Dept. Of Energy
Loan Programs Office Review

Missouri Public Service Commission
April 21, 2023

Agenda

- **LPO's Mission** | Building a Bridge to Bankability • LPO's Offering • Monthly Application Activity Report
- **LPO Financing** | LPO Loan Programs: **ICE** • **SEFI** • **ATVM** • **TELGP** • **CIFIA** • **EIR** • EIR Key Provisions • EIR Potential Use Cases • General Loan Terms • The Loan Transaction Process
- **Virtual Power Plants with LPO** | Definitions • Addressing the Challenges of the U.S. Grid • The VPP Ecosystem • Inducing Consumers to choose DER
- **Innovative Transmission Technologies** | Challenges and Opportunities • Advanced Conductors • HVDC Transmission • Grid Enhancement Technologies
- **Long Duration Energy Storage** | Benefits • Technologies • Pathways to Commercial Liftoff

LPO's Mission

"There are many areas that are mature from a technology standpoint but not mature from an access to capital standpoint — **that's a nexus where there's a clear mandate for LPO to participate.**

— LPO Director Jigar Shah

The **U.S. Department of Energy Loan Programs Office (LPO)** finances innovative clean energy, advanced transportation, tribal energy, energy infrastructure reinvestment, and CO_2 transportation infrastructure projects, **serving as a bridge to bankability for breakthrough projects and technologies,** de-risking them at early stages of commercialization so they can reach full market acceptance.

The Bridge to Bankability

Providing financing for technologies to go the last mile to reach full market acceptance

What LPO Offers Borrowers

The unique value of working with LPO for clean energy technology project financing

LPO loans and loan guarantees are differentiated in the clean energy debt capital marketplace in **three primary ways:**

Access to Patient Capital
that private lenders cannot or will not provide.

Flexible Financing
customized for the specific needs of individual borrowers.

Committed DOE Partnership
offering specialized expertise to borrowers for the lifetime of the project.

Monthly Application Activity Report — March 2023

LPO Loan Programs Office

Monthly Application Activity Report | March 2023

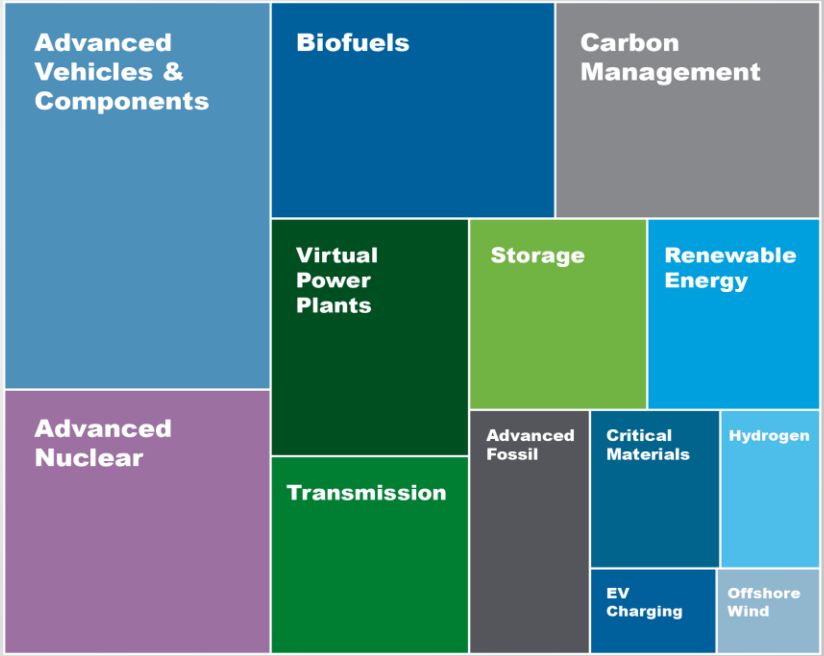
130 ACTIVE APPLICATIONS [1]

$117.9 BILLION IN LOANS REQUESTED [2]

1.6 NEW APPLICATIONS PER WEEK [3]

$117.9 BILLION

CURRENT AMOUNT OF LOANS REQUESTED BROKEN DOWN BY PROJECT TECHNOLOGY SECTOR



Notes

All data updated through March 31, 2023. For more details and a list of technology areas of interest within each LPO tech sector, see: Energy.gov/LPO/MAAR

1) Active applications include applications that have been submitted by the project sponsor(s) through LPO's online application portal and are in different stages of active review and engagement by LPO and the applicant.

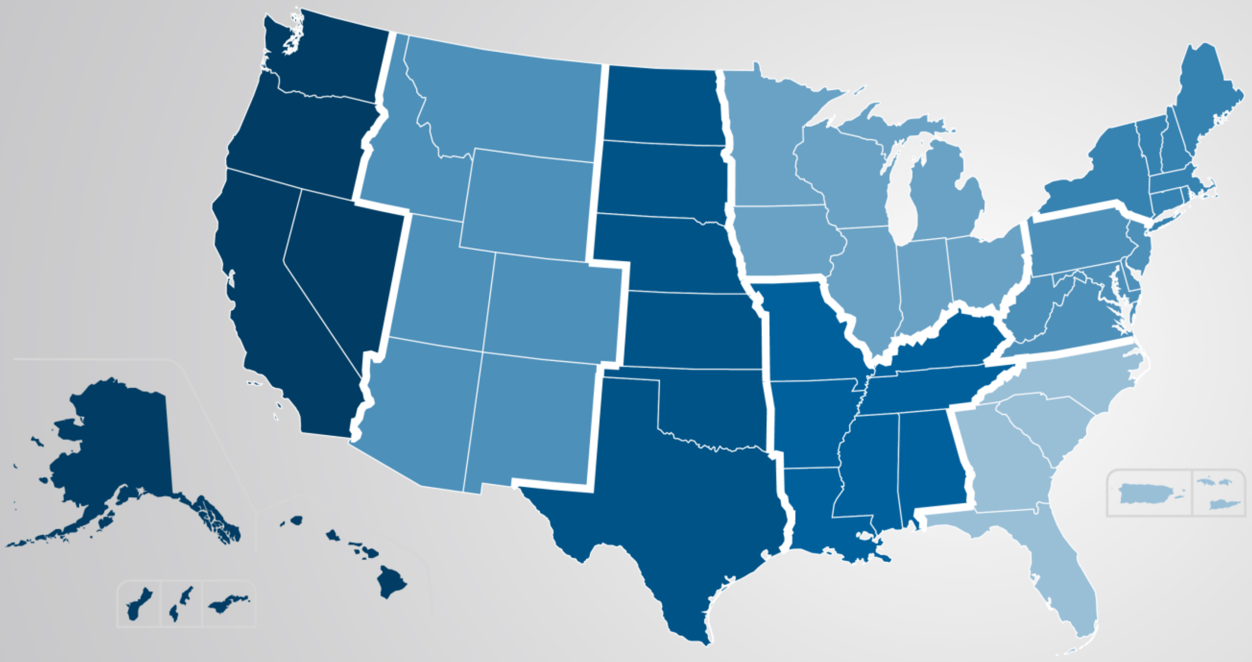
2) Individual requested loan amounts are estimated and potential, subject to change, and not necessarily representative of final financing terms. **Requested loan amounts in current active applications *do not* affect available LPO loan authority.** Figure rounded down to the nearest $0.1 billion.

3) Current rolling average of new active applications per week over the previous 24 weeks. Figure rounded down to the nearest 0.1 application per week.

Monthly Application Activity Report March 2023

LPO Loan Programs Office

Monthly Application Activity Report | March 2023



130 ACTIVE APPLICATIONS[1] WITH

154 PROPOSED PROJECT LOCATIONS ACROSS ALL REGIONS OF THE U.S.[2]

WEST	AK, CA, HI, NV, OR, WA *(AS, GU, MP)*	42
PLAINS	KS, ND, NE, OK, SD, TX	26
SOUTH	AL, AR, KY, LA, MO, MS, TN	18
NORTHEAST	CT, MA, ME, NH, NY, RI, VT	17
MID-ATLANTIC	DE, MD, NJ, PA, VA, WV *(DC)*	14
MOUNTAIN	AZ, CO, ID, MT, NM, UT, WY	14
MIDWEST	IA, IL, IN, MI, MN, OH, WI	12
SOUTHEAST	FL, GA, NC, SC *(PR, VI)*	11

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2) Regions depicted are for representation purposes only and are not meant to denote LPO consideration of regional variation in project evaluation.

LPO Financing Programs

Project Types	Loan Program	Loan Types
Innovative Energy and Supply Chain	Title 17 (1703)	Loan Guarantees
State Energy Financing Institutions	Title 17 (1703)	Loan Guarantees
Advanced Transportation	Title 17 & ATVM	Loan Guarantees (Deployment) Direct Loans (Manufacturing)
Tribal Energy	TELGP	Direct Loans & Partial Loan Guarantees
CO_2 Transportation Infrastructure	CIFIA	Direct Loans
Energy Infrastructure Reinvestment	Title 17 (1706)	Loan Guarantees

Energy Infrastructure Reinvestment 1706 EIR

A new Inflation Reduction Act (IRA) program that leverages existing energy infrastructure

Eligibility

EIR guarantees loans to energy infrastructure reinvestment projects that:

1. Retool, repower, repurpose, or replace energy infrastructure that has ceased operations *

or

2. Enable operating energy infrastructure to avoid, reduce, utilize, or sequester air pollutants or anthropogenic emissions of greenhouse gases.

