



ROVI: Transformative Energy Storage Innovations for the Future Grid

April 16th, 2024
Frontiers in Energy Storage: Next-Generation
AI Workshop

Wei Wang
Laboratory Fellow
Pacific Northwest National Laboratory

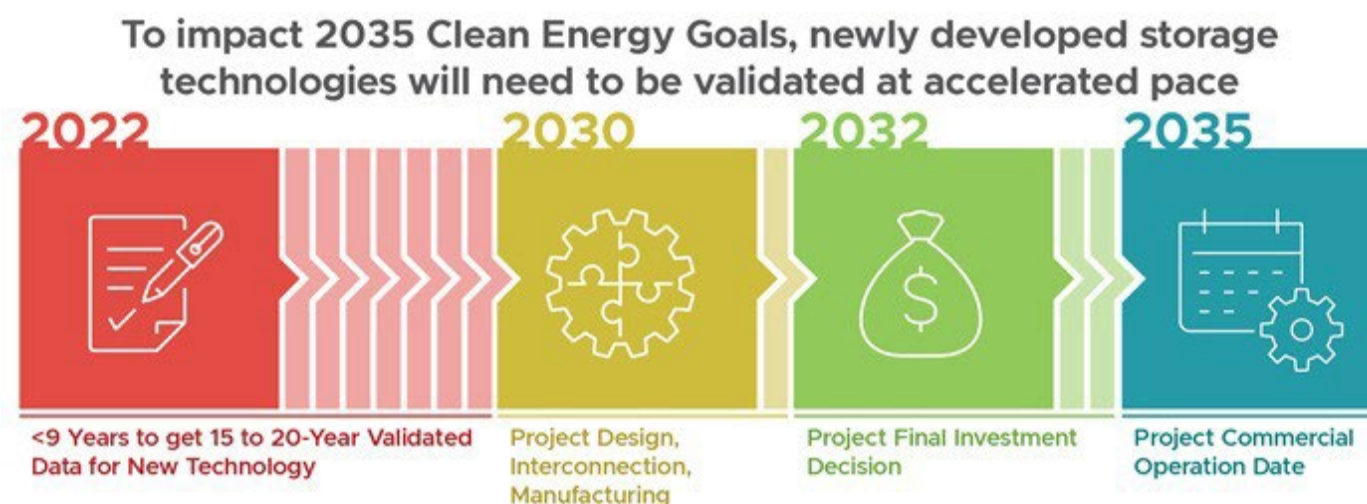


PNNL is operated by Battelle for the U.S. Department of Energy



Rapid Operational Validation Initiative (ROVI)

A six national lab consortium supported by DOE OE



- Accelerated material and chemistry discovery is needed
- Lack of means to predict the functional lifetime performance of emerging energy storage assets accurately and reliably in individual investment scenarios
- Evolving grid use scenarios impact value generation

