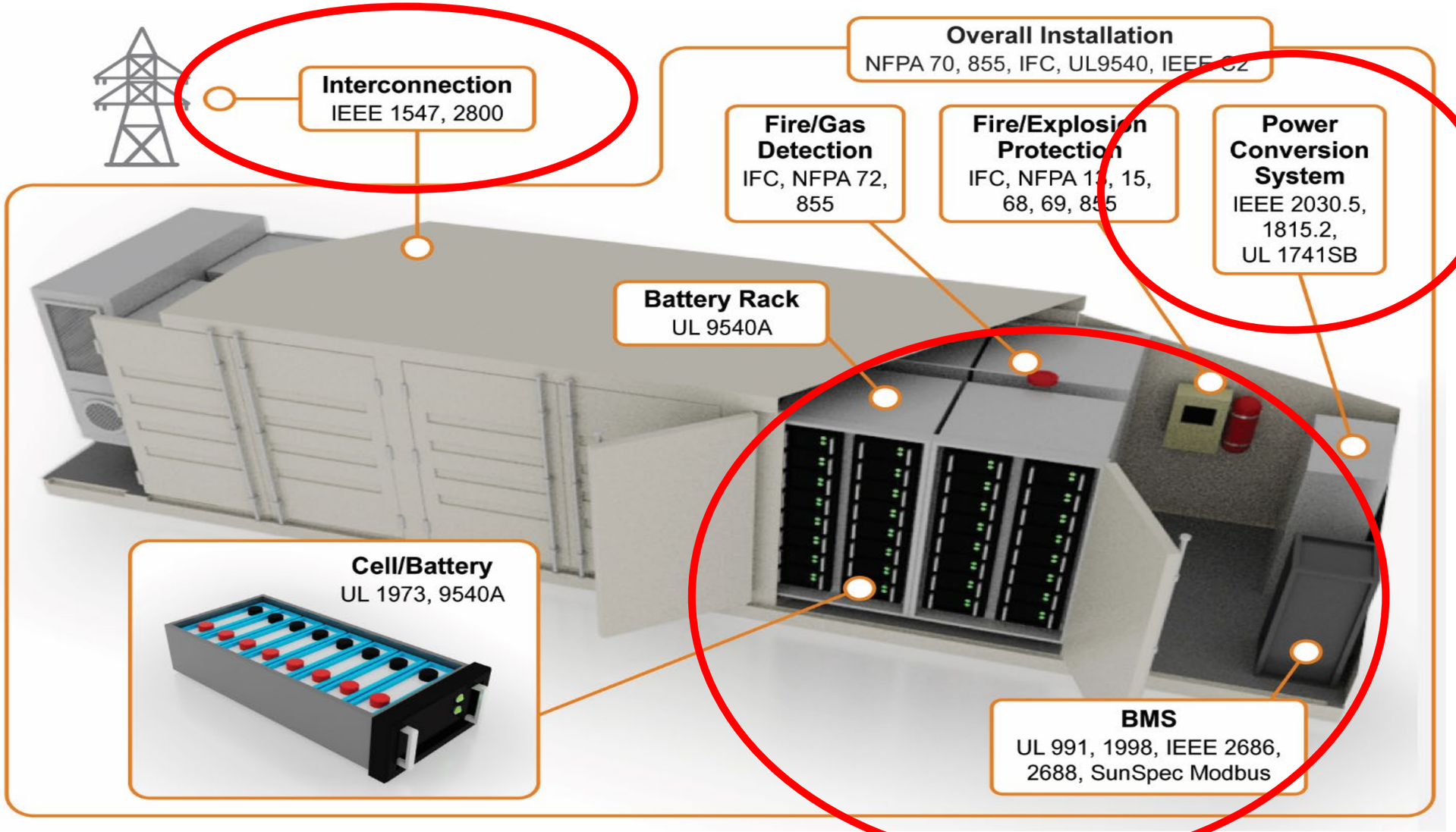
DOE OE Energy Storage Peer Review & Annual Meeting, 2026

Complex Communications and Data Exchange



Program Overview

- Goal: Develop guides, recommended practices, and standards to grow the cost-effective deployment of energy storage.
- Current Practice: Systems are deployed in an ad hoc fashion as one off projects with costly integration and unrealized value.
- PNNL is known for strong utility and industry partnerships, leadership in system integration, Grid Architecture, and standards development.
- Innovation: While working with Standards Development Organizations (SDOs) and alliances to develop standards, we also validate them from modeling to production, providing the supporting capabilities like prototyping and test tool development. This provides a grounded approach and instills confidence in technology users.
- Duration: Focus on outcomes of FY25 and for FY26
- Impact: Reduces integration costs for developers, utilities, and customers. Ensures reliable operation for operators. Provides reference implementations of standards, fill industry gap in standards and tools. Enables value stacking for owners.
- Vertical/Investment Area:
  - Grid Integration and Field Validation
  - Safety & Reliability
- Alignment/Supports strategic pathway: Reduces cost and increases capability that support grid stability and growth while providing a vehicle to further optimize ESS controls.

