3RD ANNUAL ENERGY STORAGE GRAND CHALLENGE SUMMIT

OCED Perspective on LDES Market Adoption & Commercial Liftoff

ENERGY STORAGE GRAND CHALLENGE
U.S. DEPARTMENT OF ENERGY

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Office of Clean Energy Demonstrations

THE OFFICE OF

CLEAN ENERGY DEMONSTRATIONS

DOE Energy Storage Grand Challenge Summit

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OCED Mission

Deliver clean energy technology **demonstration projects at scale** in partnership with the **private sector** to **accelerate deployment**, **market adoption**, and the **equitable transition** to a decarbonized energy system.”

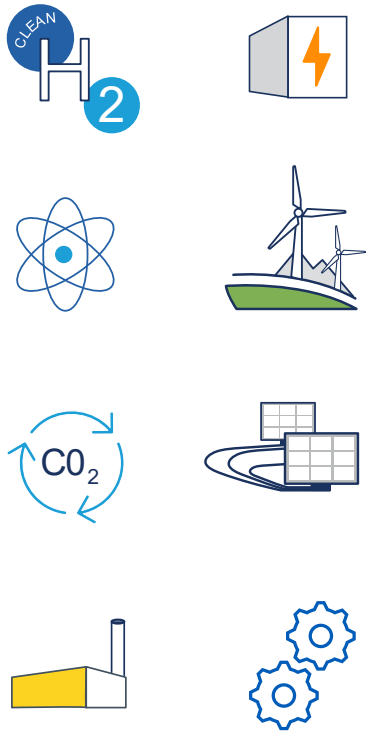
$90B+

→ $25B+

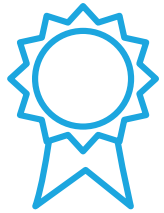
→ 50%

Early investments will catalyze a commercial wave

Focused on triggering a wave of private sector financing for commercial deployment of emerging clean energy technologies before the end of the decade.



OCED Mandate

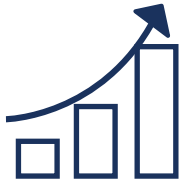


CENTER OF EXCELLENCE

Serve as primary DOE office to deliver full scale clean energy demonstration projects and project management oversight excellence

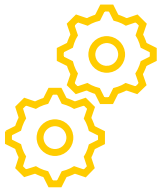
CLEAN ENERGY & EQUITABLE

Help enable 100% clean electricity by 2035 and net zero emissions by 2050 through an equitable energy transition



FOLLOW ON INVESTMENT

Unlock and scale trillion-dollar clean energy follow on investment from the private sector and other sources of capital



DE-RISK TECHNOLOGY

Maintain risk-based, balanced, and defensible portfolio of investments

ENGAGEMENT & OUTREACH

Leverage private sector and broader energy ecosystem to inform OCED and DOE technology commercialization efforts

Prioritizing Community Benefits in OCED Projects

OCED **requires** applicants to include a Community Benefits Plan to help ensure broadly shared prosperity in the clean energy transition.

By **prioritizing community benefits**, we can ensure the next chapter in America's energy story is marked by greater justice, equity, security, and resilience.

Community & Labor Engagement

Diversity, Equity, Inclusion, & Accessibility

Investing in the American Workforce

Justice40 Initiative

Long-Duration Energy Storage Demonstrations

Three programs

$350M for Long-Duration Energy Storage Demonstrations:

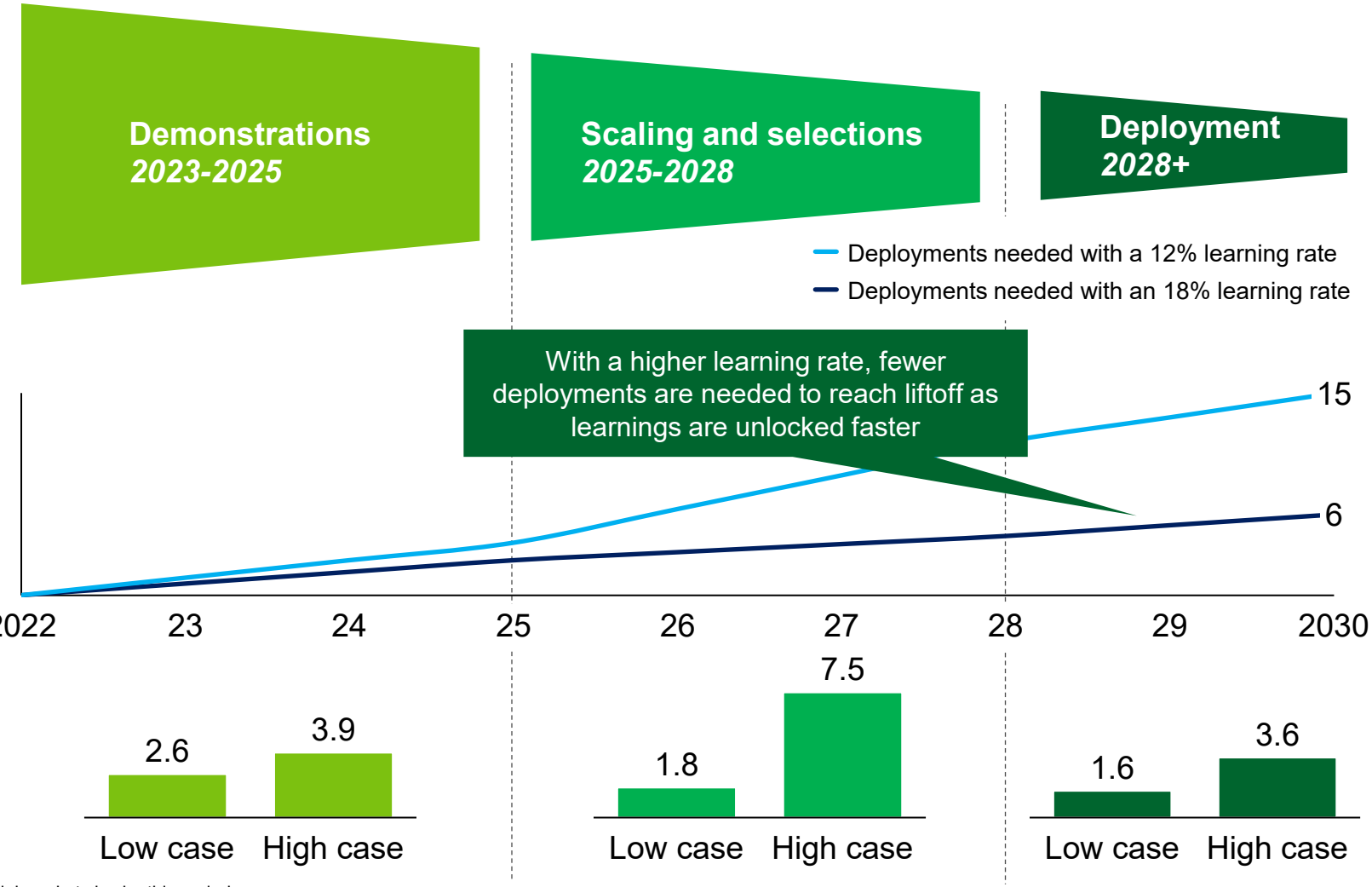
Set of demonstration projects targeted towards a range of LDES technology types.

$30M for Lab Call:

Testing and validation of early stage LDES systems and installation of LDES for resiliency

OCED and Commercial Demonstrations in LDES

External support (e.g., grants or cost share) for projects through scale-up phases assists reaching competitive technology cost / performance



$9-12B of total US investment will be needed by 2030

- Global investment will **ramp at a faster rate due to desire for energy independence**
- By 2040, **US investment alone would reach $140B**
- Specific external support of these projects could result in **3-9 technologies achieving aggressive learning targets** by 2030

1 Not indicative of total potential market size by this period

What are commercial demonstrations?