The DOE's plan to accelerate the transition from lab to mass deployment

ROVI Story: Prior R&D at PNNL

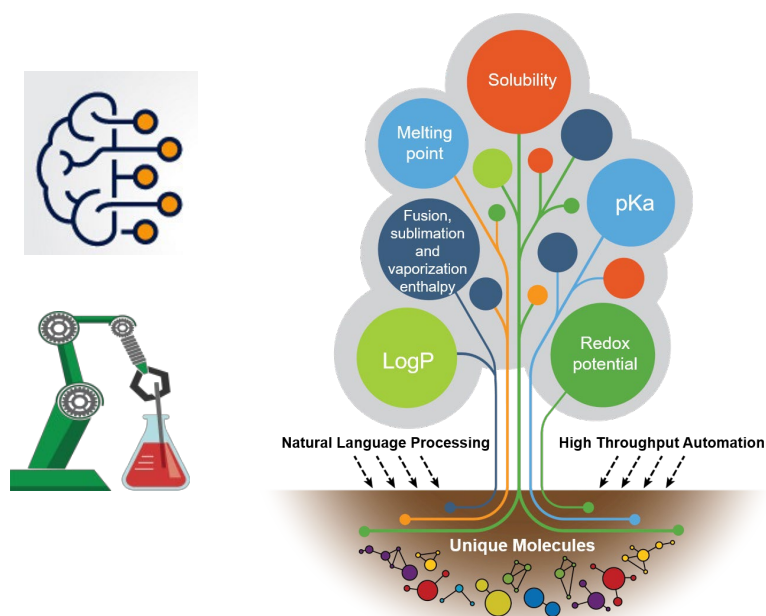
Energy Storage Material Initiative

To develop a physics-informed digital twin approach for accelerated discovery and design of battery materials and systems, integrating traditionally siloed experimentation and modeling scales.

