Rapid Operational Validation Initiative: Industry Roundtable

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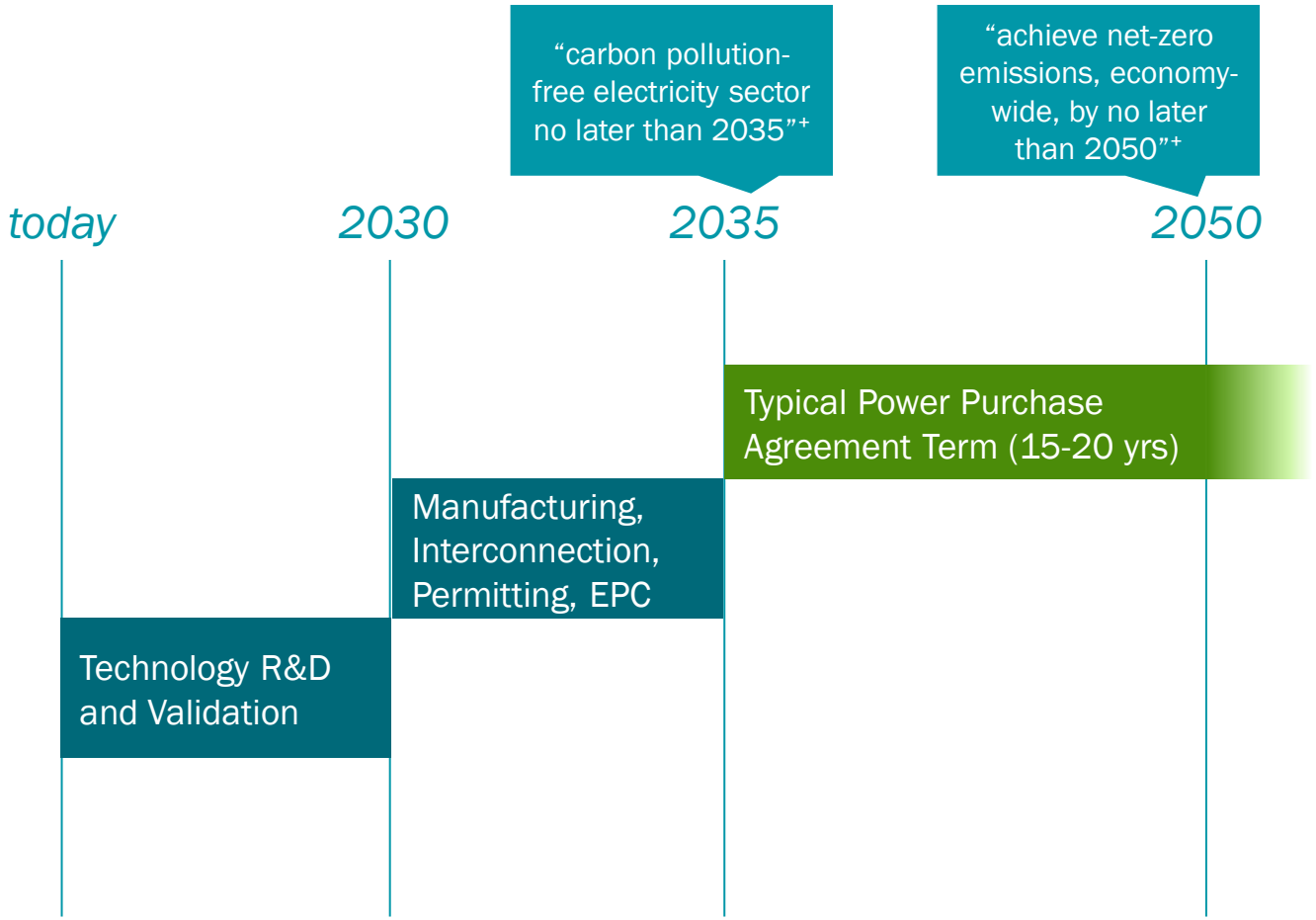
A Mismatch in Time

- New technologies will open paths to cost-effective clean energy transitions
- Utilities, end users, etc. need confidence that new technologies will work
- From now to deployment deadlines, there is less time than the length of most Power Purchase Agreements
- Need the ability to validate new technologies faster than the calendar



+White House, Executive Order on Tackling the Climate Crisis at Home and Abroad, January 27, 2021

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Rapid Operational Validation Initiative

National Laboratory Capabilities

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Rapid Operational Validation