- One of the first few examples of a new technology being introduced onto a given market **at the size of a full-scale commercial unit**
- Involves far **more time, cost and risk than a prototype**, and **significantly reduces investor risk** for subsequent installations
- Combination of capital requirement and risk places them in the “valley of death”, **a stage when technologies can fail to progress commercially even if they have high market potential**
- There are three main purposes of demonstration projects:

1. **Prove Technology is Effective at Scale**
2. **Reduce Perceived Risk for Investors**
3. **Inform Market Actors on Costs & Deployment Needs**

IEA Net Zero by 2050 Report

Adoption Readiness Level – Risk Dimensions[1]

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 & Sitting** 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

Commercialization in energy is really hard

DOE Offices generally design programs to help **address these gaps in investment to crowd in private capital**

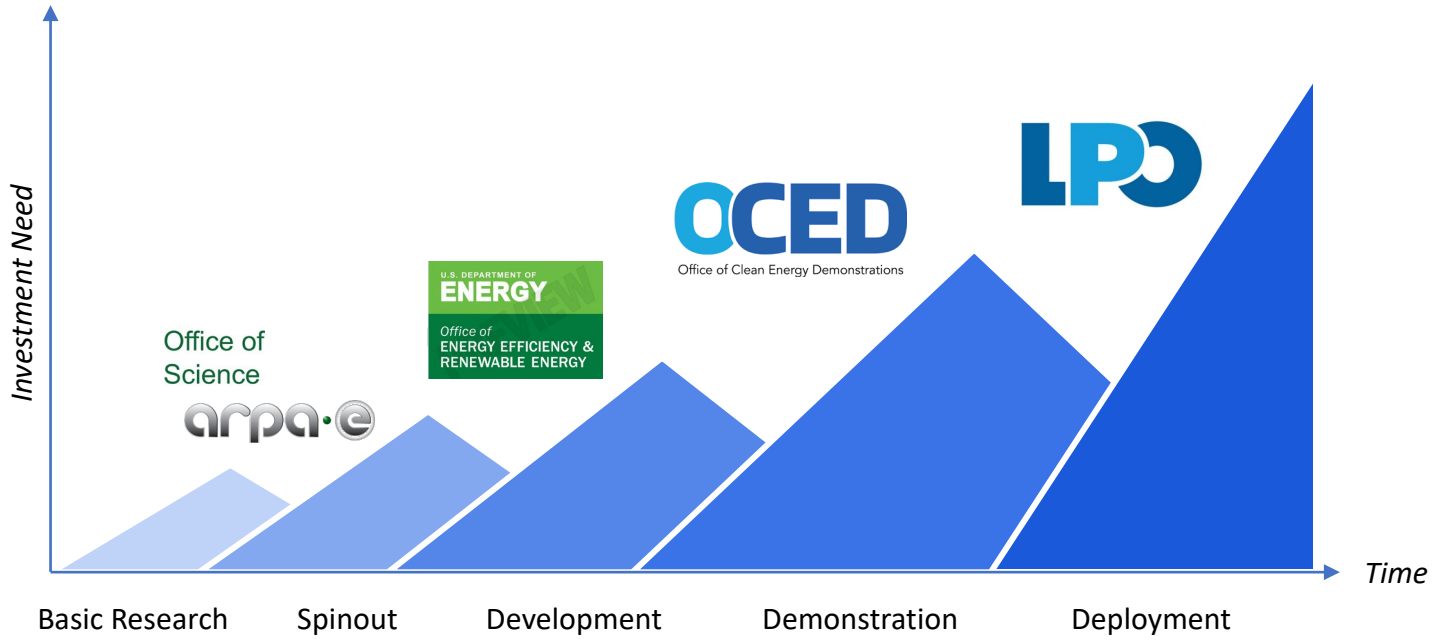
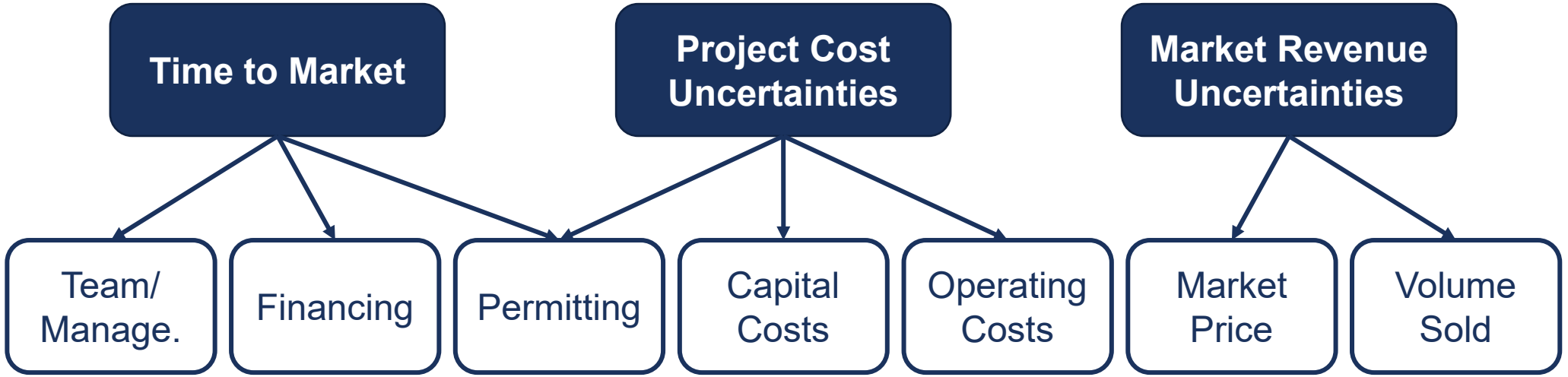
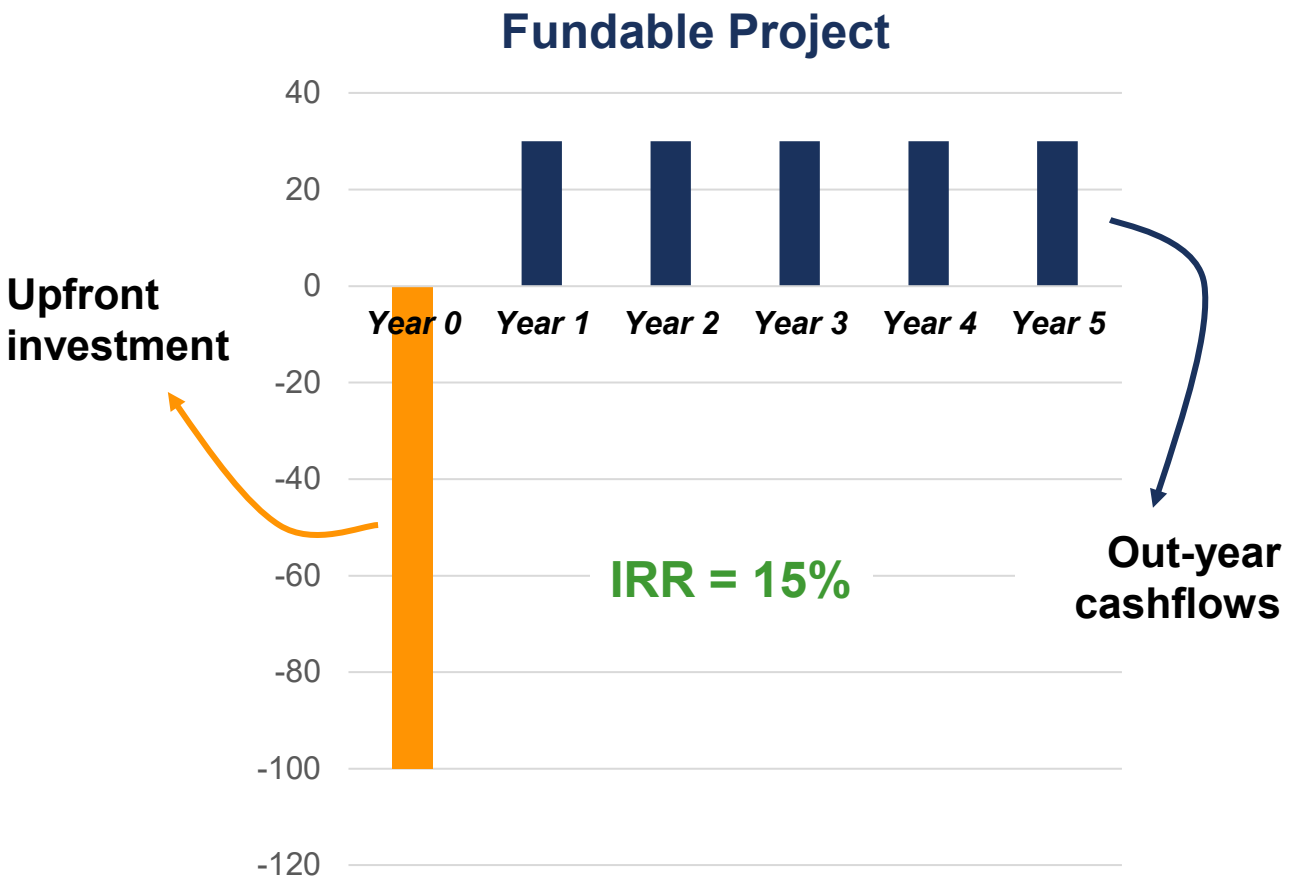