Predicative Design: From Molecule Structure to Properties



Database Curation

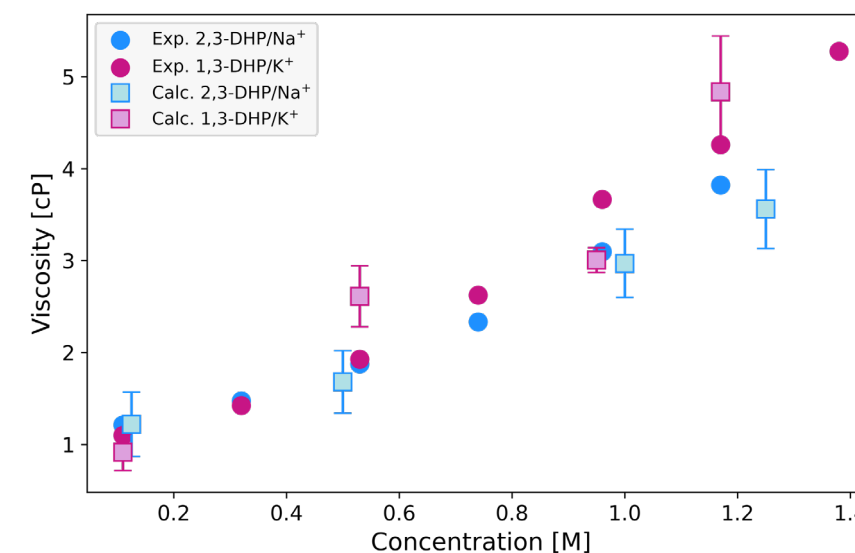


Solubility of Organic Molecules in Aqueous Solution (SOMAS) database

Automated Experimentation

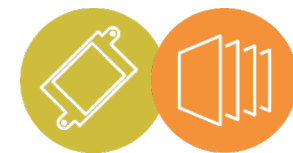


ML Property Modeling



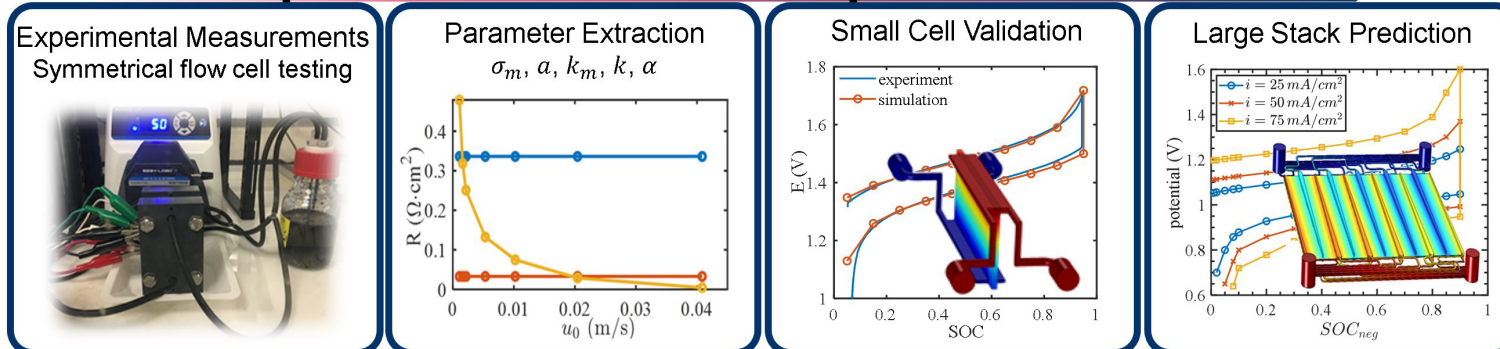
ROVI Story: Prior R&D at PNNL

Rapid Prototyping: From Properties to Cell/Stack Performances



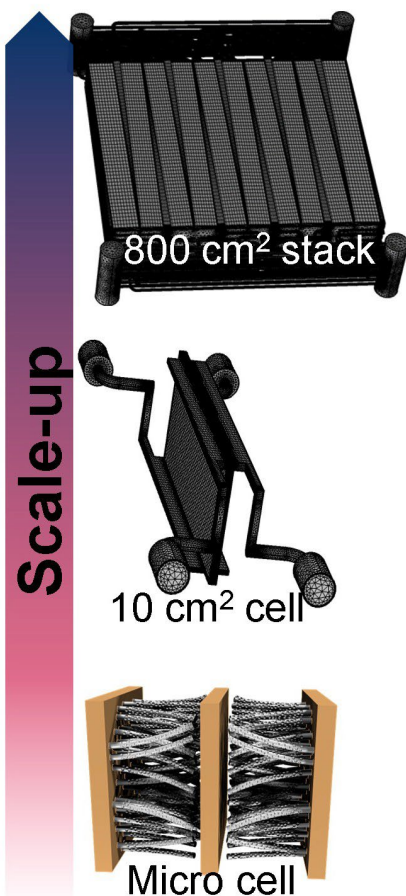
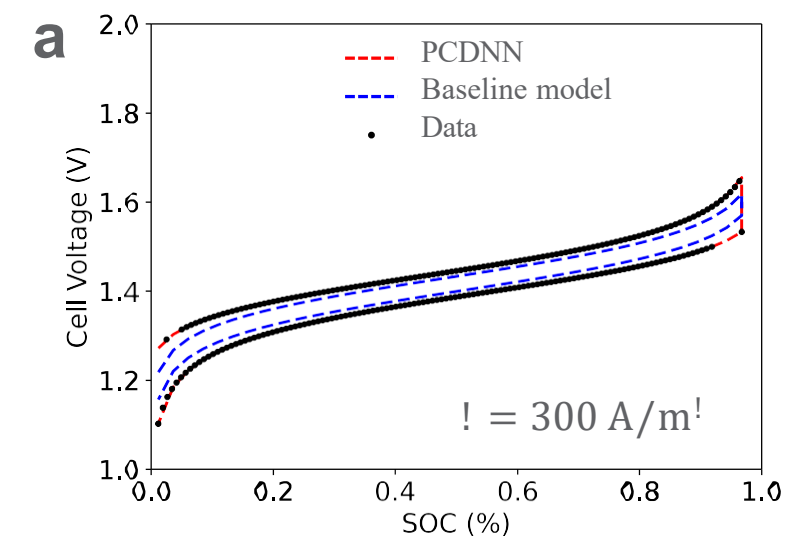
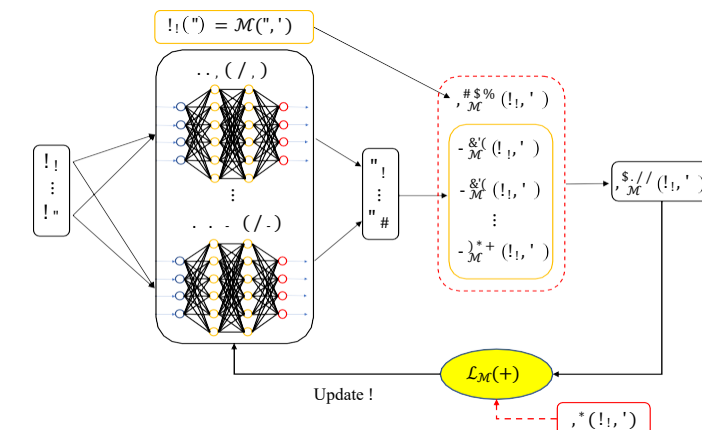
Upscale Modeling