* Projects replacing energy infrastructure with fossil electricity generation require controls or technologies to avoid, reduce, utilize, or sequester air pollutants and anthropogenic emissions of greenhouse gases.

- **No innovation requirement**
- **Environmental remediation** costs can be eligible for EIR financing as part of a large reinvestment project.

*** NOTE:** IRA appropriates $5 billion through Sep 30, 2026 to carry out EIR, with a total cap on loans of up to $250 billion.

Energy Infrastructure Reinvestment

1706 EIR financing has the potential to support many transformative projects

Example Projects

- Power plant (or associated infrastructure) retooled, repowered, repurposed or replaced with
  - Renewable energy (and storage)
  - Distributed energy (e.g., VPPs)
  - Transmission interconnection to off-site clean energy
  - New manufacturing facilities for clean energy products or services
  - Nuclear generation
- Transmission line reconductoring and voltage upgrades
- Emissions control technologies, including carbon capture, utilization, and storage (CCUS)
- Pipeline conversion (e.g., H_2, CO_2)
- Upgrade refineries for biofuels or hydrogen
- Upgrade or uprate existing generation facilities (with inclusion of emissions control technologies in the case of projects on fossil generation)

1706 EIR financing can support an equitable energy transition

Customer and community benefits

- **Community benefits:** EIR applicants must demonstrate how they will engage with and how their project will benefit communities where the investment is taking place.
- **Financial benefits.** Electric utilities that apply for an EIR loan guarantee must provide assurances that financial benefits received from the guarantee will be passed on to the customers of, or associated communities served by, that utility.
- **Stackable tax credits.** LPO's loan guarantees can be combined with tax credits available for renewables, storage, offshore wind, and nuclear. Repurposing fossil infrastructure with cleaner generation enables a 10% bump to the tax credit for location in an energy community.

Other policy considerations (apply to all Title 17)

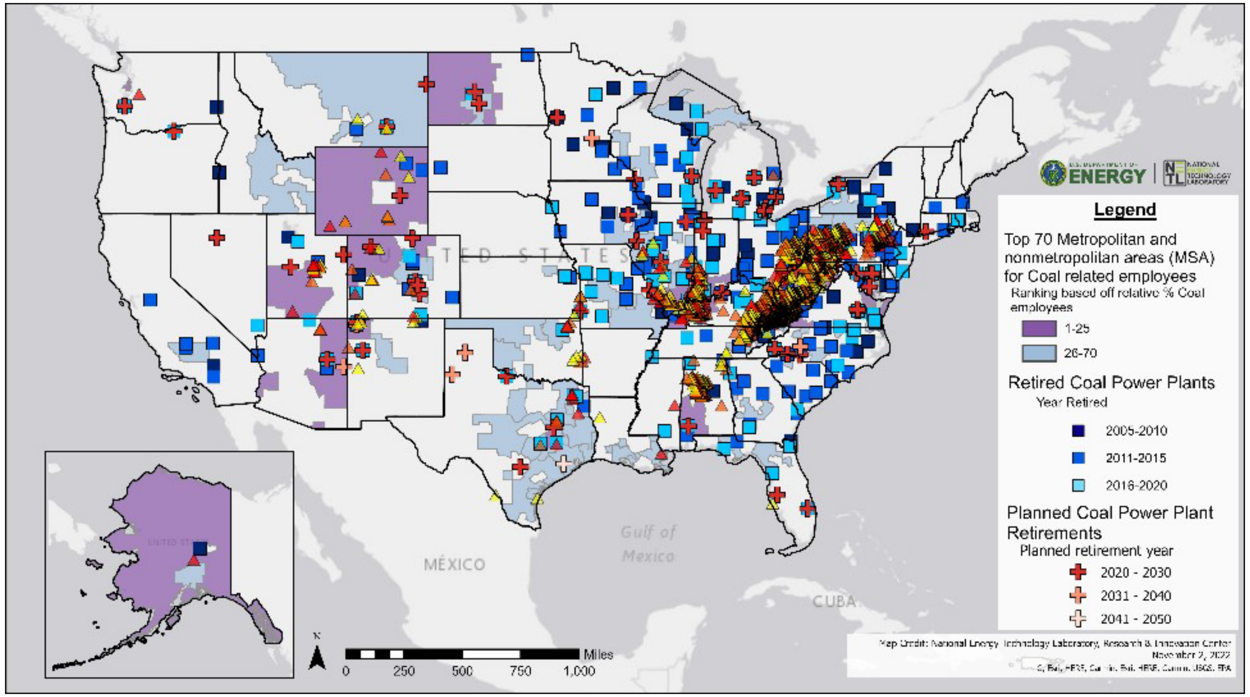
- **Federal support restriction** on *grants or some off-taker agreements*
- **GHG reduction requirements**
- **Foreign ownership considerations**

Energy Infrastructure Reinvestment

EIR is a financial tool for reinvestment and revitalization of energy communities

Financing the energy transition

- Utilization of existing infrastructure, sites, and skilled workforce
- Community benefits across U.S. policy priorities:
    - Justice 40
    - Diversity, Equity, Inclusion, and Accessibility
    - Good Jobs
    - Workforce and Community Agreements



Title 17 General Loan Terms

Interest Rate and Costs

Interest rate

- Treasury + 3/8ths (0.375%) + risk-based charge
- Treasury rate is fixed according to loan tenor (maximum thirty years)

Third-party expenses

- Advisor fees for costs of outside experts during due diligence

Other fees

- Facility fee · Maintenance fee
- No upfront application fees

Loan Structure

- LPO loan must be senior secured debt or *pari passu* with existing obligations

Eligible Costs and Other Terms

Loan size

- No minimum or maximum, but loans smaller than $100 million are uncommon
- Eligible project costs detailed in new Guidance (forthcoming)
- Loan guarantee can be up to 80% of project costs (commonly less), while significant financial interests required of project sponsor

Eligible lenders

- Federal financing bank (US Treasury) – up to 100% loan guarantee
- Commercial lender – up to 90%

LPO provides loan guarantees (not loans)

The LPO Loan Transaction Process

LPO engages early with applicants and remains a partner throughout the lifetime of the loan

1 Pre-Application Consultations

Meet with LPO for no-fee, pre-application consultations, including discussions on the application process and the proposed project.

More Variable Timing
Lengths of these stages vary greatly, depending on project complexity and readiness.

Less Variable Timing
Timing for these stages is largely fixed, with targeted timelines.

2 Formal Application Submission

Title 17: Submit Part I application to determine technical eligibility (innovation and greenhouse gas emissions calculation). There is no review of business plan or financial structure in Part I. If invited, submit more thorough Part II application to determine project viability and ability to move into due diligence.

ATVM: Submit single application to determine basic eligibility and project viability.

TELGP: Tribal borrower engages with a commercial lender. Lender applies for a loan guarantee on behalf of Borrower and project.

3 Due Diligence & Term Sheet Negotiation

Title 17 & ATVM: Enter confirmatory due diligence and negotiate term sheet.

TELGP: Borrower, Lender, and DOE engage in confirmatory due diligence and term sheet negotiation.

All Programs: Any third-party advisor costs are paid for by the applicant.

4 Credit Approval Process

Formal approval process of the term sheet, including interagency consultations.

5 Conditional Commitment

An offer by DOE of a term sheet to the borrower for a loan or loan guarantee subject to the satisfaction of certain conditions.

6 Loan Closing & Project Monitoring

Negotiate and execute loan documents using the approved term sheet. Loan closing and funding are subject to conditions precedent in the executed loan documents.

Applicant pays applicable costs and fees. After loan closing, LPO monitors the loan.

Key Considerations

What LPO needs to see in project applications

- **Projects must meet eligibility criteria for applicable program**

  For EIR, includes **qualifying 'energy infrastructure'** and achievement of **"retool, repower, repurpose, or replace" requirement** or significant emission reductions at operating infrastructure

- **Reasonable prospect of repayment**

- **Other policy considerations (e.g., community benefits, GHG reductions, etc.)**

Discussion

Common questions that we receive

- **Can I apply for both a loan and a grant?**
- **Is there a minimum or maximum project size (total cost)?**
- **Can I file multiple applications?**
- **What is the application process? How long and burdensome is it?**
- **How do customers and communities benefit from using LPO financing?**

We want to help!

- **Do you see value in LPO financing?**
- **What do you need, or will you need to see, to make LPO financing useful?**

Let's Talk About Your Project

Contact LPO to see what financing options may be available for your project

Call or write to schedule a no-fee, pre-application consultation: **202-287-5900** | LPO@hq.doe.gov

Learn more about LPO and all of its financing programs at: **Energy.gov/LPO**

Energy.gov/LPO

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Loan Programs Office

Discussion on virtual power plants with Loan Programs Office

Briefing Materials

April 2023

Jen Downing

What are virtual power plants?

Virtual power plants are **aggregations of distributed energy resources**, such as rooftop solar, electric vehicles and chargers, energy storage systems, and smart buildings and equipment that are controlled to **act like a traditional power plant**, large enough to be utility-scale, and dependable enough to be utility-grade.