Chart: Climate Tech's Four Valleys of Death and Why We Must Build a Bridge (third-derivative.org)

What is so tricky about these project investments?

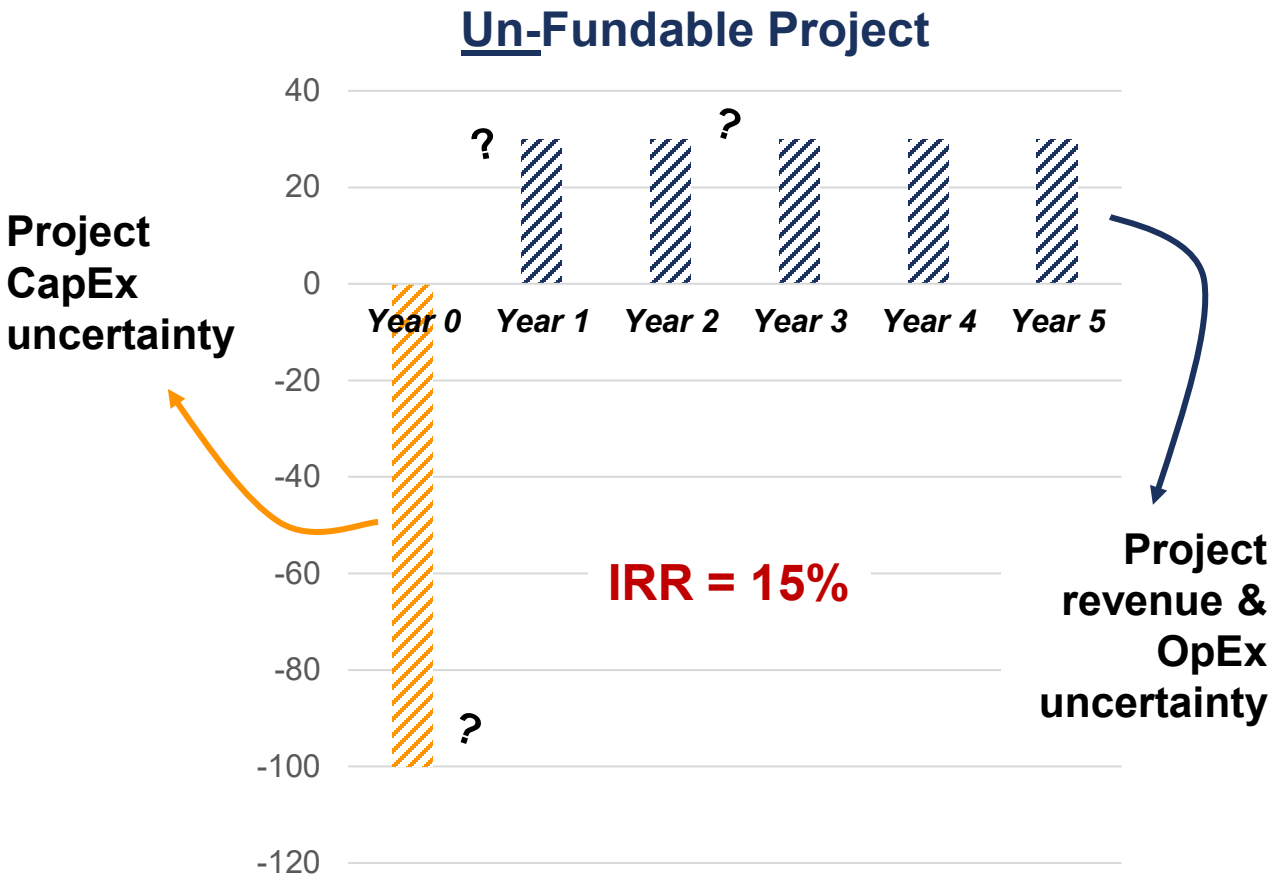


A typical project in a known sector will pencil



- ✓ **Costs are well characterized:** dozens or hundreds of installations worth of data
- ✓ **Performance is well characterized:** years of operating data from previous installations
- ✓ **Revenues are well characterized:** known market with contracted offtake or active hedging instruments