In-situ parameter extraction protocol

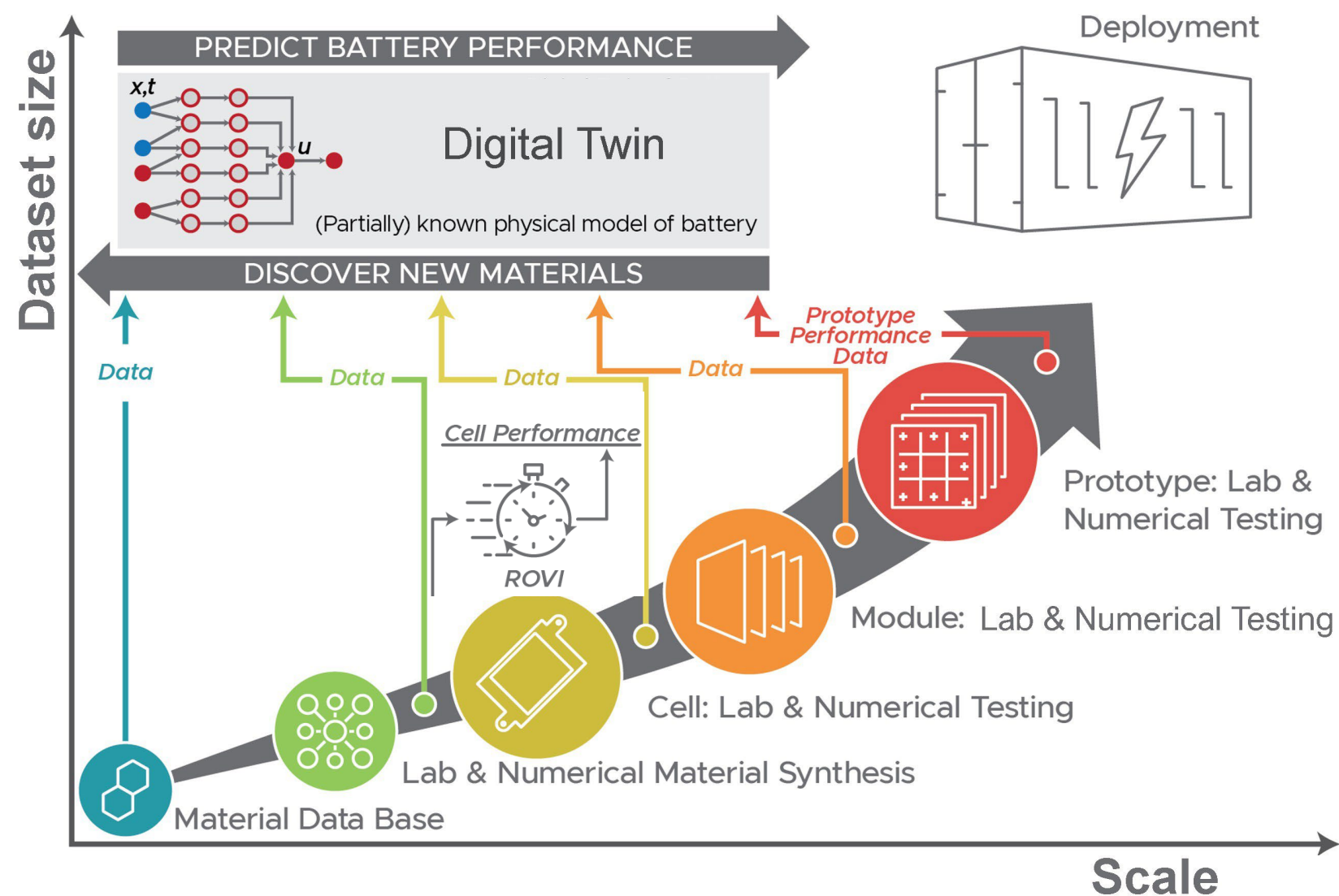


- In-situ parameter extraction
- Experimental validation of the protocol model
- Predict the large cell/stack performance