- ✓ The term VPP refers to a **wide range of models** for aggregating and managing DERs
- ✓ VPPs **aggregate** DERs and manage devices collectively to supply power, store power, and provide other services
- ✓ VPPs can be **integrated** into real-time grid operations and long-term grid planning

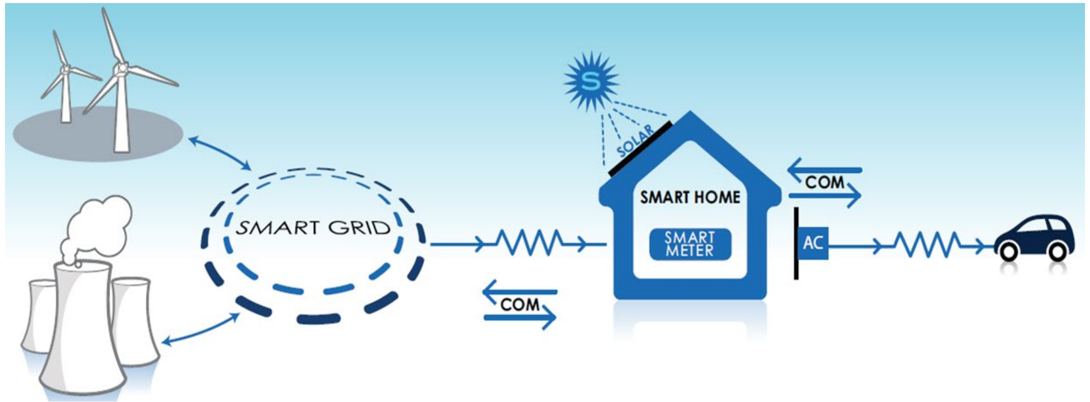


Image source: Voltimum

Challenges the US grid is facing

We must address several challenges to electrify and decarbonize the US grid while maintaining US economic competitiveness and avoiding undue burden on consumers

Resource adequacy	• Electricity consumption is expected to rise for the first time in ~15 years as key sectors of the economy, such as transportation, are electrified
Affordability	• Electricity costs are rising, driven in large part by growth in capital expenditure • Low- and moderate-income households are often priced out of energy-saving devices
Rapid decarbonization	• Decarbonizing the power sector by 2035 will require reducing reliance on fossil fuel generation
Load shaping	• Electrification of cars and heating creates demand swings on 24h cycles • Supply from wind and solar are variable and potentially mismatched with demand
T&D needs	• Transmission and distribution (T&D) infrastructure is underutilized, old and aging • Communities oppose building new T&D lines
Reliability & Resilience	• Extreme weather events are becoming more common and less predictable

How VPPs address these challenges

VPPs address each challenge to modernize grid operations and meet our goals

Resource adequacy	• **Integrate distributed generation and storage capacity** into grid operations • **Shift consumption** away from hours when power is scarce to hours it is abundant
Affordability	• **Avoid or defer T&D and peaker plant capex** when capacity is added locally via DERs instead of centralized assets; this lowers system costs and consumer bills • Potentially **compensate consumers and businesses** for participation in load-shifting events and for excess energy that is injected back to the grid
Rapid decarbonization	• Add **distributed renewable generation** – e.g., rooftop solar • Add **distributed energy storage capacity** – e.g., batteries – to smooth the supply swings associated with variable renewable sources and reduce curtailment • **Reduce reliance on fossil** baseload generation and peaker plants
Load shaping	• **Decrease or delay energy load** – e.g., at-home EV charging, electric water heaters, heating and cooling – in response to signals from grid operators
T&D needs	• **Bypass transmission** lines during peak hours when generation/dispatch is sited closer to where power is used; **shrink spikes** in load to increase avg utilization
Reliability & Resilience	• Equip homes and businesses with **back-up power** (generation and/or storage) • Network distributed assets to build redundancy and **eliminate single-point-of-failure**

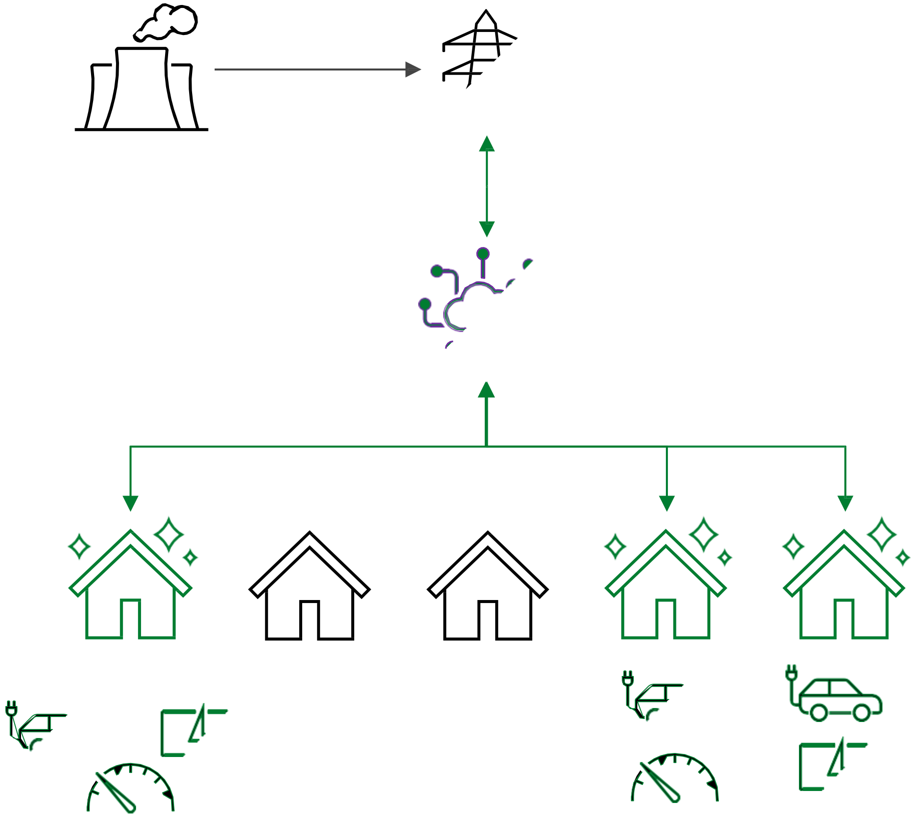
✓ **Cleaner energy**

✓ **Lower cost**

✓ **More resilient**

The VPP ecosystem

Scaling VPPs requires support across the full ecosystem, including DERs



VPP business models monetize the value of aggregated capacity & grid services

Distributed energy resource providers sell/finance the devices that generate capacity

LPO aims to **mobilize investment** across the VPP and DER ecosystem

Inducing consumers to choose DER

With targeted LPO investment to effectively lower the cost of VPP enabled DER, we can induce consumers to 'go green' with their capital purchases, accelerate deployment of VPP technologies, *and* help ensure all American homeowners have access to credit

Homeowners and businesses seek energy solutions, e.g. heating systems, EV chargers, backup power

DERs are chosen as the more **affordable, convenient option**

US households and business are **equipped for VPPs**

LPO provides low-cost financing to companies offering 'green' solutions, ensuring they are low-cost and widely available to all American homeowners

For discussion

What role can you play in accelerating the deployment of distributed energy resources and virtual power plants?

Examples			
	Performance-based ratemaking	*Distribution system planning requirements*	*All-source procurement*
	Energy efficiency resource standards	*Non-wire alternatives*	*Time-variant pricing*

LPO Loan Programs Office

Discussion on Innovative Transmission Technologies

Briefing Materials

April 2023

Jonathan Abebe

Challenges with US Grid and LPO Opportunities

- The U.S. has established a goal of carbon free power by 2035
- The U.S. has adequate renewable energy resources to achieve this goal
- LPO can fund transmission solutions that:
  - **Provide access to stranded renewables via new builds**
  - **Improve efficiency of existing systems**
- Potential innovative transmission technologies LPO can consider include:
  - **Advanced Conductors**
    - Composite and/or carbon cores instead of steel cores
  - **High Voltage Direct Current (HVDC)**
    - Voltage Sourced Converters
  - **Grid Enhancement Technologies (GETs)**
    - Dynamic Line Rating
    - Advanced Power Flow Control
    - Topology Optimization

Advanced Conductors

Advanced conductors are electric conductors that use a **modern composite and/or carbon cores (instead of steel wires)** and shaped, low resistance aluminum wire, that can operate at higher temperatures and for an extended period of time with low sag, **allowing for significant increases in the thermal rating**.

Type of applications:

- ✓ Reconductoring of existing lines that use ACSR conductors with advanced conductors
  - ✓ Helps maximize the thermal transfer capacity on existing ROW
  - ✓ Lowers power line losses
- ✓ New construction lines using advanced conductors instead of ACSR conductors
  - ✓ Enhance grid performance and flexibility

HVDC Transmission

Voltage Sourced Converters (VSC) is the latest generation HVDC technology that replaces the previous generation Line Commutated Converters (LCC) technology.