Problem Statement

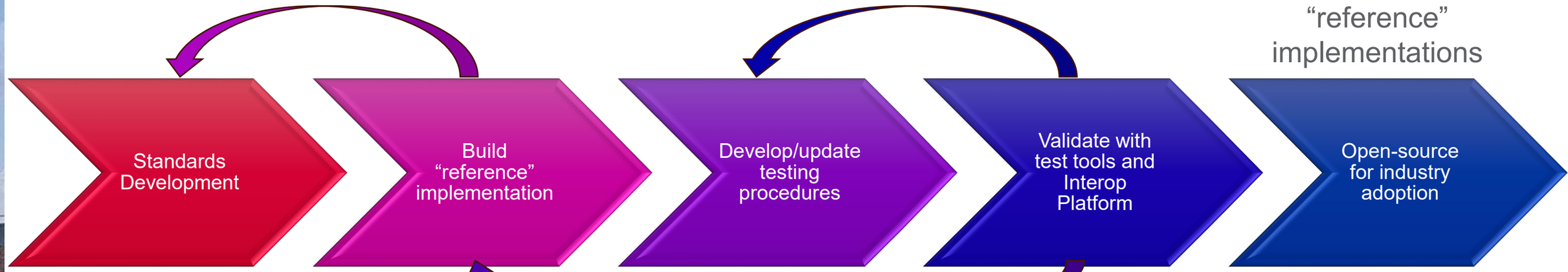
- Standards are constantly evolving, not well defined, and sometimes don't exist.
- Test procedures are limited, typically only covering those that are mandated through codes or regulation.
- Because of the previous two, and a lack of understanding of complex ESS by purchasers:
  - Integration (mostly ad hoc) is very costly.
  - Missed opportunity of "value stacked" capabilities.
  - High expectations of ESS go unrealized.

Programmatic Approach for ESS Standards Adoption

Work with SDOs and Alliances to develop and update standards for ESS designs, interfaces, and controls

Working with stakeholders through workshops, SDOs, and Alliances to develop communications and functional test procedures.