Physics-constrained Deep Neural Networks



ROVI Consortium



DOE OE ROVI Flow Battery
Lab Call issued in August 2022

PNNL led the six-lab proposal
team won the lab call and
ROVI begins in early 2023

ROVI ORGANIZATION

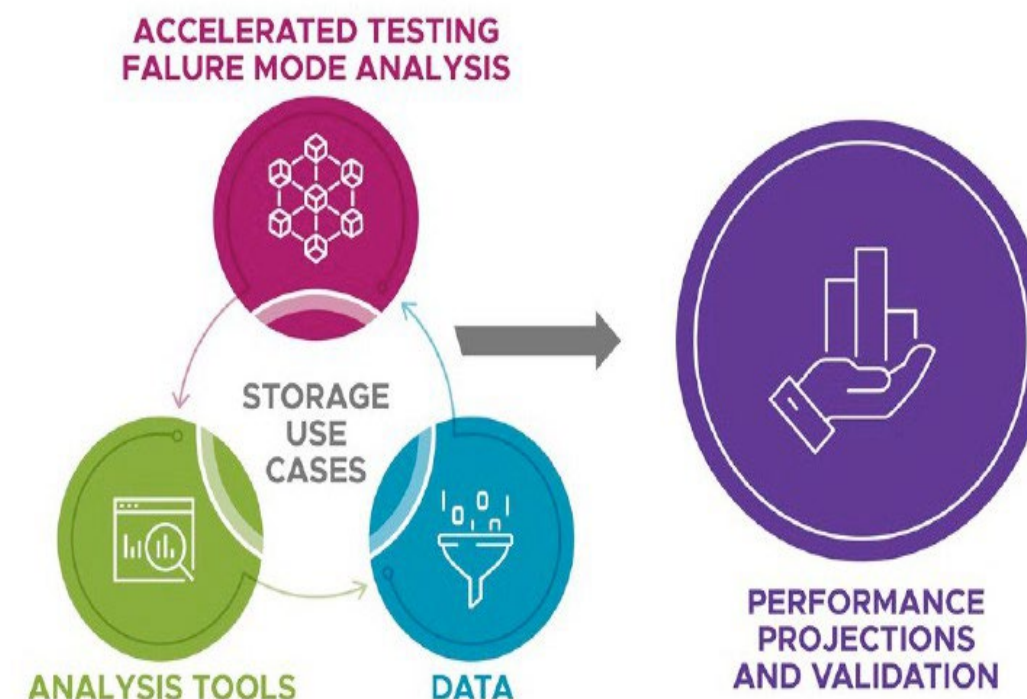
Integrating established expertise, capability, and strong support across six NLs

Use-Cases: Define use-cases (especially long duration) that inform system operating parameters

Data Framework: Collect system data and correlate it to data from lab experiments

Analysis Tools: Create a comprehensive suite of AI/ML tools that facilitate 10+ years of life prediction

Accelerated Testing: Understand technology failure modes and develop accelerated testing methods



ROVI is establishing data collection requirements for \$400 million of US DOE-funded LDES demonstration projects (for Li, flow, and beyond⁶)