HVDC Transmission provides a number of advantages over traditional High Voltage Alternative Current (HVAC) Transmission. Among these are:

Unlimited Cable Length	High Power Density	Low Line Losses	Independent Reactive Power Control	Connection of Unsynchronized Systems	High Reliability

Grid Enhancement Technologies

Dynamic Line Rating	Hardware and/or software used to appropriately update the calculated thermal limits of existing transmission lines based on real-time and forecasted weather conditions (ambient air temperature, wind, solar heating intensity, etc.) and measurements of other conditions of the line (transmission line tension or transmission sag).
Power Flow Controllers	Hardware and software used to push or pull power, shifting the flow of power across a mesh network, helping to balance overloaded lines and underutilized corridors within the transmission network.
Topology Optimization	Software used to find reconfiguration options of transmission systems that can reliably route power around the congested facilities

Q&A

Pathways to Commercial Liftoff: Long Duration Energy Storage

April 21, 2023

Briefing for the Missouri Public Service Commission

Katheryn Scott

LDES complements renewables, reduces the need for new natural gas, and diversifies storage supply chains

Enabling high renewable development and enhancing resilience

LDES **reduces the cost and risk associated with high renewable pathways** by balancing intermittent renewables and reducing the costs and risks around grid expansion.

LDES also **enhances local resiliency** to respond to increasingly extreme weather events.

Reducing the need for new natural gas capacity

Having available and cost-effective LDES **reduces the need for 200 GW+ of new natural gas capacity** in a net-zero world.

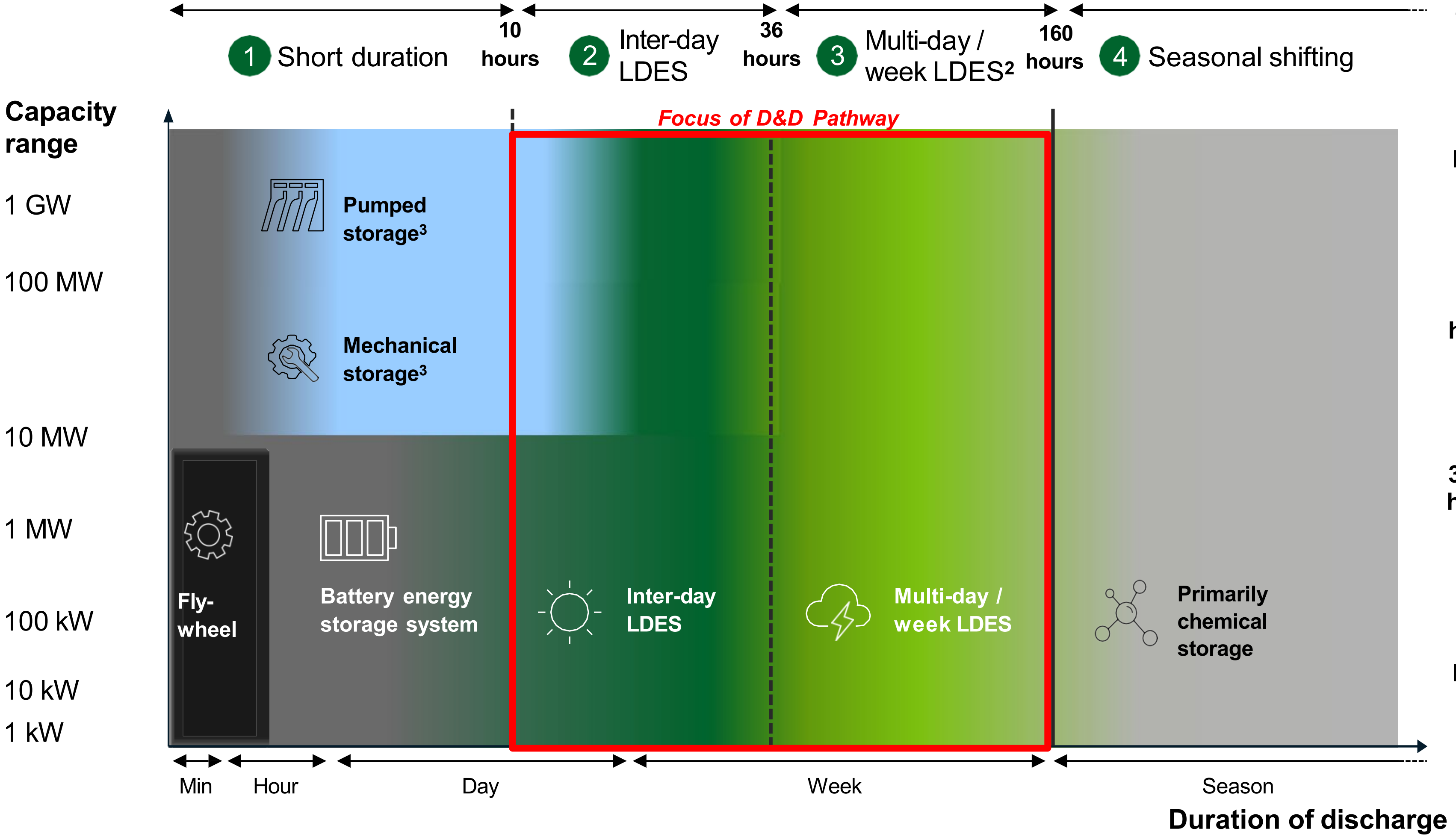
As a result, pathways that leverage LDES are projected to **deliver ~$10-20B in annual savings by 2050.**

Diversifying domestic energy storage supply chain

A diversified set of storage **technologies reduces the risk of net-zero goals being contingent upon lithium-ion manufacturing** buildout, in addition to increasing the potential availability of lithium-ion for EVs.

Source: DOE LDES Pathw ay to Commercial Liftoff Report

Storage technologies can be segmented based on their duration of dispatch with LDES filling the Inter-day to Multi-day / week role



Codifying the technology

0-10 hours	1	**Short duration:** Durations up to 10 hours
10-36 hours[2]	2	**Inter-day LDES:** Sometimes called "diurnal"
36-160 hours[1]	3	**Multi-day / week LDES:** Commonly called "seasonal"
160+ hours	4	**Seasonal shifting:** Generally included in "seasonal", but distinct in that this does function as a conventional, storable fuel

1 Technologies & market use cases may span across duration categories (e.g., technology's duration may encompass both Multi-day / w eek and Seasonal shifting
2 LDES systems w ith 36+ hours of duration are considered Multi-day / w eek as they can discharge to cover 2+ full days of peak demand (e.g., 8a to 8p)
3 Pumped storage and Mechanical storage can operate effectively as both short-duration and inter-day LDES systems

Source: DOE LDES Pathw ay to Commercial Liftoff Report

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There are three types of energy storage divided by the type of energy stored

NON-EXHAUSTIVE – MORE DETAIL ON NEXT PAGE

Mechanical

- Stored as **mechanical potential energy** (elevated material or pressure)
- Used as **kinetic energy** to power a turbine.

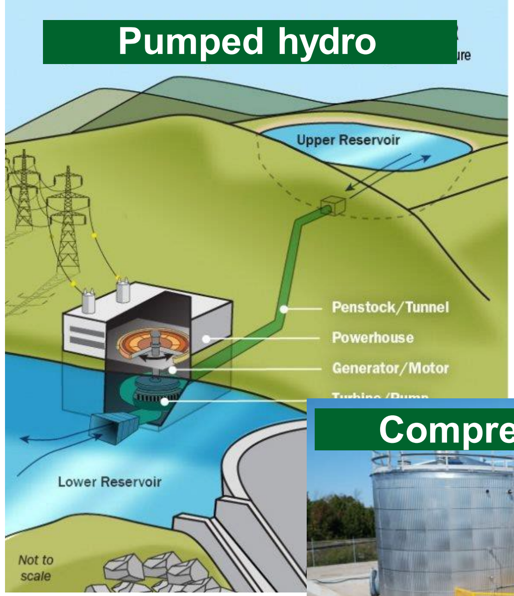
Thermal

- Stored as **thermal potential energy / heat**
- Used as **steam** for turbine or with specialized **semiconductor panels**

Electrochemical

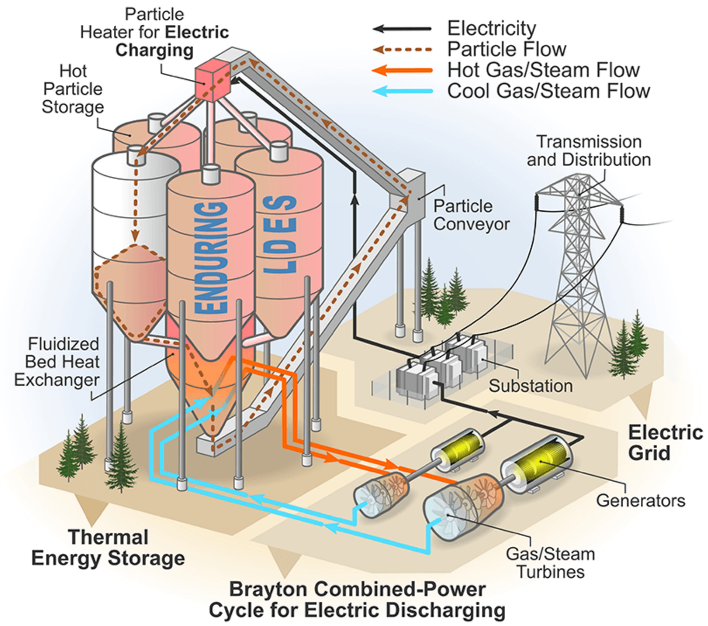
- Stored as **chemical potential energy** (unreacted chemicals)
- Used as **chemical bonds** formed and release electrons