A typical project in an OCED sector might not



? **Capital costs are uncertain**

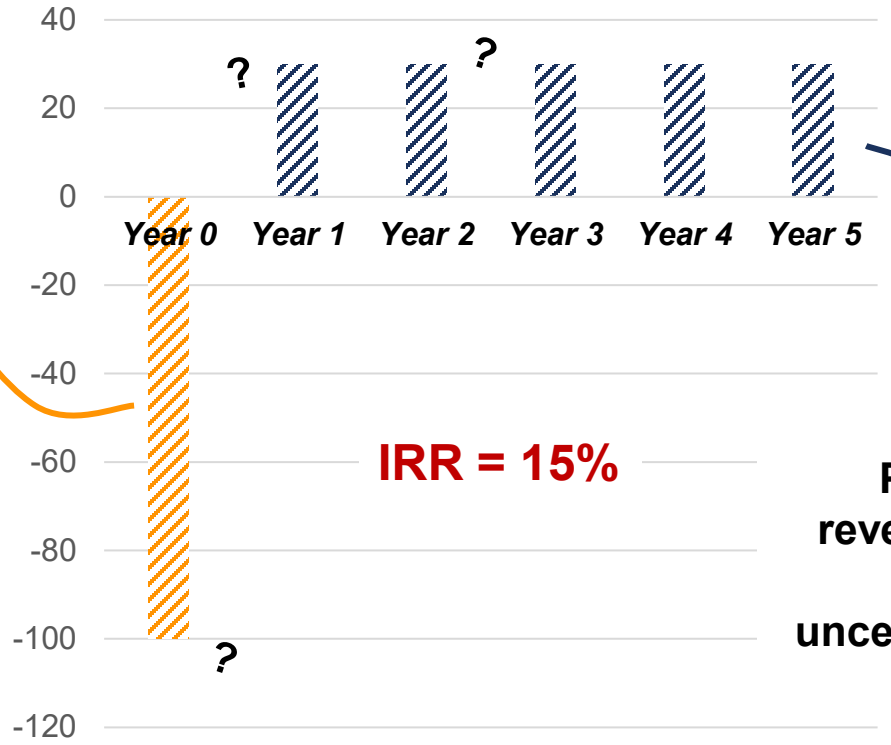
? **Tech performance is uncertain**

? **Revenues are uncertain**

Catalytic capital can take many forms

Un-Fundable Project

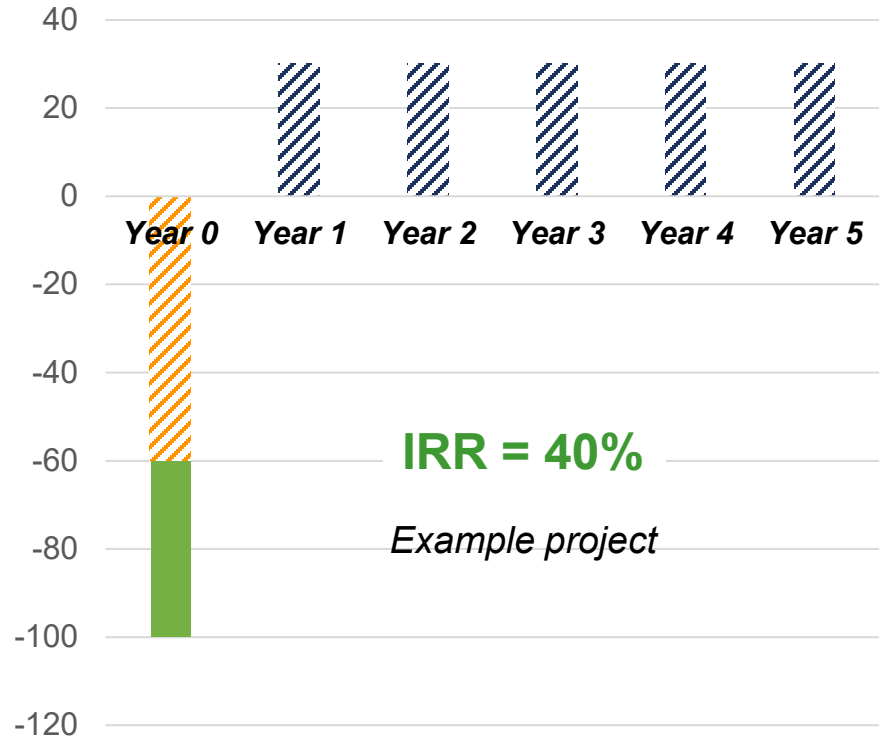
Project CapEx uncertainty



Project revenue & OpEx uncertainty

Cooperative Agreement

CapEx Support Raises Return

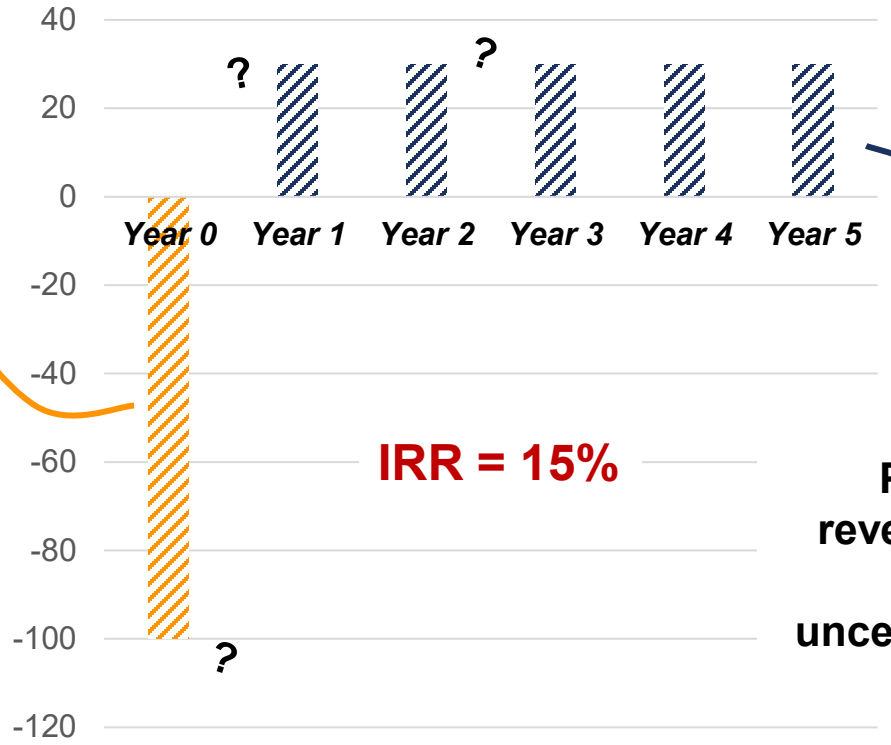


OPTION 1

- Providing up to 50% of the capital costs increases the calculated return
- ➢ Match between risk and return, project is funded

Catalytic capital can take many forms

Un-Fundable Project

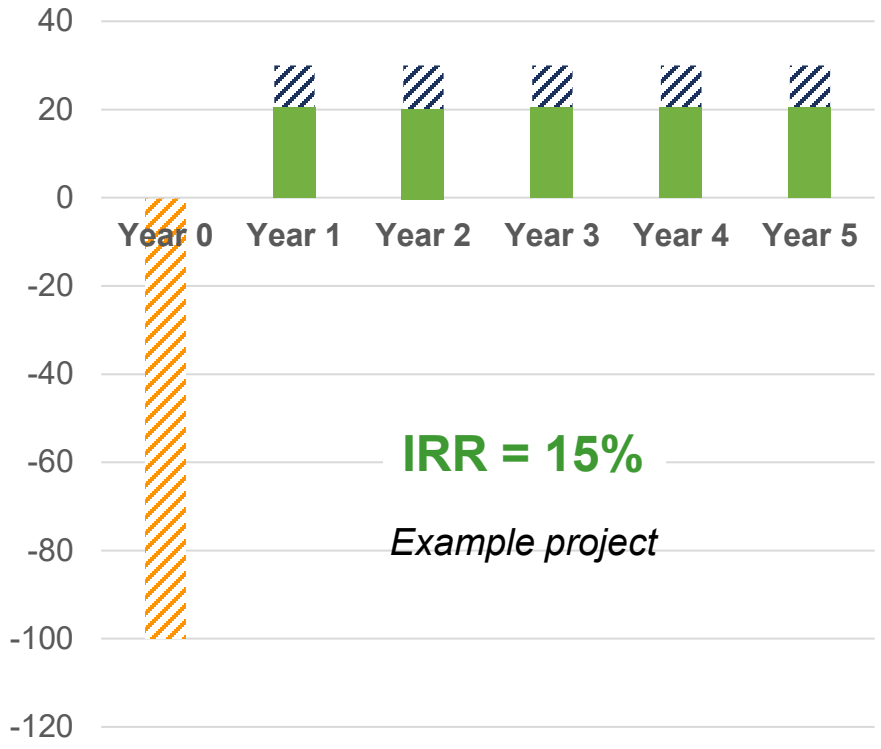


Project CapEx uncertainty

Project revenue & OpEx uncertainty

Demand-Side Support

Offtake Support Lowers Risk



OPTION 2

- Proper diligence on offtake, or direct financial support (e.g., contract for difference)
- ➢ Match between risk and return, project is funded

Demonstrations of near-term applications represent the best path towards necessary cost and performance improvements