Industrial Partners Involved in the Projects with Required ROVI Data Reporting



Li-ion



2nd life Li-ion



Zn-MnO₂



Zn air



Fe air



Zn-Br



Zn-Br Flow Battery



Vanadium Flow Battery



Organic solid flow battery



H₂ storage



Falling particle thermal
energy storage

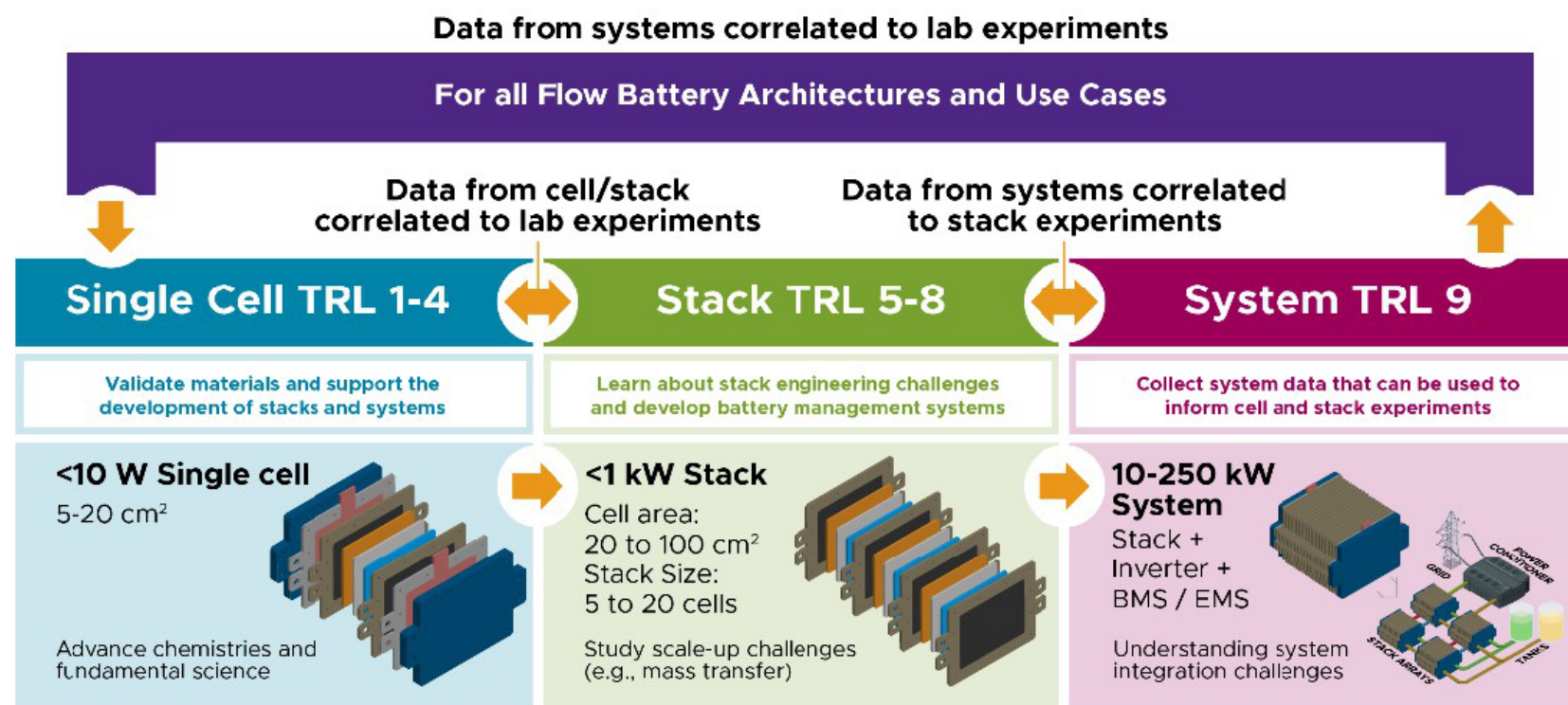


Pumped thermal storage



CO₂ CAES

ROVI DATA Needed for Accelerated Validation



ROVI requirements leverage:

- Existing guidance (e.g., IEEE, EPRI, NERC)
- DOE labs' experience with Li-ion and flow demonstration projects
- Perspectives of representative stakeholders (utility, developer, manufacturer)
- Reference Performance Test (RPT) requirements

ROVI requires data across all TRLs: from laboratory basic materials and cells, developer stack/modules, and deployment data.