Pumped hydro

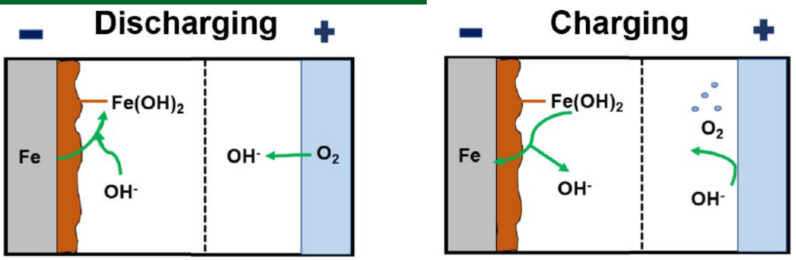


Compressed air

Sensible heat (Hot sand)



Metal anode batteries



Flow batteries

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Image Sources from left to right: DOE Water Power Technology Office, Hydrostar, National Renewable Energy Laboratory, Rachel McKerracher, Redflow, Sumitomo Electric

These numerous LDES technologies have different characteristics

NON-EXHAUSTIVE – HYDROGEN AND HYBRID LONG DURATION STORAGE EXCLUDED

Less Desirable → More Desirable

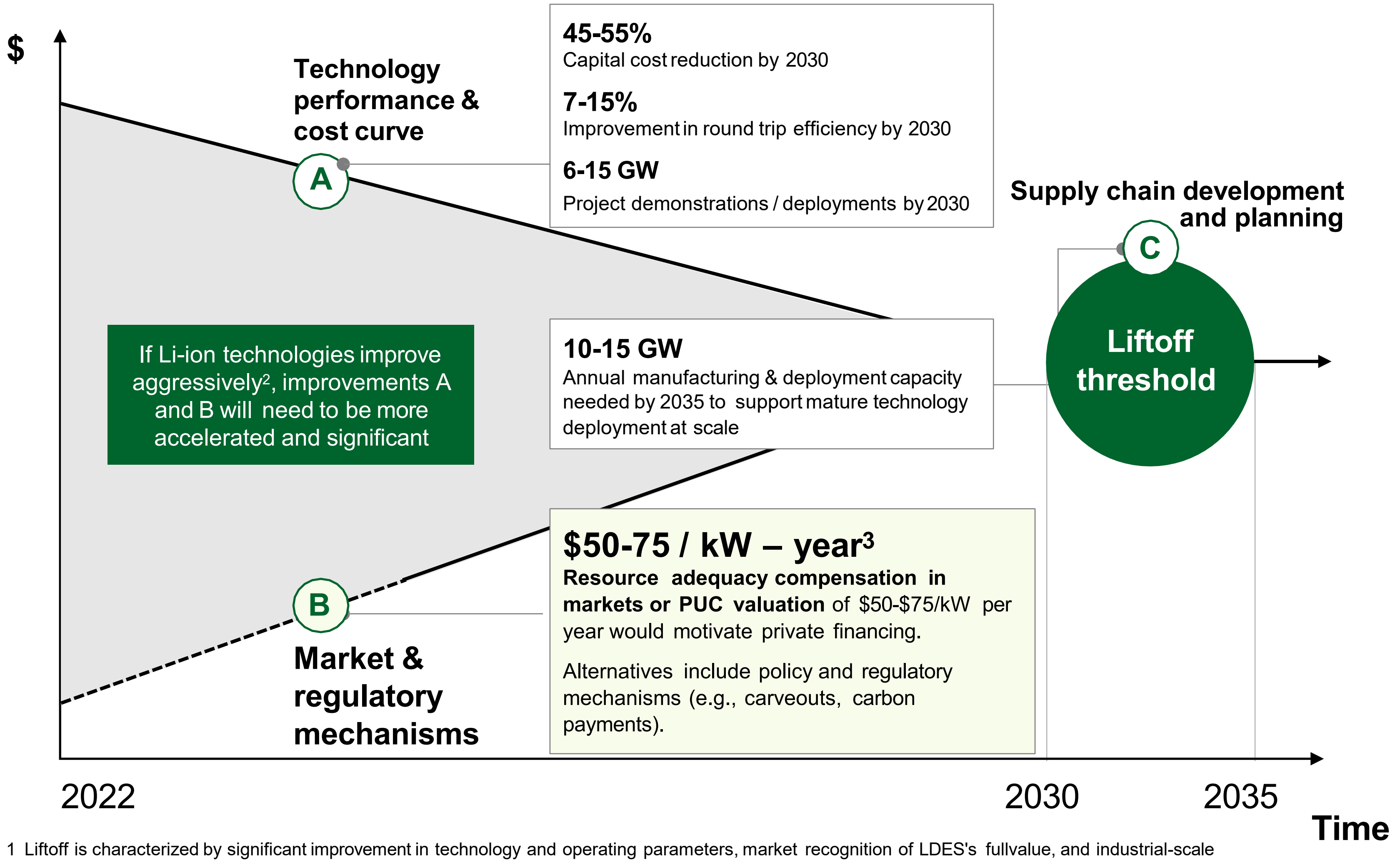
△ Faces geologic constraints[1] | Not enough public datapoints to obtain a reliable value | Inter-day | Can function as both | Multi-day / week

Duration	Energy storage form	Technology	Nominal duration, hrs	LCOS[5], $/MWh	Min. deployment size, MW	Average RTE[1], %	TRL
Inter-day	Mechanical	Traditional pumped hydro (PSH) △	0–15	70–170	200 – 400	70–80	9
		Novel pumped hydro (PSH)	0–15	70–170	10–100	50–80	5-8
		Gravity-based △	0–15	90–120	20–1,000	70–90	6-8
		Compressed air (CAES) △	6–24	80–150	200–500	40–70	7-9
		Liquid air (LAES) [1]	10–25	175–300	50–100	40–70	6-9
		Liquid CO2[1]	4–24	50–60	10–500	70–80	4-7
Multi-day / week	Thermal	Sensible heat (e.g., molten salts, rock material, concrete)[2]	10-200[2]	300	10–500	55–90	6-9
		Latent heat (e.g., aluminum alloy)	25–100	300	10–100	20–50	3-5
		Thermochemical heat (e.g., zeolites, silica gel)	XX	XX	XX	XX	XX
	Electrochemical	Aqueous electrolyte flow batteries	25–100	100-140	10–100	50–80	4-9
		Metal anode batteries	50–200	100	10–100	40–70	4-9
		Hybrid flow battery, with liquid electrolyte and metal anode (some are Inter-day) [2,3]	8–50[2]	XX	>100	55–75	4-9

1 Demand potential / market size is limited by the requirement for specific geological formations
2 Codified based on primary technology type
3 Can function as inter-day, but organized based on longest duration potential
4 Some flow batteries under development will not work for multi-day, but it is categorized here as such given the technology's maximum duration

Source: DOE LDES Pathway to Commercial Liftoff Report, LDES Council Net-Zero Power Report 2021, Wood Mackenzie Long Duration Energy Storage Report 2022, Company websites, Academic research

Achieving liftoff – self-sustaining commercial deployments – requires improvements in technology, market compensation, and supply chain development



1 Liftoff is characterized by significant improvement in technology and operating parameters, market recognition of LDES's fullvalue, and industrial-scale manufacturing and deployment capacity. These improvements are needed to attract the private capital that is needed to meet LDES deployment targets
2 Need for Multi-day / w eek technologies remains in both Li-ion scenarios; Aggressive Li-ion w ill reduce need for supply chain buildout
3 $ / kW - year varies by geography

- Liftoff occurs when **LDES technologies are deployed** (without project-specific intervention) **at scale across the US power grid**
- Within this decade, it is most important that **LDES technologies are demonstrated in-field** and begin to receive adequate **market compensation for the future value** they bring to a net-zero grid

Why Pathways to Commercial Liftoff

This is a critical moment of transition

We are facing a climate crisis, and must act in the next 10 years

COVID & geopolitical events have disrupted global supply chains

The Biden Administration has set bold decarbonization goals via an equitable transition that creates jobs and strengthens supply chains & domestic manufacturing

$10T[1] of incremental investment is needed to achieve net-zero 2050

20+ technologies must commercialize (i.e., move across the RDD&D continuum) and get to scale (on order of $100B per sector); interdependent systems must transition in coordination

Each technology faces complex barriers to deployment that require intentional, coordinated action across public and private sector

Private sector will lead the required investment, but DOE / USG must enable through public investments & policy