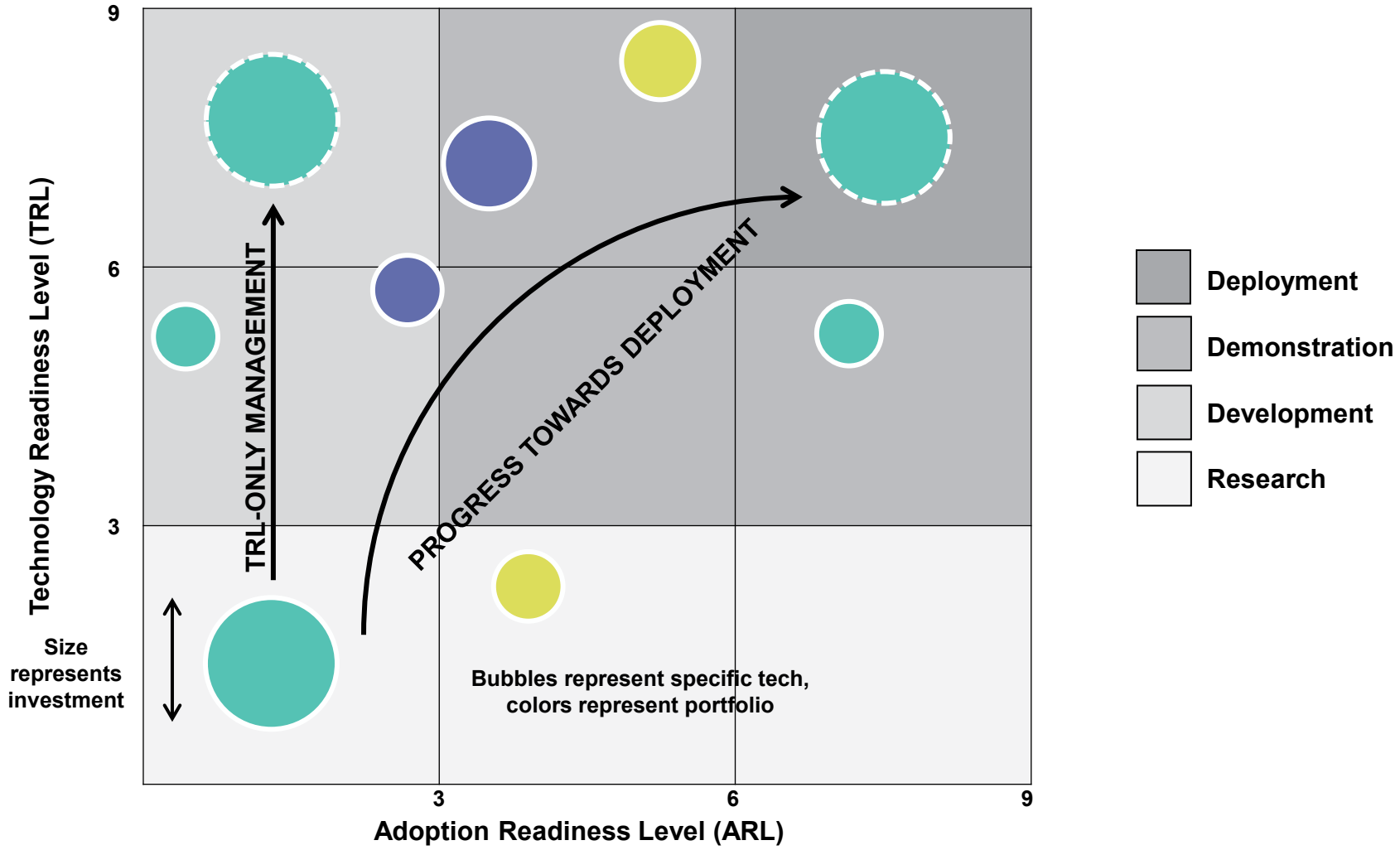
Inter-day LDES | Multi-day / week LDES | Low | Medium | High

Likely year of Deployment	Potential Market Size in High RES[1], GW	Potential Market Size with Aggressive Li-ion[2], GW	Use case	Application	Key stakeholders (non-exhaustive)	Competitive with Lithium-ion today[5]
2022 → 2030 +	28 28[3]	30 30[4]	**Load management services**	Large energy consumers (e.g., distribution centers, industrials) could use LDES to manage demand changes (e.g., freight charging purposes during peak season)	• Large peaking power consumers • Energy services players	High
	10 10[3]	1 1[4]	**Firming for PPAs**	Renewable PPAs can use LDES to ensure that businesses can procure 24/7 renewable electricity	• Leading ESG customers	High
	24 24[3]	26 26[4]	**Microgrid resiliency**	LDES can ensure reliable power in isolated areas or where the grid has shown to be unreliable / insufficient	• Local power authorities • Microgrid developers or integrators	High
	157 85 242	17 77 94	**Utility resource planning**	Utilities or CCAs can include LDES in integrated long-term energy planning to meet VRE balancing needs	• Vertically integrated & T&D utilities	High
	Highly dependent on state regulatory decisions – will be most applicable for multi-day / week LDES		**Transmission and Distribution Deferral**	LDES can offset the need for new transmission and distribution capacity by installing storage in constrained areas	• Utilities • T&D developers • Equity infra investors	Medium
	117 101 217	18 119 137	**Energy market participation**	LDES can play a role in shifting electricity from times of high supply to times of high demand, meet system peaks, and provide grid stability (e.g., inertia, frequency regulation)	• RES / T&D developers • Asset owners (IPPs) • Debt investors	Low

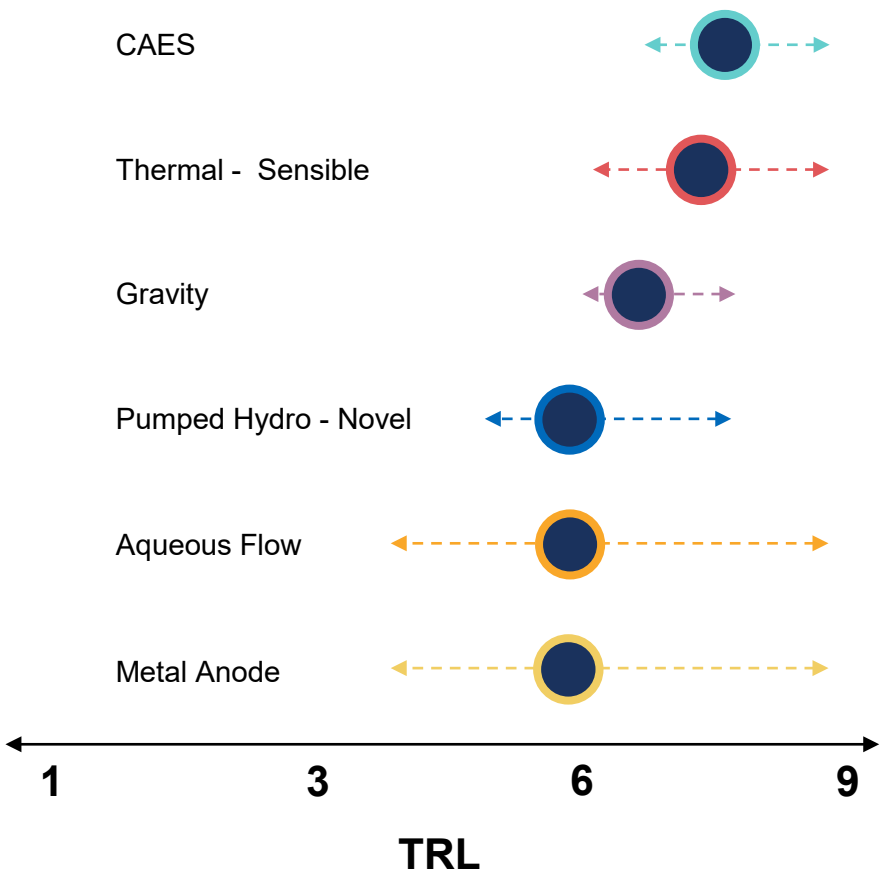
1 Based on demand potential from High Renewables Net-zero 2050 scenario
2 Based on net-zero 2050 scenario with a significant drop in Li-ion CAPEX according to NREL 'optimistic' projections
3 Based on the LDES Council Report use case opportunity sizing and adjusted to meet expected ISO demand
4 Maintains ratio of demand potential relative to sum of Utility resource planning & Energy shifting, capacity provision, and power system stability used in High-RES scenario and applies to Aggressive Li-ion scenario
5 Economic (e.g., IRR for customer) and strategic (e.g., resiliency needs, ESG goals) competitiveness for LDES compared to lithium-ion batteries