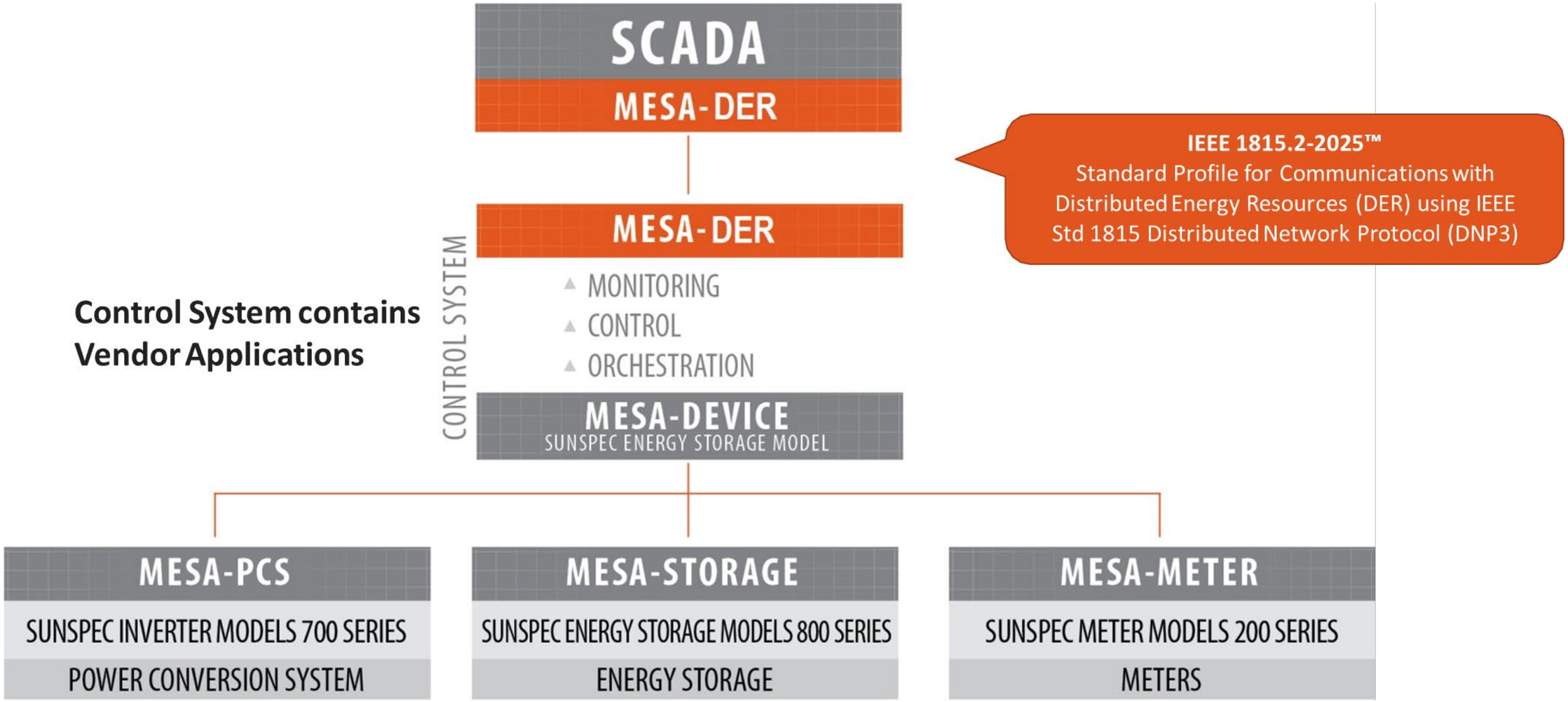
Work with GSL and industry partners to adopt/deploy ESS standards, test procedures/tools, and "reference" implementations



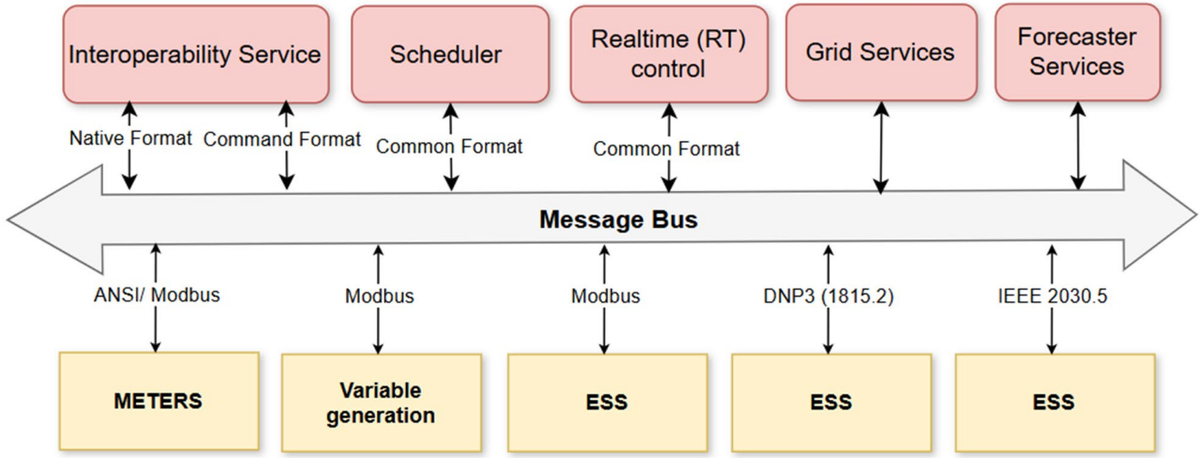
Work with Industry SMEs to develop agreed upon implementations of standards-based communications and controls. Inform procurement language.

