Office of Technology Transitions

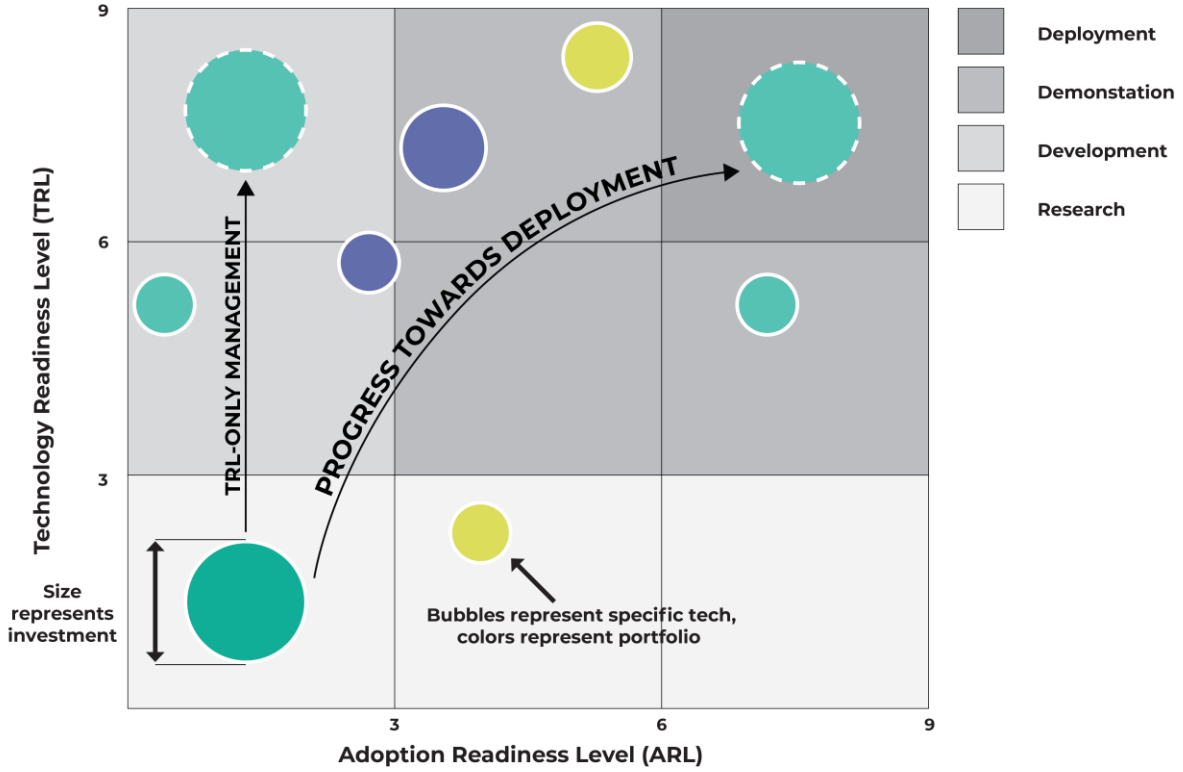
Pacific Northwest NATIONAL LABORATORY

Liftoff Lab Addendum: Adoption Readiness Level of Redox Flow Batteries

ESGC Summit
Friday, August 9th 2024

Throughout RDD&D, risks to commercialization remain high. TRLs aren't enough to drive Deployment - "ARLs" are also required

- Technology Readiness Level does not capture essential tech commercialization risk factors.
- OTT has created "Adoption Readiness Level (ARL) Framework" to describe and assess key adoption risks beyond technology risks.
- We have refined this framework through many industry discussions, as well as through pilot projects