- **PROBLEM**
  - Evolving grid has increasingly complex demands that require a step-change in the amount of accurate ES performance information needed for efficient & robust designs.
  - ES characterization today is too slow & expensive to meet urgent information needs

- **SOLUTION**
  - AI/ML for rapid, accurate & cost-effective performance characterization, with quantitatively reliable certainty

National Labs can serve as critical leaders

ROVI requires coordinated public/private participation

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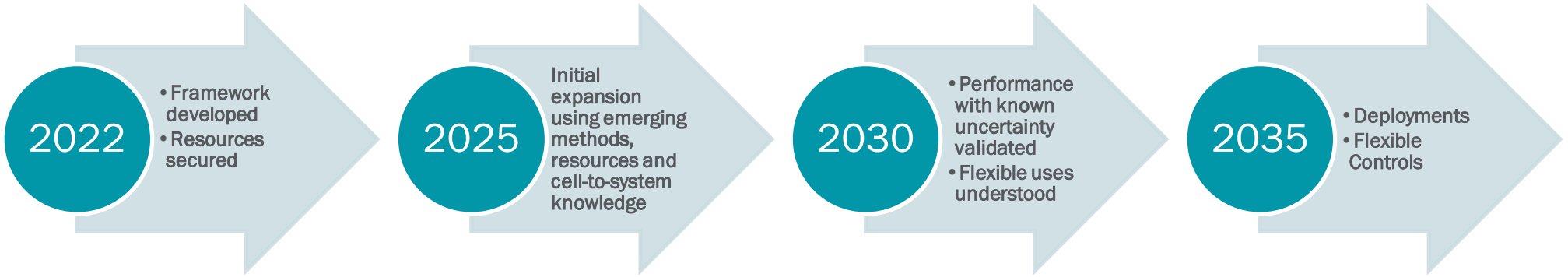
Rapid Operational Validation

- Enables *flexible, reliable and cost-effective* ES performance for an evolving grid
- Catalyzes net-zero 2050 emissions goals which require *widespread adoption* of flexible energy storage technologies
- Needs public-private cooperation to develop robust predictive framework by *harnessing characterization/use data* & developing meaningful use-cases
- Existing data and methods can provide a crucial steppingstone for method development to accelerate emerging technologies and designs



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Gaps

- **Significant data needed for ROVI resides in disparate areas - limiting ability to fully utilize advanced ML and AI techniques**
  - Slowed deployments of available commercial ES, such as Li-ion
  - Complications for emerging technologies to validate and gain traction
  - Performance uncertainty limits investment
  - Lack of understanding on path dependence resulting in under-utilized assets
- **New technology development cycle prohibitively slowed by iterative life testing**
  - Need to understand earliest stage of development at which validation is reliable (smallest representative form factor)