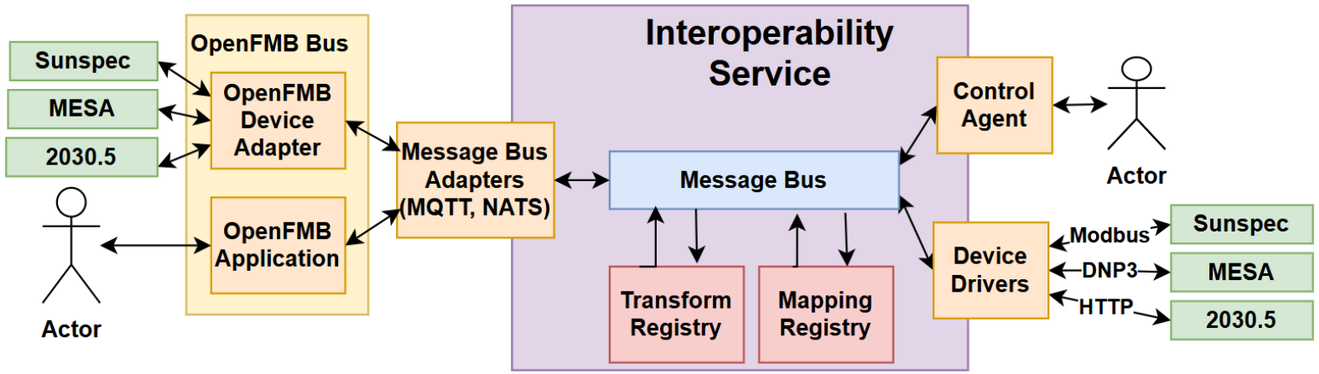
Work with ES Controls team and industry partners to validate the reference implementations. Develop open-source test tools where none exist.

MESA-ESS is now IEEE Std 1815.2!!!



Interoperable Control and Communication





APPROACH

Provide templates for standards-based communication and control to reduce integration complexity:

- Reduces vendor-specific integration effort and deployment risks.
- Supports interoperability across protocols including SunSpec Modbus, IEEE 1815.2, IEEE 2030.5, IEC 61850-7-420, and **OpenFMB**.
- Translates communication interfaces and data models to enable seamless device-to-application interaction regardless of native protocol.

Enable protocol-agnostic control and reference implementations:

- Decouples control applications from underlying communication protocols.
- Ensures reliable and consistent operation across multiple ESS and DER vendors.

Updates

More than 21 control modes including:

- Active power smoothing
- Dynamic reactive current support
- Power factor mode

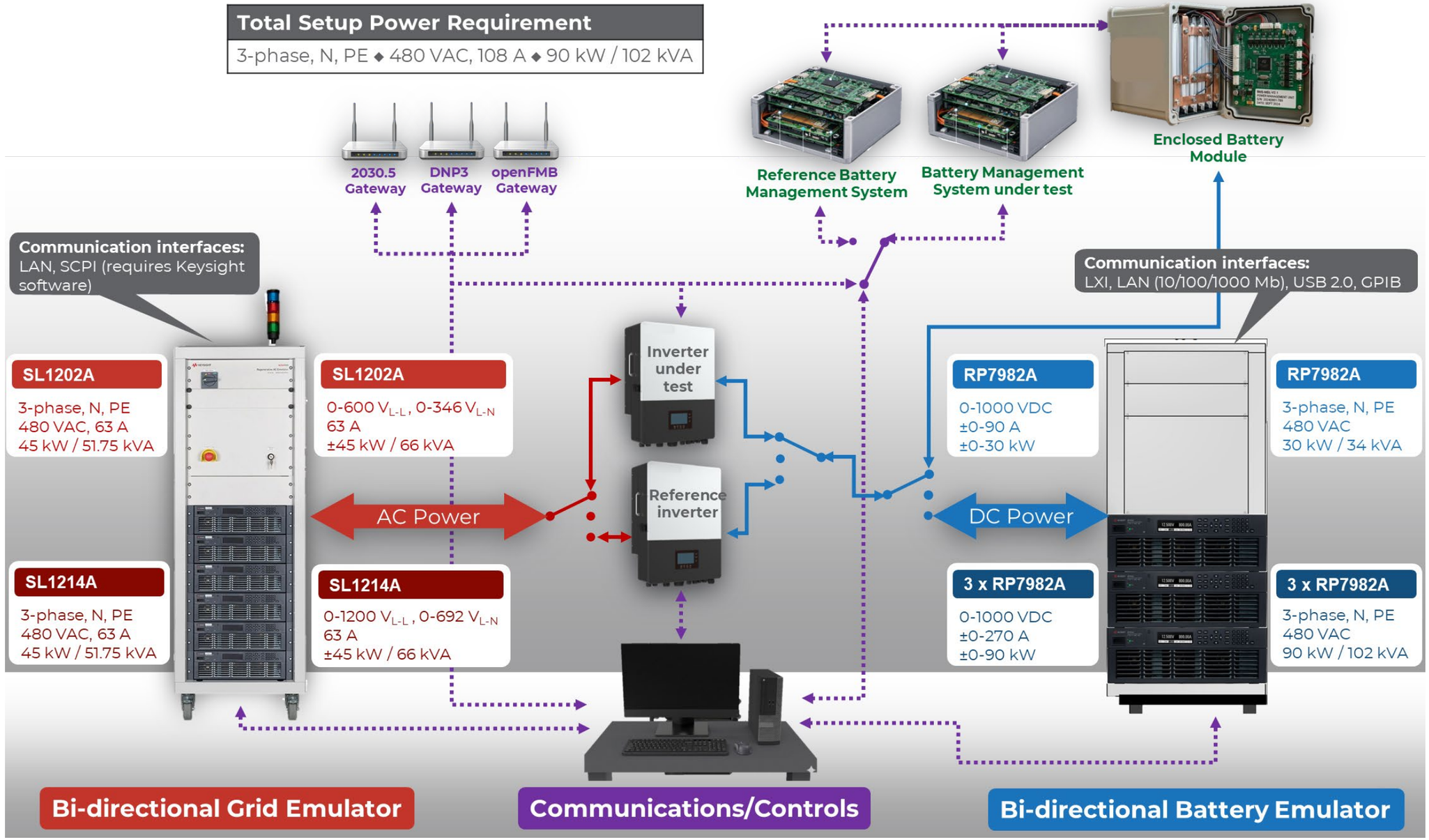
Demonstrated using:

- ESControl
- PNNL VOLTTRON ESS deployments
- Eaton EdgeAP Gateway

EPRI Plugfest

Courtesy of Ben Ealey and Brian Seal, EPRI

GSL T&V1 ESS Interop Testbench



INTEROPERABILITY TEST BENCH

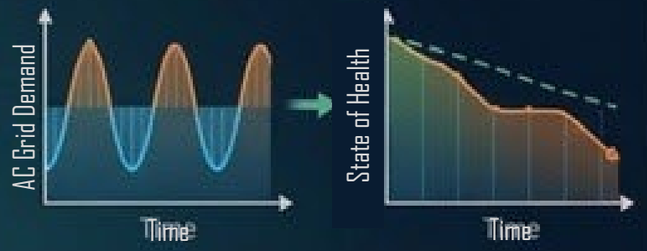
Parameterized "Standards-based" BMS

Li-ion
LFP
Na-ion

Ability to be used for various chemistries by implementing characteristics parameters

Cell Balancing, Module Balancing

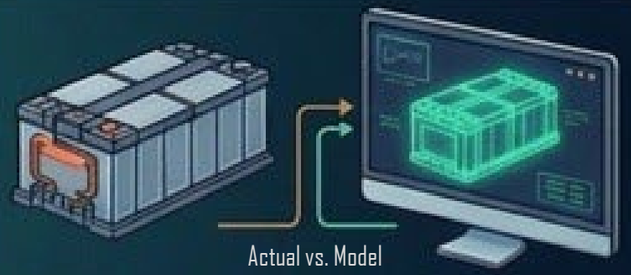
DC Degradation Studies based on AC Application (Grid Services)



Reference Control & Outstation

Control and data acquisitions from both local and remote stations

Model Validation, Digital Twin Development



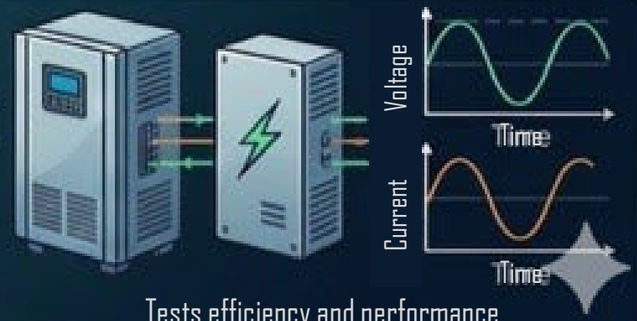
Control Mode Validation

Verify accurate response under different control schemes

Hardware in the Loop (HiL)

Simulated models interact with physical devices (e.g., BMS)

Power Electronics Characterization



Tests efficiency and performance

Acknowledgements

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- Roshan Kini – Interoperability Platform Task Lead
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- **David Reed,** Safety and Reliability Codes and Standards
- **Di Wu,** Grid Integration and Field Validation
  - ES Control Team - https://es-control.pnnl.gov/

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