Pathways effort was started to shape and accelerate this investment

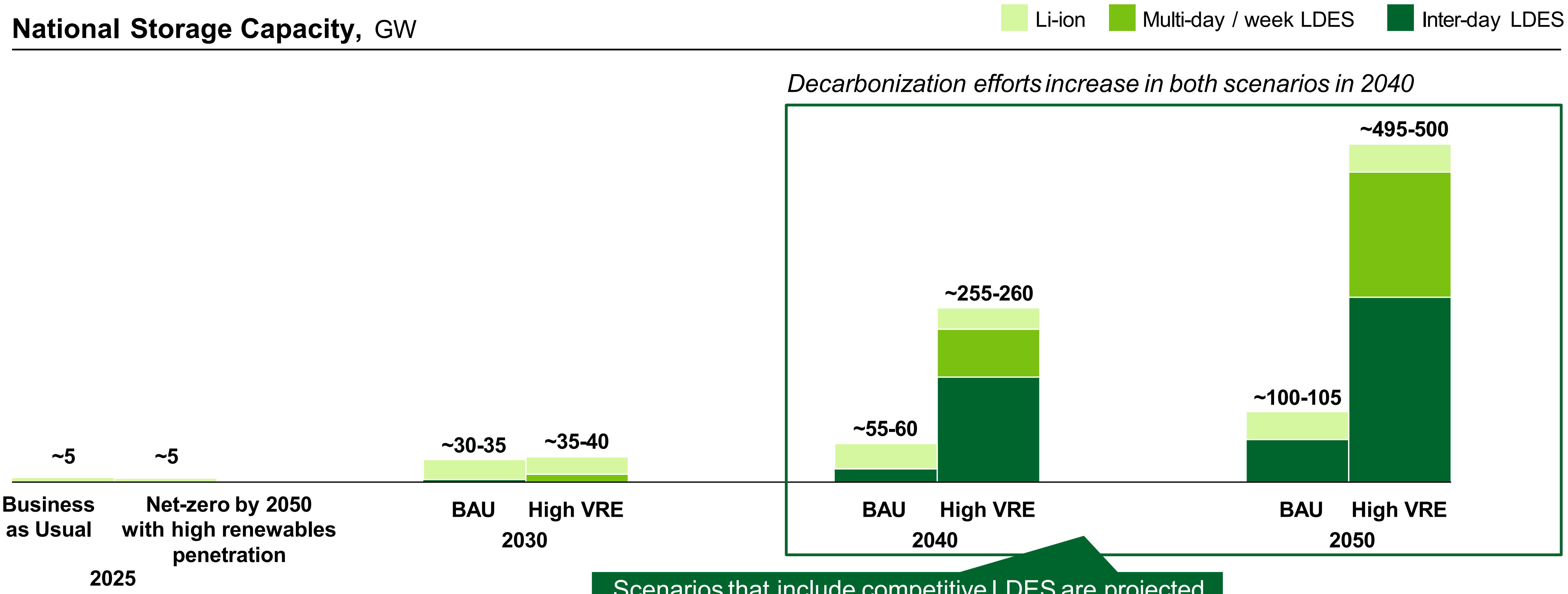
OCED, OTT, LPO, and OP (w/ sponsorship from senior DOE leadership) launched effort to collaborate, coordinate, and build trust with the private sector and create a common fact-base that drives public and private investment decisions and changes behavior of key actors across RDD&D

The effort will help to inform capital allocation decisions that address risks and barriers to scale starting with four high priority technologies – Advanced Nuclear, Carbon Management, Clean Hydrogen, and LDES

1. Princeton Net Zero America Report

Appendix

High renewables scenario drives LDES market growth with additional LDES required in scenarios with net-zero goals



Scenarios that include competitive LDES are projected to deliver **~$10-20B in annual savings** in operating costs and avoided capital expenditures by 2050.

Source: Pathw ays to Commercial Liftoff modelling efforts

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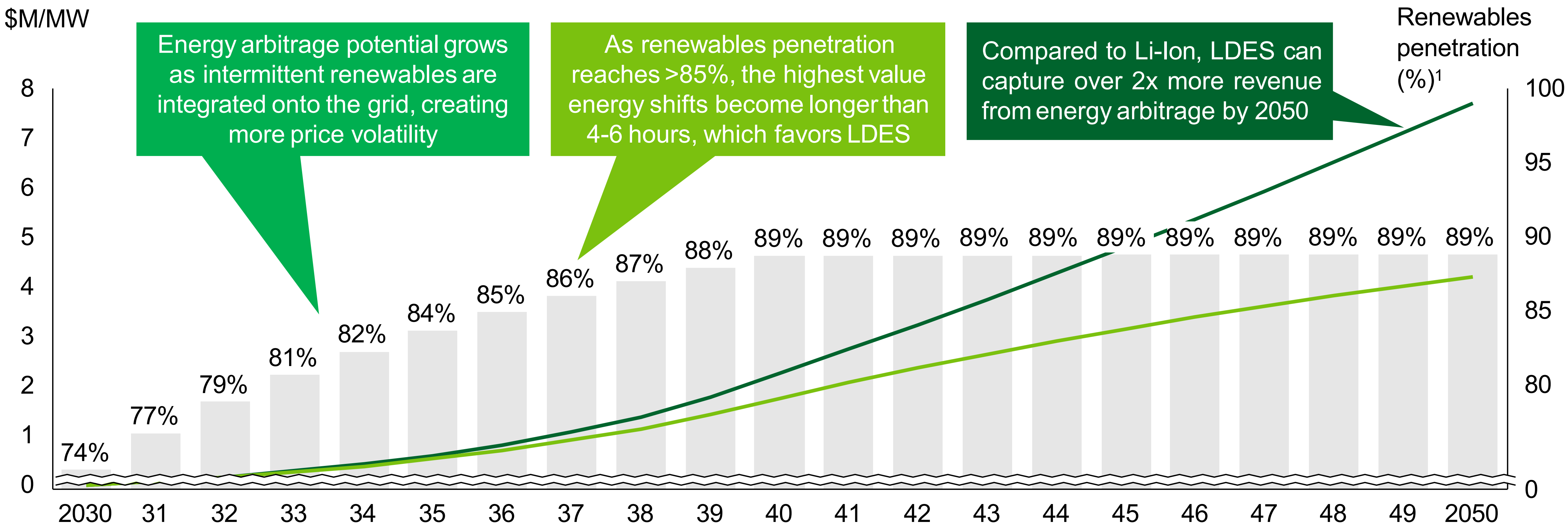
4f The arbitrage opportunity for LDES increases steadily as variable renewables penetration grows

Indicative cumulative arbitrage potential in CAISO, $M/MW

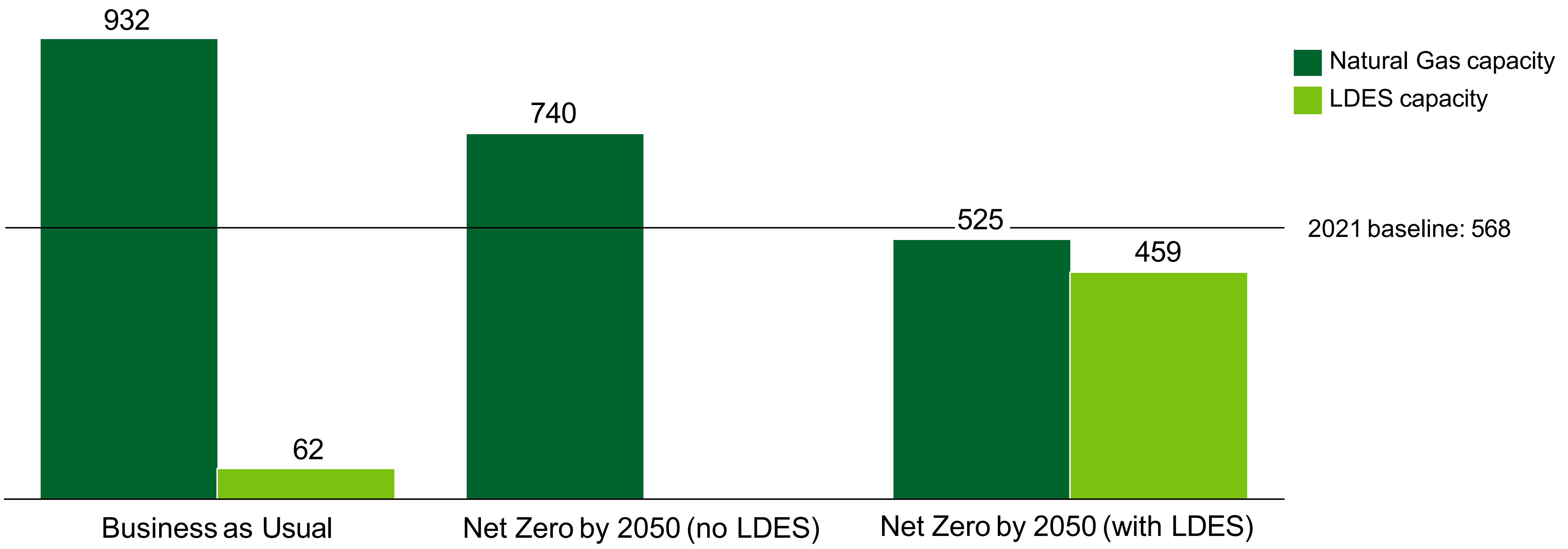


1 Percent of total CAISO energy generation that is generated by renew ables (Net-Zero 2050 High RES Scenario)

Source: DOE LDES Pathw ay to Commercial Liftoff Report

Net zero scenarios all include Natural Gas with CCS; however, LDES removes the need for 200GW+ of Natural Gas capacity