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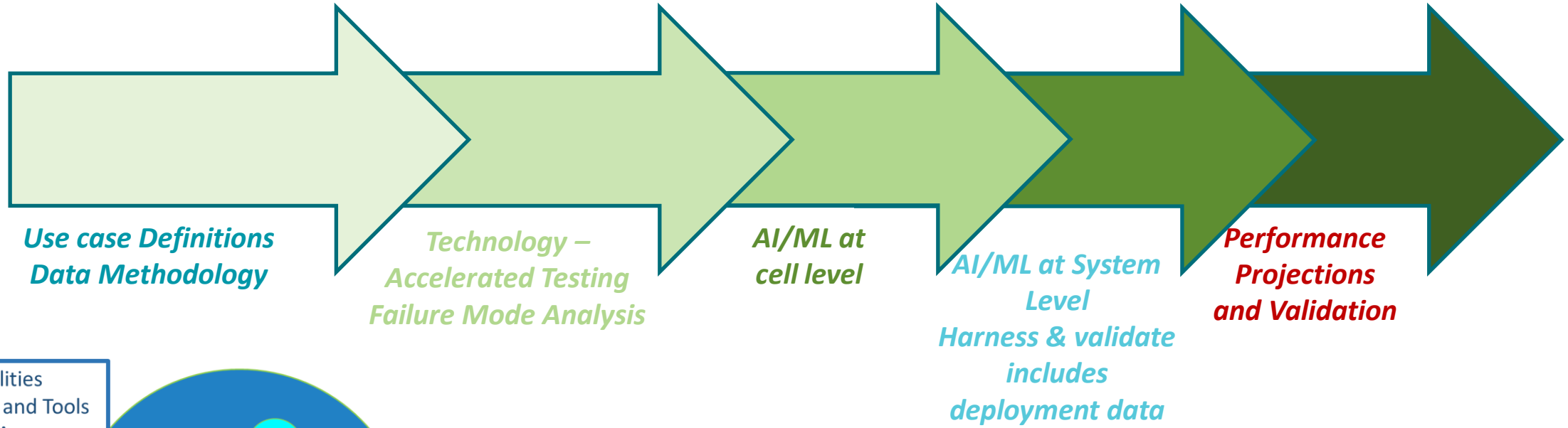
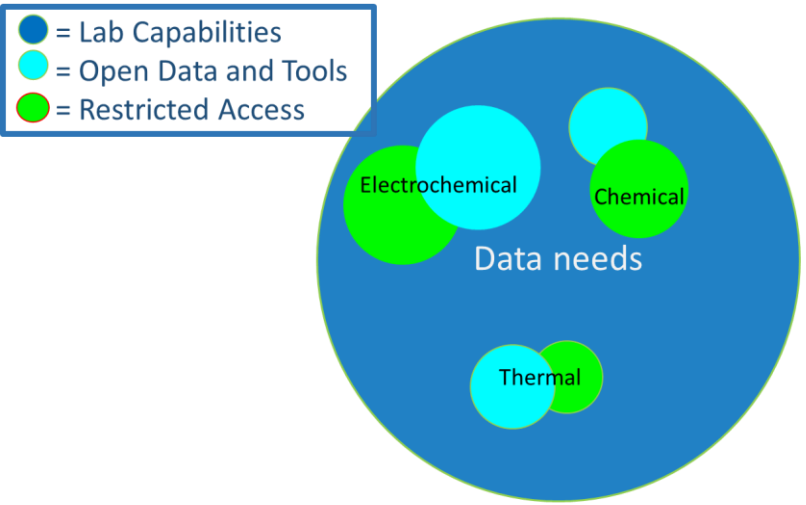
Harnessing National Laboratory Capabilities for Climate Goals





- Growing capabilities for all ES technologies
- Providing open-source software solutions
- Creating datahubs for coordination of both open and protected/controlled data
- Tool development to normalize data streams for multiple sources
- Protocol development to enhance uniformity & facilitate ML/AI use

Expanding coordination and opportunity for Data Capture, Use and Protection

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L. Ward et al. https://arxiv.org/abs/2109.07278v2

Complementary National Laboratory Capabilities

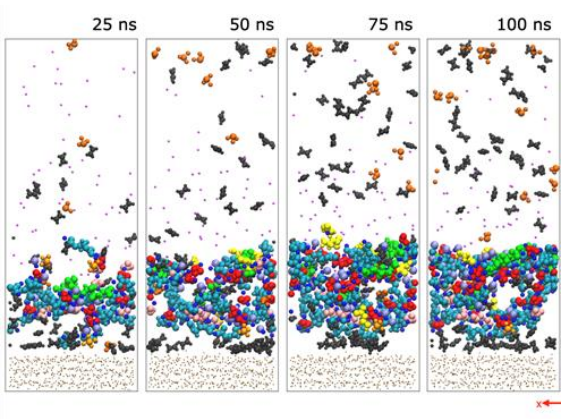
Long Duration Use case Definition

Data Methodology

Technology – Accelerated Testing Failure Mode Analysis

System – Accelerated Testing Failure Mode Analysis

Performance Projections and Validation



Understanding limitations across length scales enables use of research info for deployment