Adoption Readiness Level – Risk Dimensions

Value Proposition	**Delivered Cost** Cost competitiveness when produced at full-scale (incl. amortization of development and capex, and switching costs		**Functional Performance** Performance compared to incumbent solutions or ability to create new end-use materials		**Ease of Use / Complexity** Operational switching costs, ability of new user to adopt and operationalize the technology with limited training, requirements or special resources	
Market Acceptance	**Demand Maturity/ Market Openness** Demand certainty and access to sales & contracting and natural / structural barriers to entry (network effects, first-mover advantages, existing monopolies)		**Market Size** Overall size and certainty of market that can be served by the technology		**Downstream Value Chain** Projected path to get product from producer to customer along the value chain	
Resource Maturity	**Capital Flow** Availability of capital needed to get to production at scale ($ # investors, insurance, speed)	**Project Development** Processes and capabilities to successfully and repeatedly execute projects	**Infrastructure** Large-scale systems needed to facilitate deployment at scale (pipelines, transmission lines, roads)	**Manufacturing & Supply Chain** Entities or processes to get to end product (integrators, component manufacturers)	**Materials Sourcing** Availability of critical materials required (rare earth minerals)	**Workforce** Human capital and capabilities required to design, produce, install, maintain, and operate at scale
License to Operate	**Regulatory** Regulations, requirements/ standards that must be met to deploy at scale	**Policy Environment** Policy actions that can support or hinder adoption at scale	**Permitting & Siting** Process to secure approvals to site and build equipment/ infrastructure	**Environmental & Safety** Hazardous side effects or adverse events caused by the solution	**Community Perception** Perception by communities of the solution and its risks / impact	

[1] Version as of March 2023. Now available at: https://energy.gov/technologytransitions/arl

ARL Pilot: Assessing Commercialization of LDES

Goal: Accelerate the commercialization of RFB technologies through integration and use of the Adoption Readiness Level framework into national lab thinking and activities.

Why?

- Build in-house ARL expertise at PNNL, with a focus on developing a replicable approach to market research.
- Understand the value of ARLs to assessing market risks and identifying the solution space.

What?

- Conduct an ARL assessment of redox flow batteries
- Deliver findings in a Lab Addendum to the Pathways to Commercial Liftoff: LDES report (~Sept. 2024)

How?

- Capitalize on PNNL data collection, as well as publicly available data
- Conduct interviews with relevant stakeholders to confirm findings.

Who?

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Senior Commercialization Manager, PNNL

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Senior Chemical Engineer

Isabella Ragazzi, MSc.
ORISE Fellow, OTT

Methodology: Applying ARLs to LDES

1. Define key technologies & scope → Technology scope, value chain scope, timeline for evaluation

Source: PNNL

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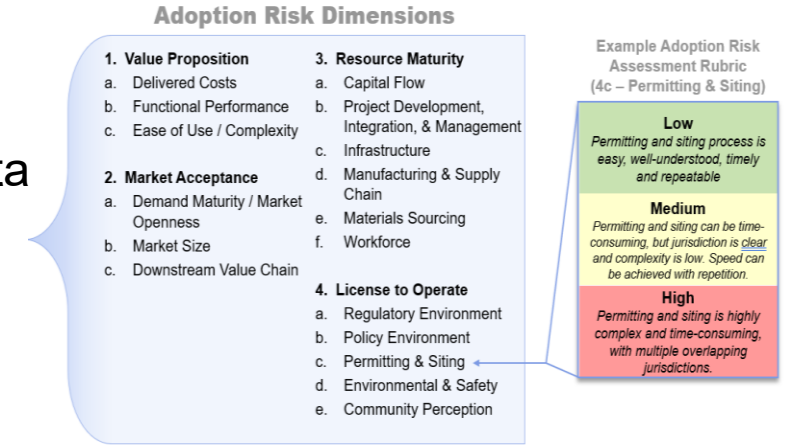
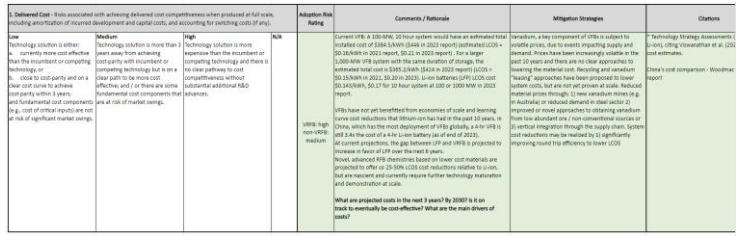
2. CARAT assessment → Publicly available reports & data; Latest performance/cost data from PNNL