Total Installed Capacity in 2050, GW



1. Includes both Diurnal and Seasonal LDES; Does not include Li-Ion.

Source: Pathw ays to Commercial Liftoff modelling efforts

4e Deferral of transmission upgrades using LDES could result in savings of 40%

Key assumptions

LDES

Capacity: 20 MW

Duration: 80 hrs

Storage: 1,600 MWh

Energy Capital Cost: $8.8/kWh

Power Cost: $1,812/kW

ITC: 30%

Transmission upgrade

Constraint: 20 MW

Upgrade costs ($/KVA): ~$22,000

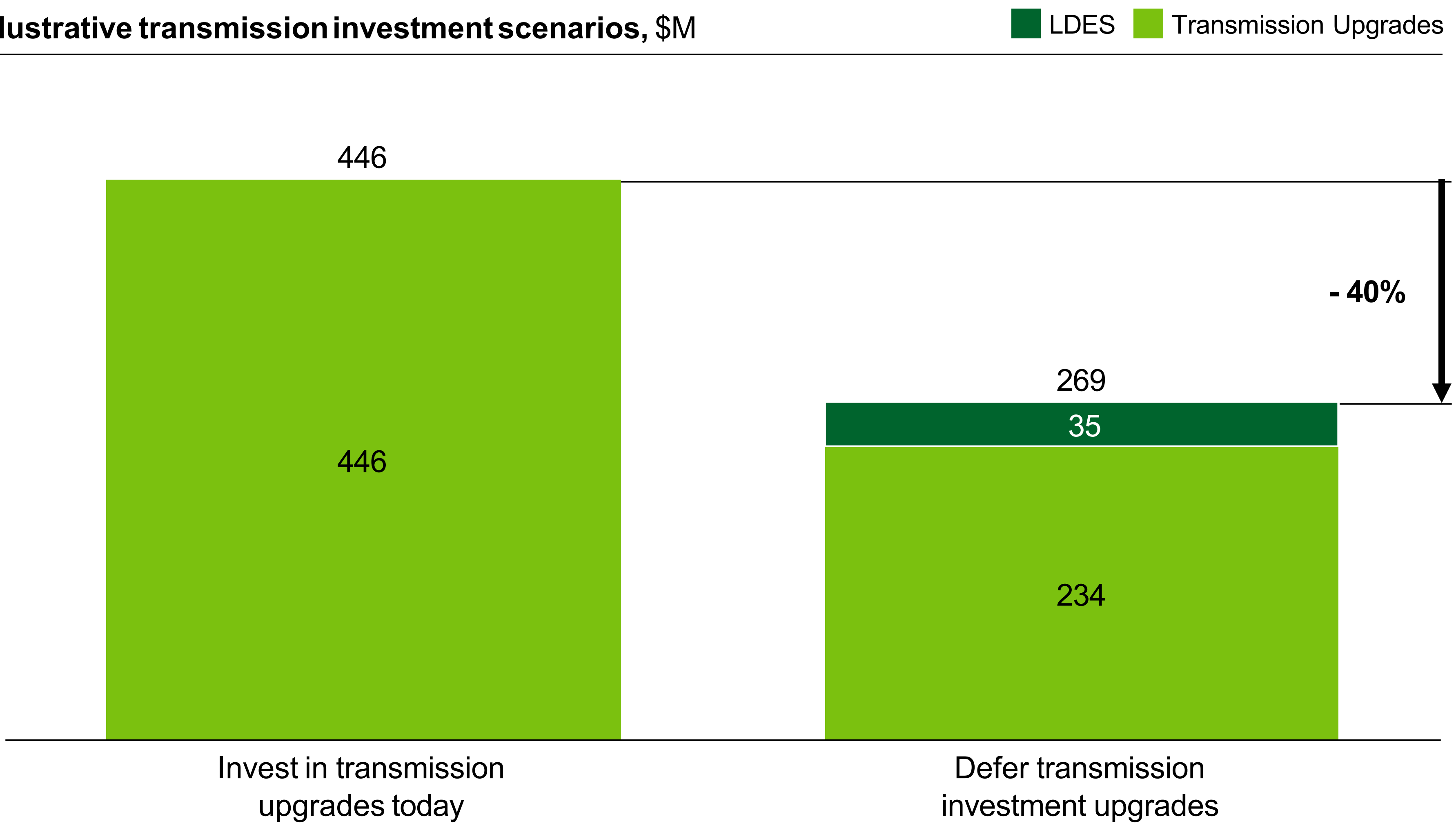
Discount rate: 11%

Inflation rate: 2%

Deferral period: 8 years

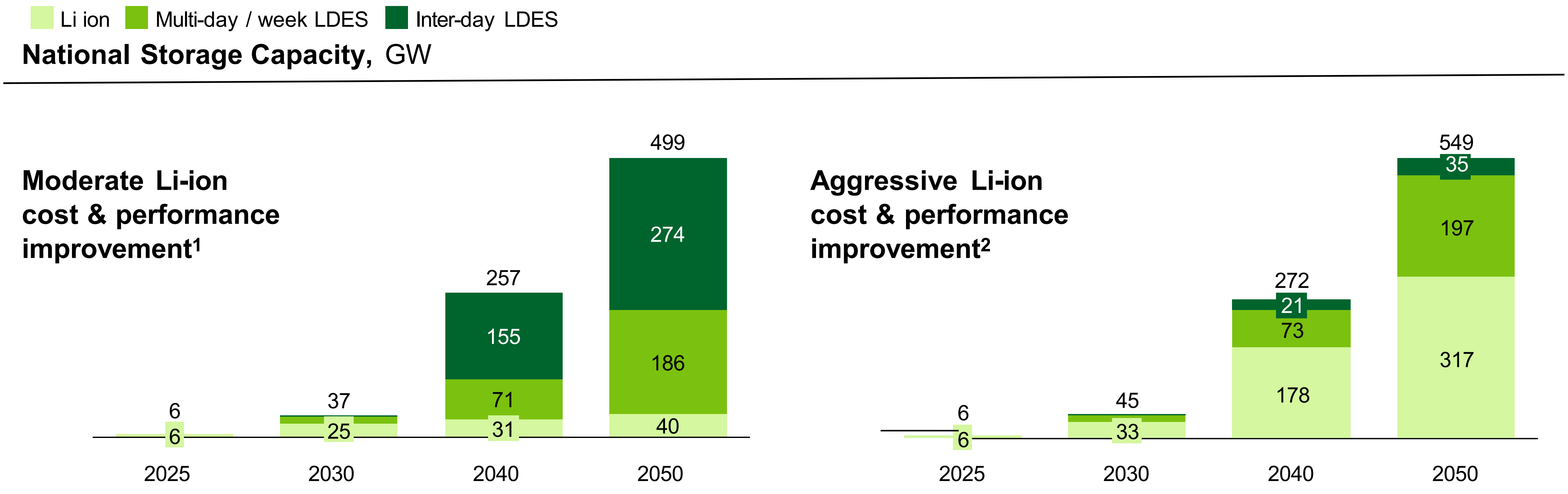
Analysis assumes that LDES is considered a transmission investment

Illustrative transmission investment scenarios, $M



Source: DOE LDES Pathw ay to Commercial Liftoff Report, Transmission Cost Estimation Guide for MTEP 22, Nantucket Island Energy Storage Assessment 2019 PNNL, ISO NE Open Access Transmission Tariff 2020

Regardless of Li-ion cost and performance, there is a need for Multi-day LDES

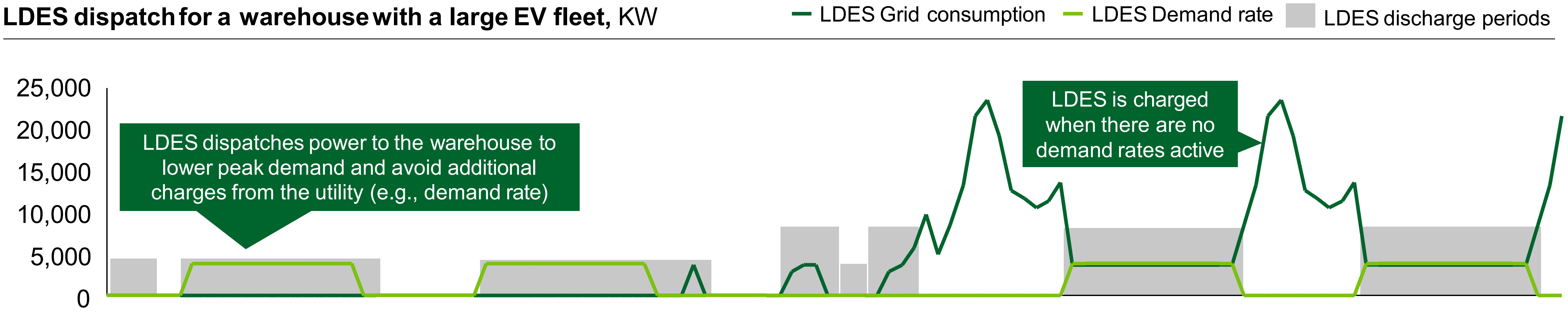


1 Assumes Li-ion batteries improve costs and performance at a moderate rate based on current Li-Ion cost curve (54% cost improvement through 2030 and 65% total improvement through 2050 relative to 2021 prices)
2 Assumes capex costs associated with energy component (e.g., battery cell) are 50% low er than in moderate scenario