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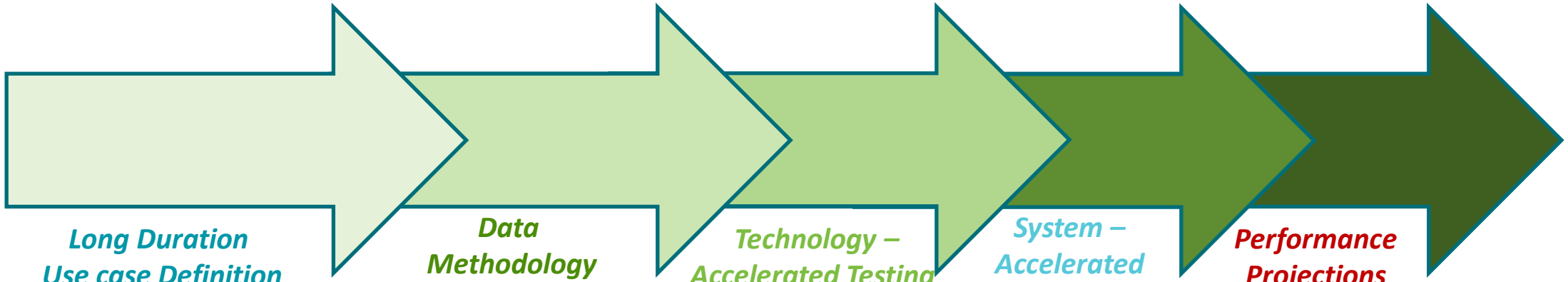
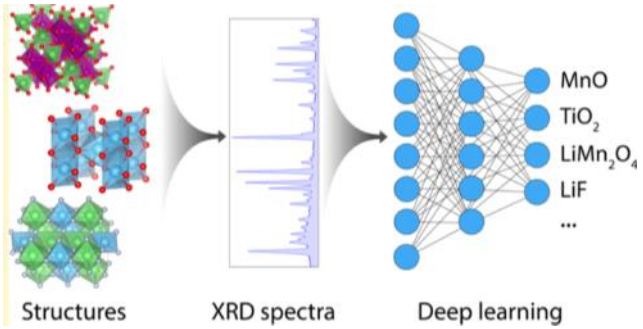
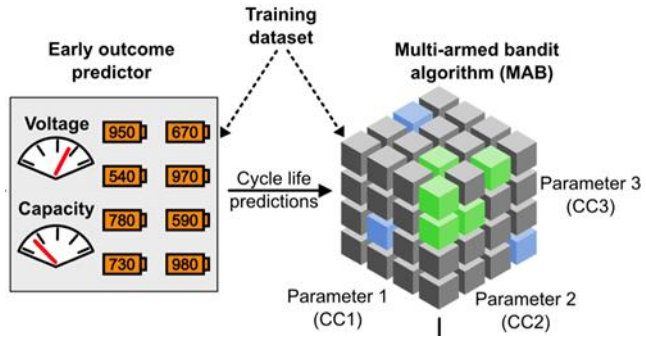
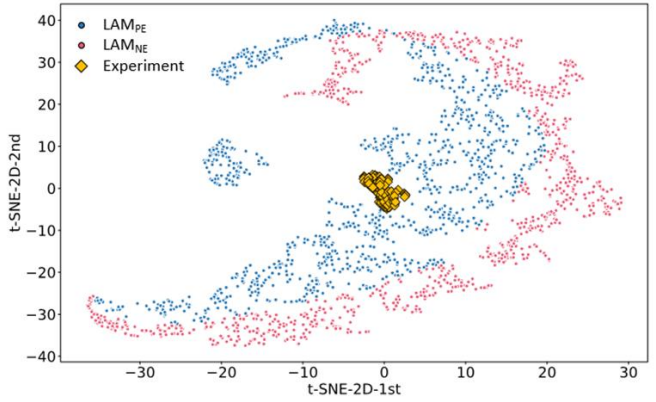
Complementary National Laboratory Capabilities









Physics-based ML & AI tools for advanced prediction across length scales enables improved accuracy in complex uses with less experimental data

Szymanski et al, Chemistry of Materials, 2021
Attia et al, Nature, 2020
Kim et al. Energy Storage Materials, 2021

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Capabilities and Technologies

Existing Machine Learning Activities

- Life, performance and failure mode prediction
- Safety/abuse response prediction
- Design and performance optimization
- Materials discovery

Aligned Technologies

- Li-ion Batteries
- Flow Batteries
- Aqueous Battery Systems
- H_2 generation, storage and use
- Low, intermediate and high temperature thermal storage
- Coordinated digital real-time simulation linking assets across the complex

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A brief glance at some of the Open-source projects and Databases

Use Case Definitions & Performance Validation

- Energy Storage Evaluation Tool (ESET, PNNL): https://eset.pnnl.gov/document#best
- Energy Storage Evaluation Application Suite (QUEST, SNL): https://www.sandia.gov/ess-ssl/tools/quest
- Battery Manufacturing Cost Estimation (BATPAC, ANL): https://www.anl.gov/partnerships/batpac-battery-manufacturing-cost-estimation

Data Collection and Methodology

- Battery Archive Database (SNL): http://www.batteryarchive.org
- Materials Project (LBNL): https://materialsproject.org/

Technology and Systems modeling of degradation and failures

- Battery Lifetime Analysis and Simulation Tool Suite (BLAST LITE, NREL): https://www.nrel.gov/transportation/blast.html
- Computer Aided Engineering for Batteries (CAEBAT, ORNL/NREL): https://vibe.ornl.gov/

Additional information on facilities, capabilities and non-open-source tools available. Controlled access data sharing environments under preparation.