ROVI Phases

Data framework is foundational 1st phase; others running parallel

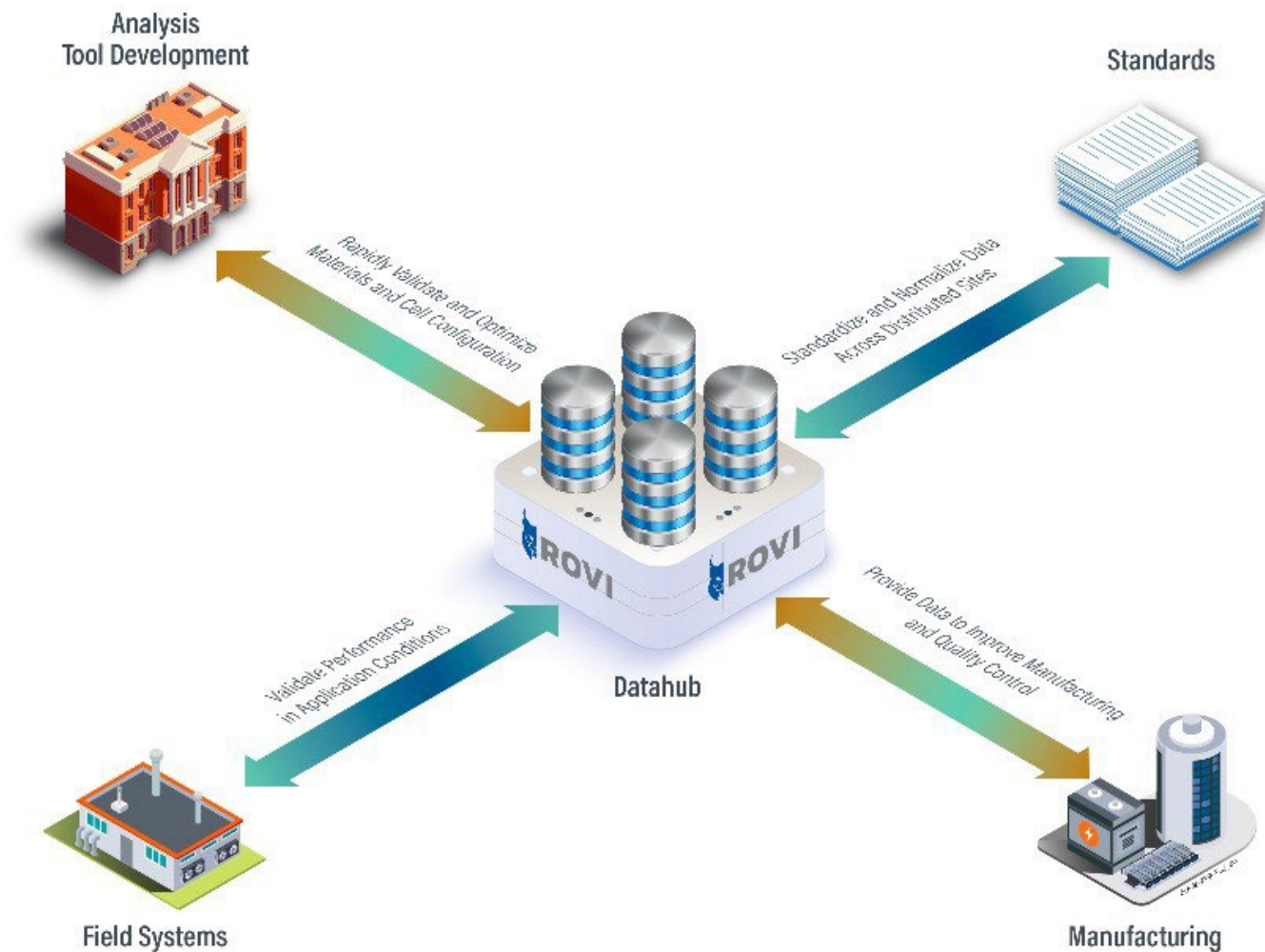
Phase 1: Data Requirements Framework

Phase 2: Collection and Monitoring Protocols

Phase 3: Protocol Implementation and Refinement

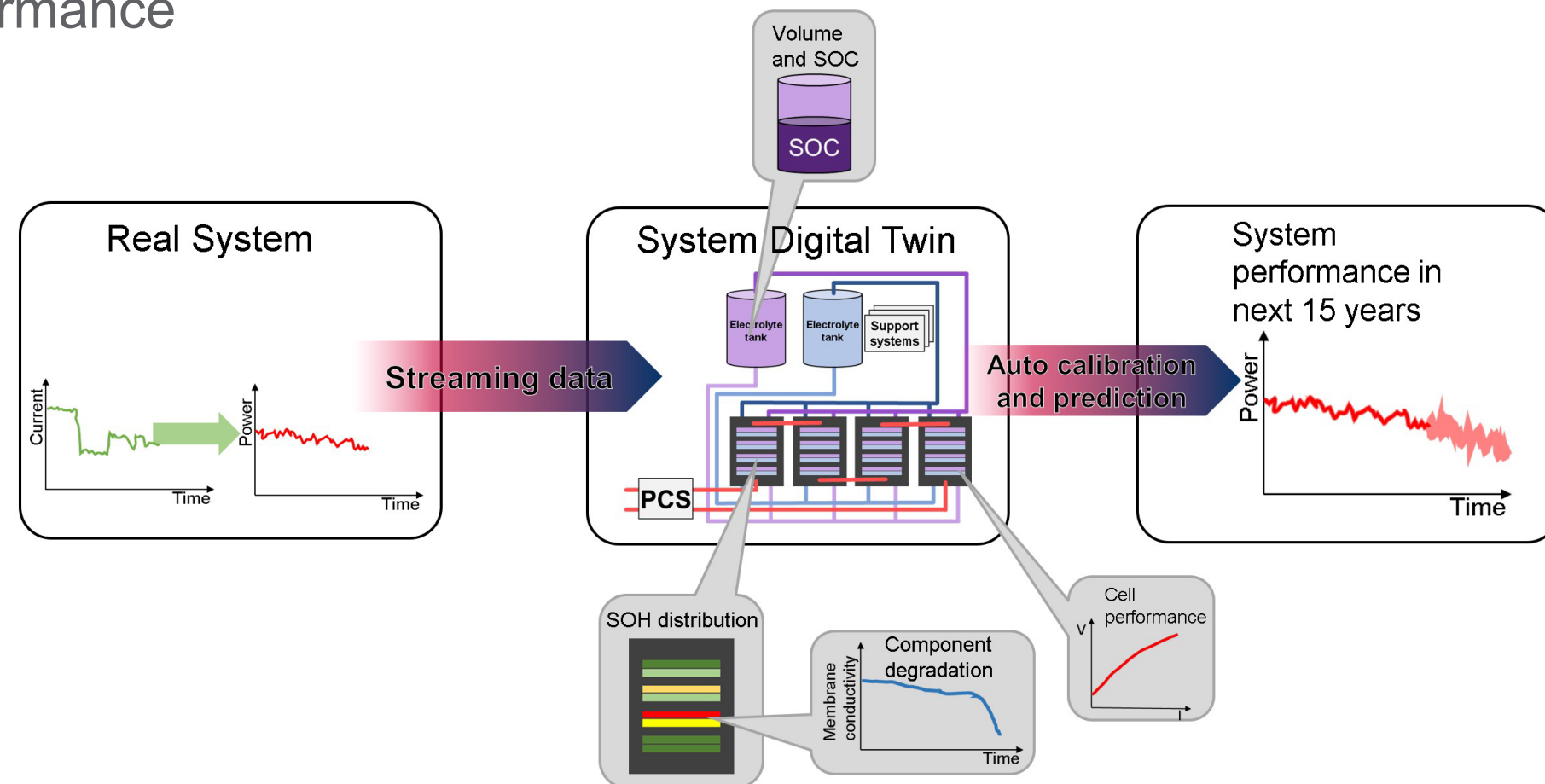
Phase 4: Data Collection

Phase 5: Testing and Validation Method Development



A Redox Flow Battery Digital Twin

- The RFB system digital twin is the surrogate of the real deployed system
- Continuously receive the streaming data
- Automatically calibrate to best match the streamed data
- Predicts the system future performance
- Predict the performance of sub-system, cell, components' degradation at any given time in an interactive graphic user interface



Thank you