Commercial Adoption Readiness Assessment Tool





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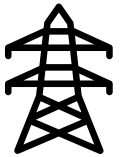
Latest performance/cost data from PNNL

3. Stakeholder engagement → Interviews with tech developers, utilities, potential customers, investors, & subject matter experts

7 tech developers

3 customers (utilities, industry)



2 ISOs

2 investors

4 SMEs (gov't, thinktanks, consultants)

18 interviews so far

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4. Share results → Briefings, publicly available report, shareable ARL assessment templates

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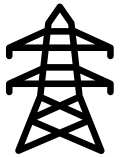

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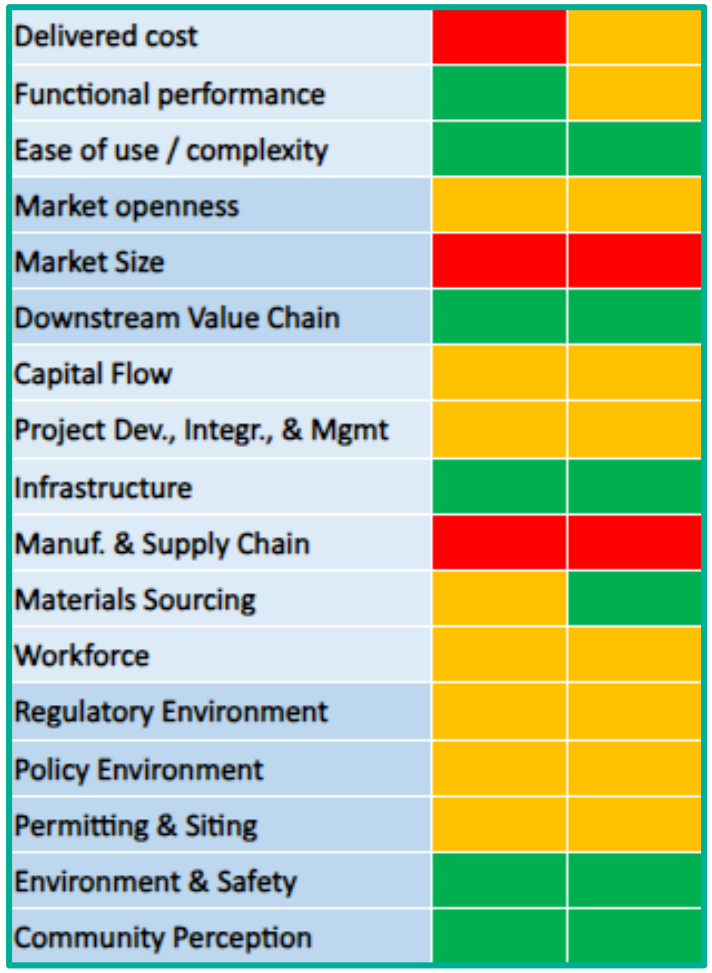
Preliminary findings suggest RFB face high risks in cost competitiveness, market acceptance, and supply chains to scale.

ARL risk levels (VRFB, Others)



Key challenges

- Steep cost declines for LFP
- Lack of market or regulatory incentives to support inter-day durations
- Limited domestic manufacturing and workforce capacity
- Geopolitical considerations around supply chains for components and vanadium
- Slow down in capital flow

Solutions we've heard work today

- Targeting behind the meter customers where economics already pencil
- Developing strategic partnerships in jurisdictions with decarbonization objectives or locations with fire safety concerns

Suggestions we've heard for tomorrow

- Market redesign (capacity accreditation, changes to modeling methods)
- Regulatory valuation of RFBS (valuing tech's safety)
- Standardize permitting and siting
- Build out of workforce and domestic manufacturing (building resource maturity)

Next steps

- Additional interviews planned through August
- Consolidation of findings published in September, 2024
- ARL assessments of other PNNL technologies

Questions?

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