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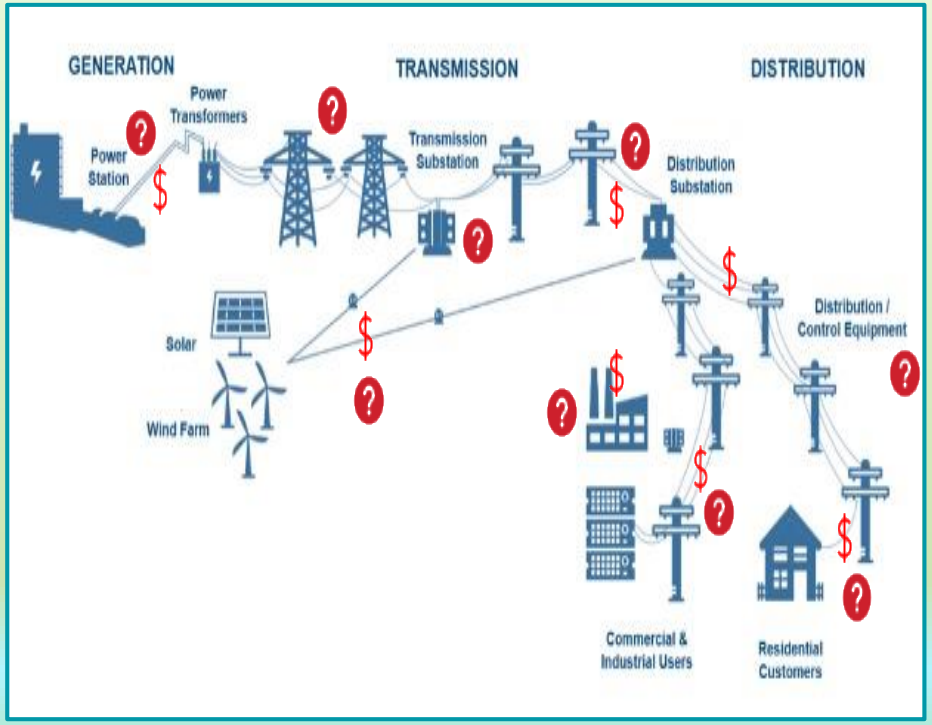
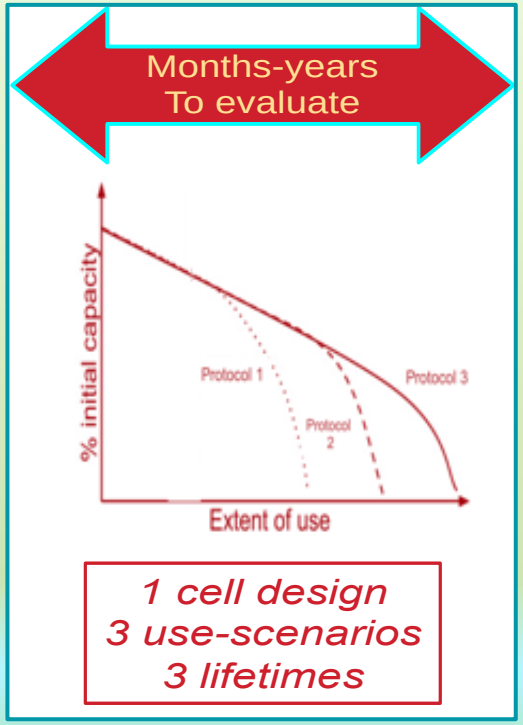
PROBLEM: INFORMATION GAP SOLUTION: AI/ML NEED: MORE DATA

1) LET'S TALK ABOUT INFO GAP TODAY: PROBLEMS? RAMIFICATIONS?

2) THE AI/ML SOLUTION – WHAT TYPE INFO DO YOU NEED? HOW BIG CAN THIS BE?

3) DATA SHARING – HOW CAN YOU PARTICIPATE & CREATE A FLEXIBLE COMMUNITY – WHAT DO YOU NEED?





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Any Questions?

Thank you!

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