Source: NREL (Storage Futures Study: Key Learnings for the Coming Decades), LDES Flagship Report (Net-zero power: Long duration energy storge for a renewable grid)

TRLs + ARLs can be used to track progress against RDD&D



LDES through the TRL x ARL lens helps focus efforts on near-term commercialization barriers and tracking to 2030 progress



Key ARL Barriers

Value Proposition	**Delivered Cost** LDES systems today are generally not cost competitive with shorter-duration storage technologies

[1] TRL and ARL assessments distilled from US DOE LDES Liftoff Report

Execution will require focus on key leading and lagging indicators

Leading indicators by 2026

$1,000 / kW

Inter-day capex

$1,700 / kW

Multi-day / week capex

70%

Inter-day RTE

50%

Multi-day / week RTE

25+

Inter-day players meeting these indicators

15+

Multi-day / week players meeting these indicators

$75 / kW-year

Consistent capacity market access for LDES

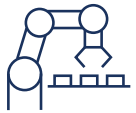
Lagging indicators by 2030

6-15 GW

Deployed LDES capacity

$10-25B

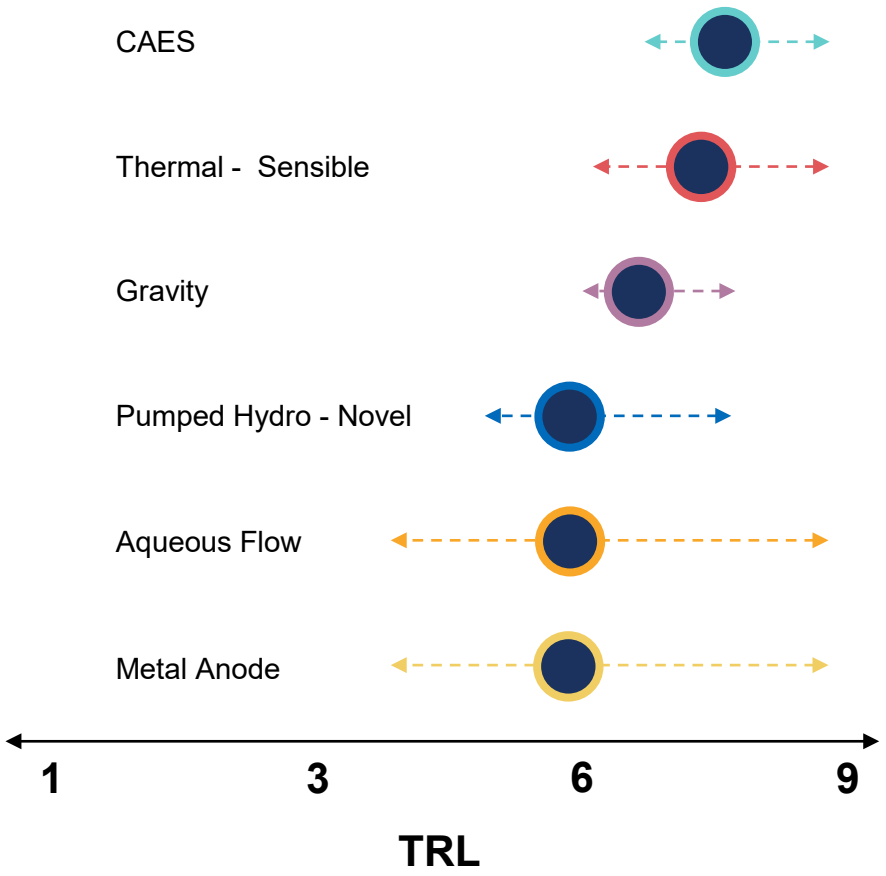
Private capital mobilized for projects



3 GW

Domestic manufacturing capacity

LDES through the TRL x ARL lens helps focus efforts on near-term commercialization barriers and tracking to 2030 progress



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Market Acceptance	**Demand Maturity / Market Openness** No consistent market construct for LDES Stakeholders (ISOs, PUCs, Utilities) with unique goals		

[1] TRL and ARL assessments distilled from US DOE LDES Liftoff Report

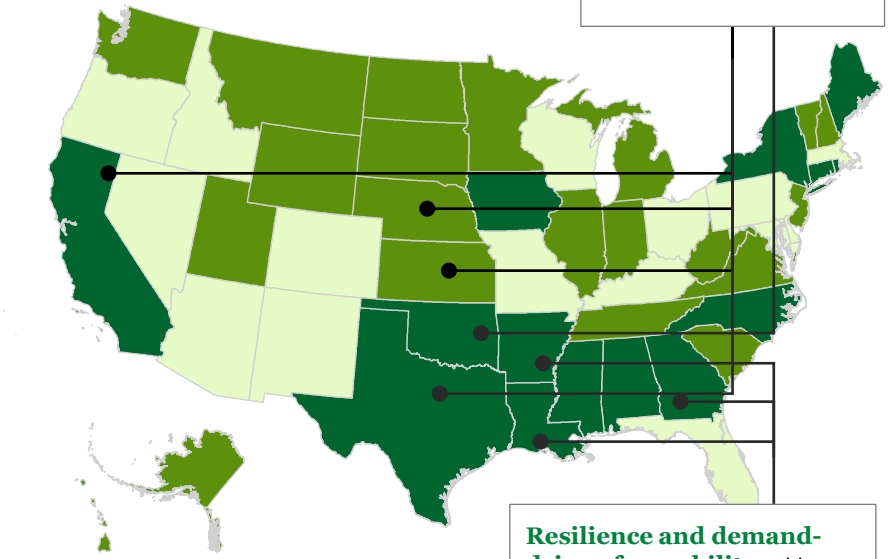
Different market conditions could require different types of interventions to prompt LDES deployment

Key

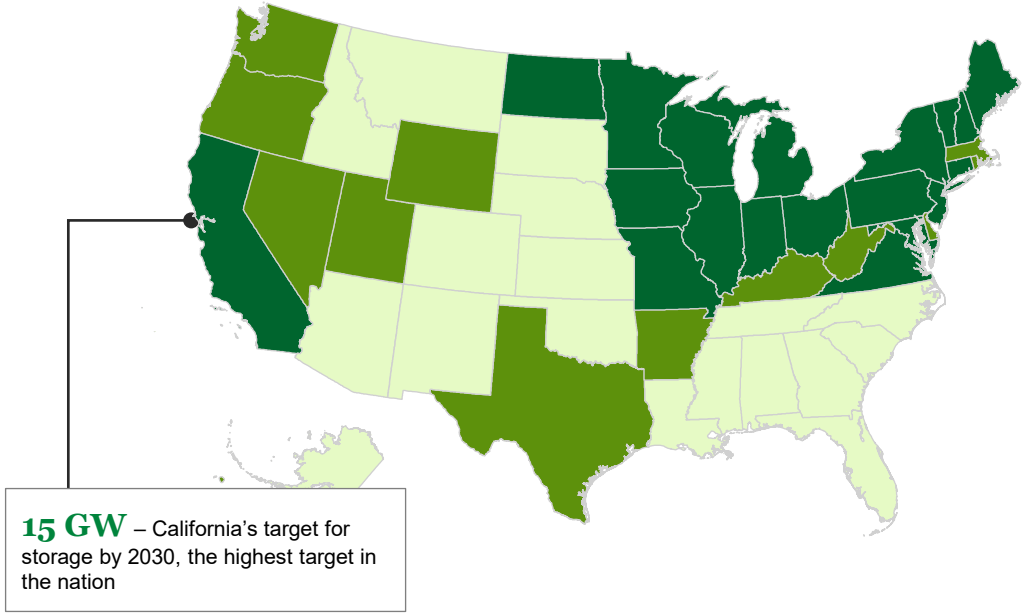
Conditions for LDES deployment are:

Favorable | Emerging | Unfavorable

Grid conditions



Policy & market construct



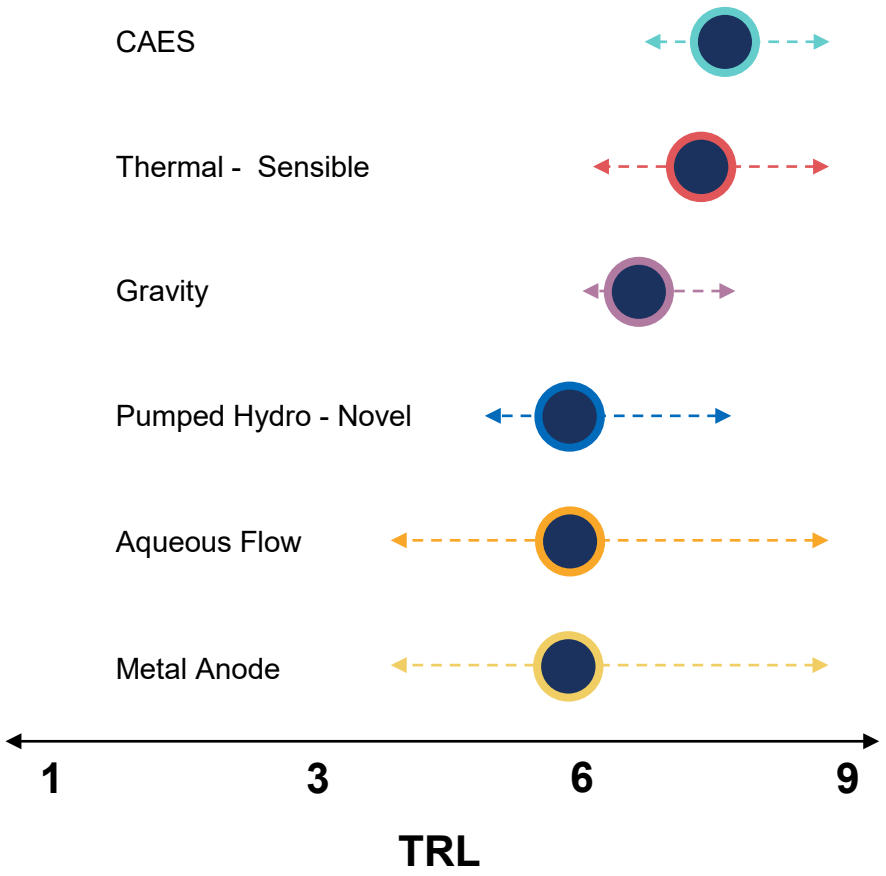
Potential market mechanisms tied to grid conditions:

- Response to extreme weather events results **in substantial increase of public and private investment in resiliency with recognition of storage infrastructure** for transmission and distribution value
- **LDES incorporated into grid planning** to accelerate renewable interconnection

Potential market mechanisms tied to policy and market construct:

- **LDES procurement targets** matched to RPS targets
- **Capacity market expansion (in ISOs)**
- Longer-term recognition of **resource adequacy provisions** (e.g., 20-year IRPs with third-party integrated planning)

LDES through the TRL x ARL lens helps focus efforts on near-term commercialization barriers and tracking to 2030 progress



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Resource Maturity	**Capital Flow** Need more projects to unlock economies of scale Need demonstration project funding	

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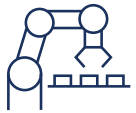

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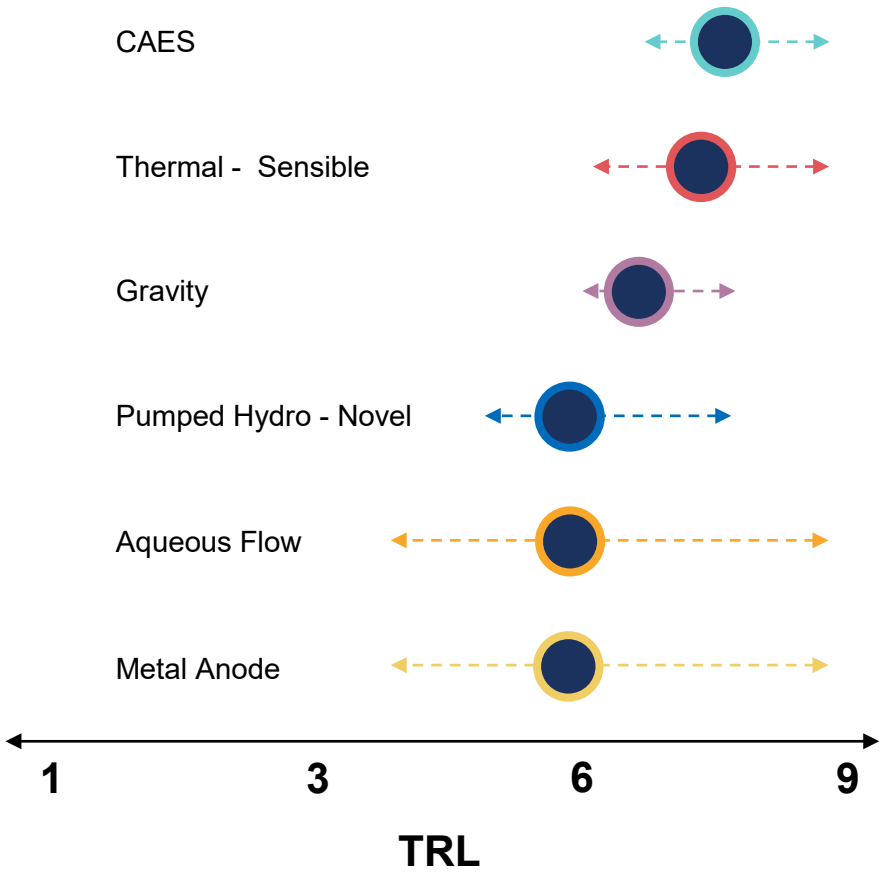

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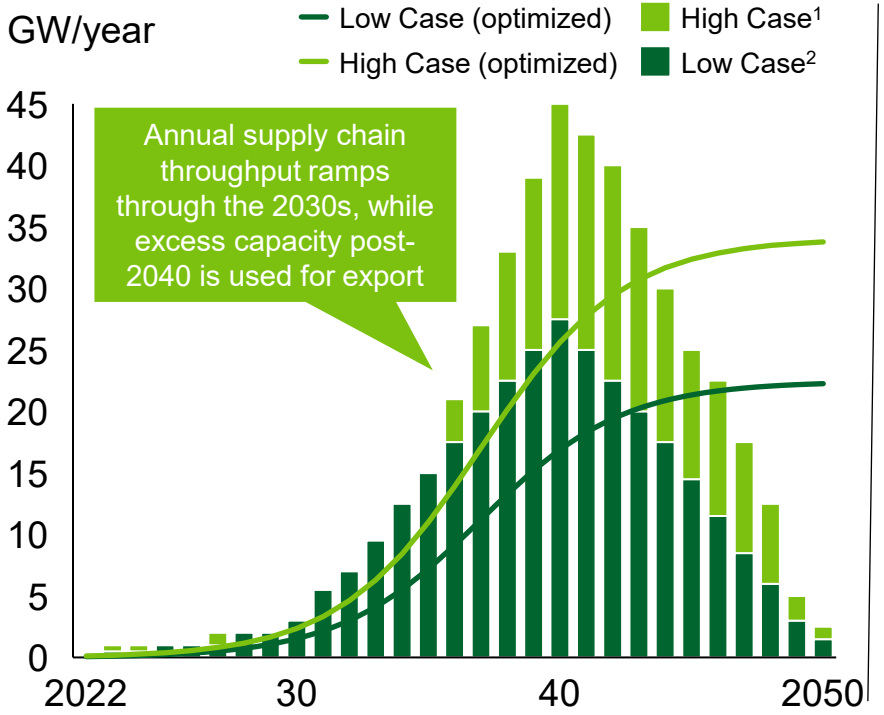
Resource Maturity	**Capital Flow** Need more projects to unlock economies of scale Need demonstration project funding **Manufacturing & Supply Chain** New manufacturing systems and capabilities needed; varied & bespoke processes across tech categories	**KPIs** 6-15 GW deployed $9 - $12B private sector capital mobilized in the US