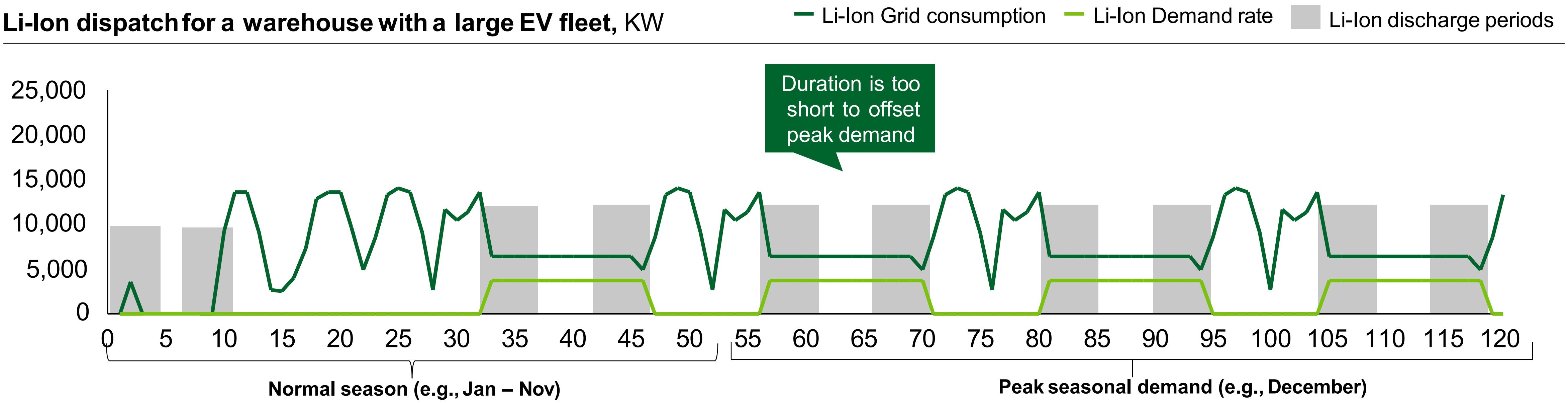
Source: DOE LDES Pathw ay to Commercial Liftoff Report

4a LDES's long duration of dispatch offers higher coverage of peak load and the ability to cover multiple peaks per day without repeated cycling

LDES dispatch for a warehouse with a large EV fleet, KW



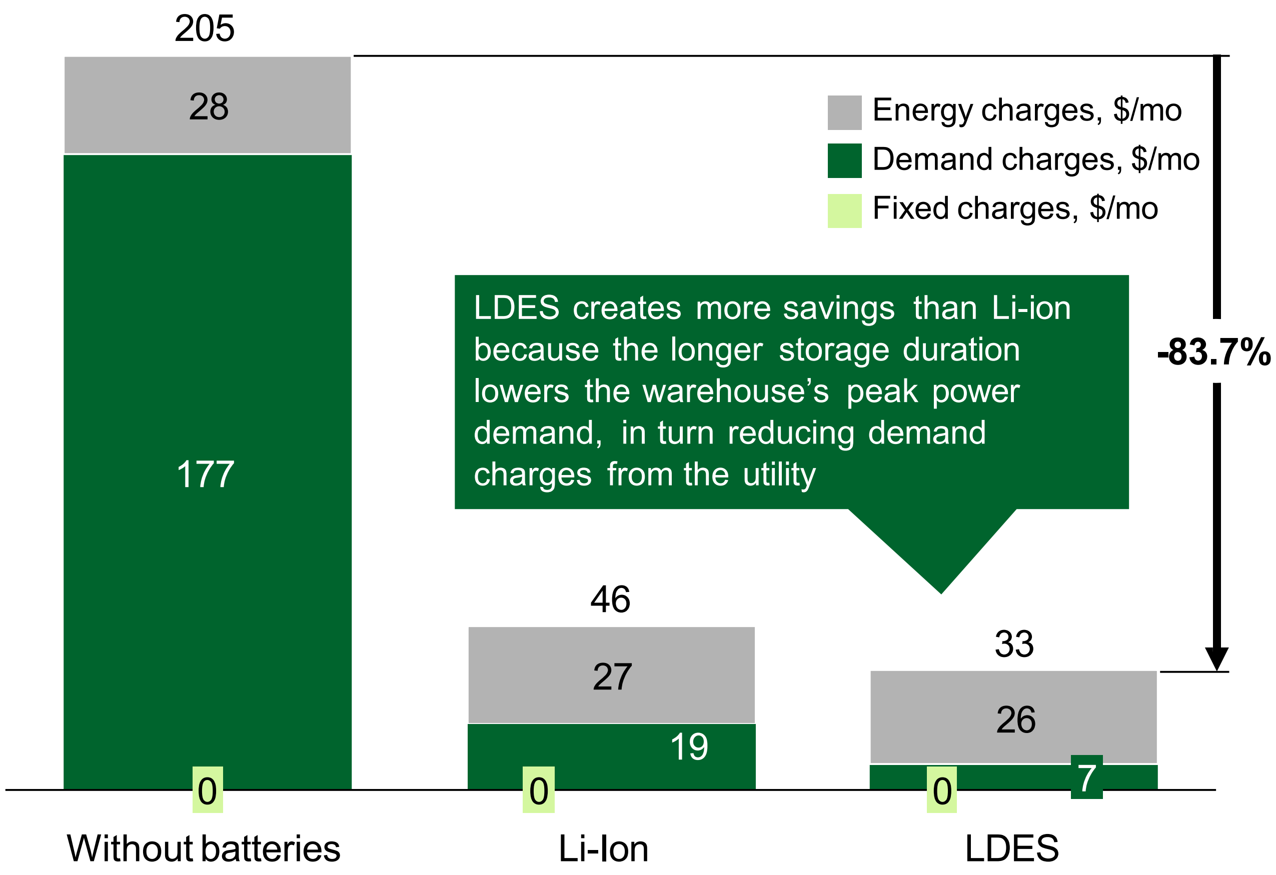
Li-Ion dispatch for a warehouse with a large EV fleet, KW



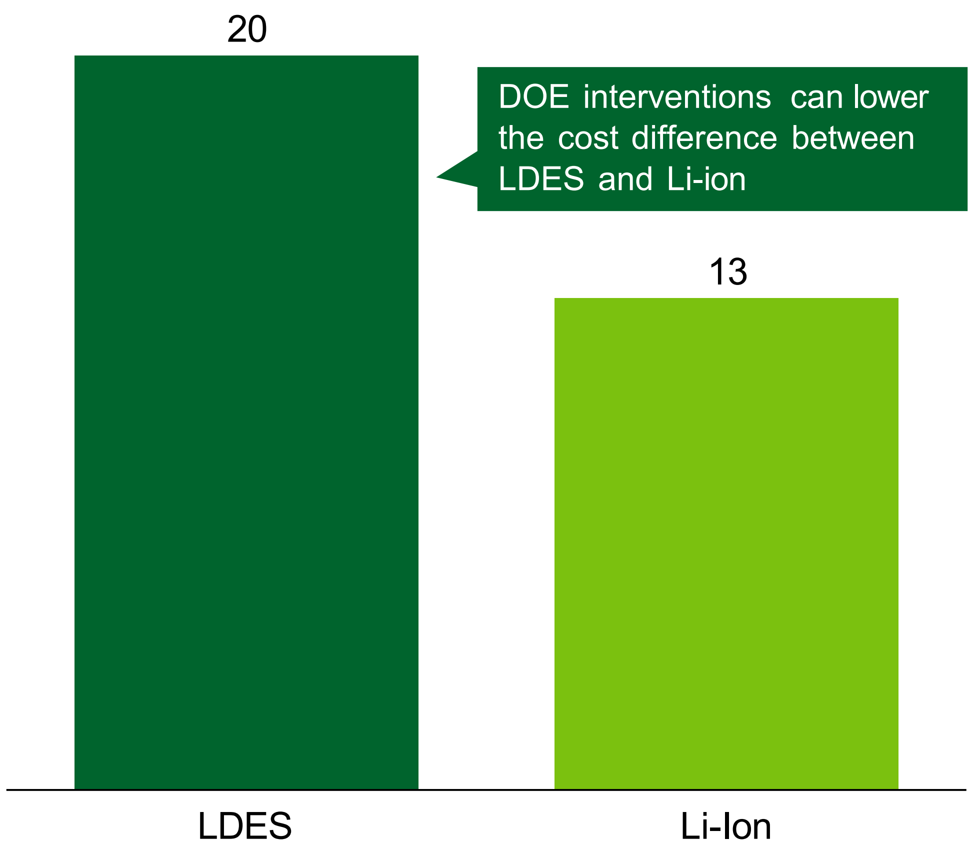
Source: DOE LDES Pathw ay to Commercial Liftoff Report, Heavy-Duty Electric Fleet Depot Charging Load Profiles & Substation Load Integration Assessment Results (NREL, 2021)

4a LDES offers better comparative savings over a much longer potential cycle life than Li-ion alternatives

Warehouse average monthly electricity bill, $ thousands



10 MW LDES vs Li-Ion capital cost (2025), $M



Source: DOE LDES Pathw ay to Commercial Liftoff Report, Heavy-Duty Electric Fleet Depot Charging Load Profiles & Substation Load Integration Assessment Results (NREL, 2021)

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