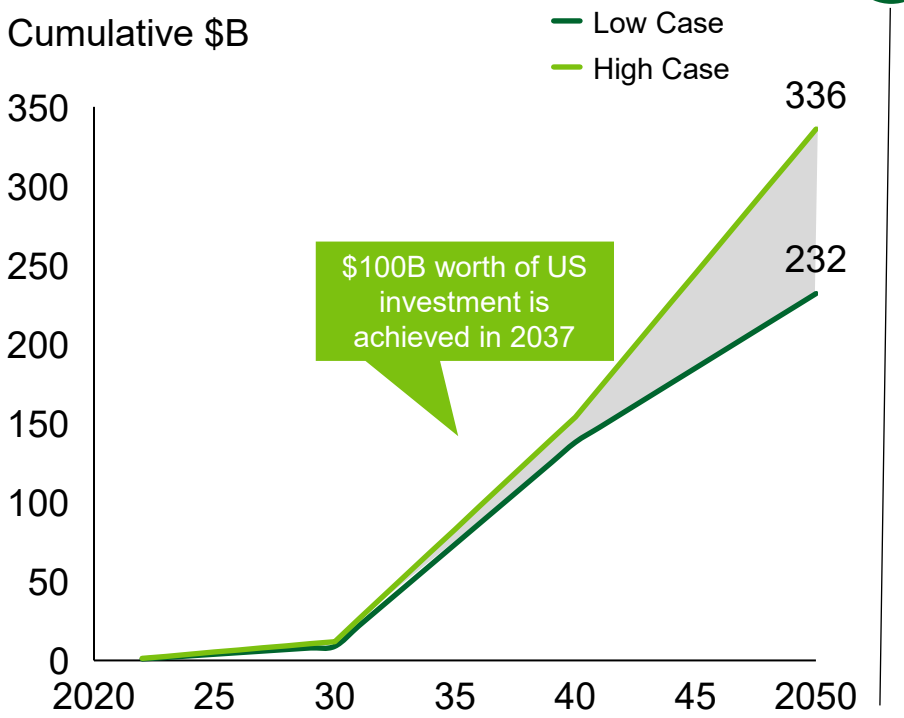
[1] TRL and ARL assessments distilled from US DOE LDES Liftoff Report

An industrial-scale supply chain could require $70-100B in manufacturing investment alone, with up to $330B in total capital formation

Annual deployment need (GW / year)



Total investment need ($B)

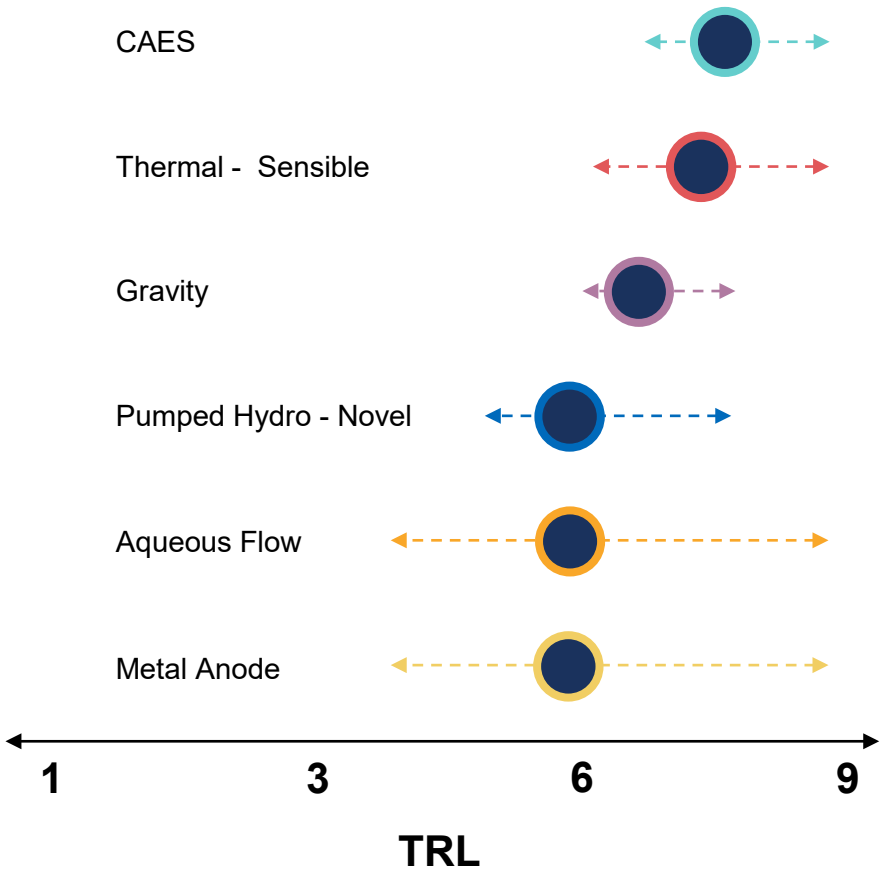


Manufacturing needs

- Nearly no at-scale manufacturing facilities exist in the US today
- ~30% of total capital formation needs, or **$70-100B, will be required for manufacturing capacity alone**
- Most technologies can be supplied through domestic or allied supply chains alone, leading to **few areas of vulnerability for large-scale stand-up** (aside from potential labor shortages)
- Annual deployment capacity will be overbuilt by 5 and 10 GW in the low and high cases, respectively, but could be **diverted to exports** post 2040 peak

1 Based on Pathways modeling Unconstrained Renewables Net-zero by 2050 Scenario
2 Based on Pathways modeling Constrained Renewables Net-zero by 2050 Scenario
NOTE: Optimized cases are based on the minimum possible manufacturing buildout by 2050 to meet scenario buildout

LDES through the TRL x ARL lens helps focus efforts on near-term commercialization barriers and tracking to 2030 progress



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Resource Maturity	**Capital Flow** Need more projects to unlock economies of scale Need demonstration project funding	**KPIs** 6-15 GW deployed $9 - $12B private sector capital mobilized in the US
	Manufacturing & Supply Chain New manufacturing systems and capabilities needed; varied & bespoke processes across tech categories	**KPIs** $3 - $4B of investment into new manufacturing capacity to adequately supply projects

[1] TRL and ARL assessments distilled from US DOE LDES Liftoff Report

In Short

Deploy Deploy Deploy!”

Thank You!

OCED Credo

T Transparency	Ensure fairness, clarity, and candor throughout the lifecycle of the demonstration projects
R Replicability	Enable private sector replicability, feasibility, and deployment through technical, financial, commercial, and human capital
U Urgency	Accelerate timeline to unleash private sector clean energy investment to meet U.S. net-zero goals
S Shared Success	Ensure OCED and its private sector partners are fully aligned to achieve win-win equitable outcome
T Timeliness	Commit to crisp decision-making to severely limit project delays