U.S. DEPARTMENT OF ENERGY

Pathways to Commercial Liftoff: Introduction

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Comments

The Department of Energy welcomes input and feedback on the contents of this Pathway to Commercial Liftoff. Please direct all inquiries and input to liftoff@hq.doe.gov. Input and feedback should not include business sensitive information, trade secrets, proprietary, or otherwise confidential information. Please note that input and feedback provided is subject to the Freedom of Information Act.

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Purpose of DOE "Liftoff" Reports

The Department of Energy (DOE) plays a critical role in accelerating the commercialization of clean energy technologies and enabling the nation's broader industrial strategy – creating high quality American jobs, strengthening domestic supply chains and global competitiveness, and facilitating an equitable energy transition. The historic Infrastructure Investment and Jobs Act (IIJA)[1] and Inflation Reduction Act (IRA)[2] have reinforced this mandate, positioning DOE to invest billions of dollars in large-scale demonstration and deployment of these technologies over the next decade. These investments are intended to drive commercialization and unlock trillions in private investment over the same period, to set the nation on a course to hit critical long-term decarbonization objectives.

DOE's Pathways to Commercial Liftoff provide public and private sector capital allocators with a perspective as to how and when various technologies could reach full-scale commercial adoption– including a common analytical fact base and critical signposts for investment decisions. Given the constantly and rapidly evolving market, technology, and policy environment, the Liftoff Reports are designed to be "living documents" – and will be updated as the commercialization outlook on each technology evolves.

The first Liftoff Reports are focused on clean hydrogen, advanced nuclear, and long duration energy storage, and additional reports will be added in the coming months. These emerging technology areas have been chosen due to their anticipated role in the clean energy transition, to complement that of mature clean energy technologies. These reports are intended to reinforce dialogue with the private sector, and DOE will be seeking continuous feedback from industry as these reports are updated and revised over time.[3] The DOE will continue to solicit input through industry forums, requests for information, and regular interaction in the context of our authorities; we also welcome direct public input which can be submitted via email to liftoff@hq.doe.gov.

The insights and takeaways found in these Liftoff Reports were developed through extensive stakeholder engagement and a combination of system-level modeling and project-level financial modeling. Taken together, these sources of insight shed light on a set of common themes and expose the interplay between the technologies of focus. They do not reflect DOE official policy or strategic plans; they are a resource intended to inform decision making across industry, investors, and the broader stakeholder community.

1 Pub. L. 117-58 (Nov. 15, 2021).
2 Pub. L. 117-169 (Aug. 16, 2022).
3 Note: The Pathways Report initiative does not represent a policy position for the DOE or the US government; nor does it reflect intentions for DOE program execution or funding.

How to read the Liftoff Reports

As of March 21, 2023 three Liftoff Reports have been developed (clean hydrogen, advanced nuclear, and long duration energy storage). Each Liftoff Report takes the view of a single technology and is designed to provide a shared understanding on the current state, pathways to commercial scale, and challenges to liftoff for each technology. The reports are organized accordingly. An Executive Summary is provided for each report that captures the key insights and takeaways. The full report also includes appendices of analysis and existing research. Each full Liftoff Report is organized into the same chapters for consistency and ease of use:

1. Introduction & Objectives
2. Current State of the Technology (e.g., value proposition, landscape, and business models)
3. Pathways to Commercial Scale
4. Challenges to Commercialization and Potential Solutions
5. Metrics and Milestones
6. Appendices of exhibits and further analysis

You can access available Liftoff Reports and corresponding Executive Summaries at https://liftoff.energy.gov. The Department of Energy welcomes input and feedback on the contents of these Pathway to Commercial Liftoff. Please direct all inquiries and input to liftoff@hq.doe.gov. Input and feedback should not include business sensitive information, trade secrets, proprietary, or otherwise confidential information. Please note that input and feedback provided is subject to the Freedom of Information Act.

The remainder of this introduction provides an overview of the technologies addressed in these Liftoff Reports. An overview of how the Liftoff work approaches societal considerations and impacts, including for equity, labor, and economic prosperity, can be found in the **Societal Considerations and Impacts Overview.**

Introduction to the Liftoff Technologies

The technologies discussed in these Liftoff Reports all have a critical role to play in the clean energy transition, but also face challenges to commercialization that need to be resolved through a combination of public and private sector actions and investments.

Advanced Nuclear

As a carbon-free, firm power generating resource, nuclear can play a critical role in complementing the buildout of variable renewables and providing a significant portion of the additional clean, firm capacity required in all decarbonization scenarios.

System modeling indicates achieving net-zero in the U.S. by 2050 requires adding on the order of 550–770 GW of additional clean, firm power. These same models indicate advanced nuclear is likely to be the economic option for at least 200 GW of this capacity addition assuming expected overnight capital cost reductions, comparing favorably with other clean, firm options (e.g., renewables paired with long duration energy storage, fossil with carbon capture, geothermal). Deploying ~200 GW of nuclear capacity in the U.S. could require ~$700B in capital formation by 2050, with $35-40B required by 2030. Challenges with transmission expansion, interconnection, land-use intensity, and other factors limiting renewables buildout are likely to make nuclear an even more attractive option.

New deployment of advanced reactors at scale, however, will depend heavily on taking action toward building a committed orderbook of 5-10 projects by 2030; and achieving predictable construction timelines and cost profiles, by incorporating lessons learned from Units 3 and 4 at the Alvin W. Vogtle Electric Generating Plant, two Westinghouse AP1000 pressurized water reactors.

Clean Hydrogen

Clean Hydrogen will play a particularly important role in decarbonizing sectors that are more difficult to decarbonize, such as refining, chemicals, and heavy-duty transport.

The U.S. clean hydrogen market is poised for rapid growth, accelerated by DOE's Hydrogen Hub funding, the hydrogen production tax credit (PTC), DOE's Hydrogen Earth Shot, and decarbonization goals across the public and private sectors. Clean hydrogen production has the potential to scale from nearly zero today to ~10 million metric tons per year (MMTpa) in 2030 across industrial, transportation, and power sector use cases and 50 MMTpa by 2050; representing an investment opportunity of $85-215B through 2030.

In many cases, the clean hydrogen PTC pulls forward Total Cost of Ownership (TCO) breakeven points to within the next ~5 years for best-in-class projects (e.g., those with access to high capacity factor renewables) across industrial and transport applications. BIL and IRA provisions have catalyzed production, such that announced clean hydrogen production projects at EOY 2022 would meet 2030 demand projections, with more announcements expected.

However, favorable supply-side dynamics will be insufficient to scale the market, unless current chicken-and-egg challenges between scaling midstream infrastructure and end-use applications are also addressed. Clusters of hydrogen projects (including adjacent production / offtake) and regional hydrogen hubs around the U.S. (including hubs to be supported by DOE funding) will provide important proof points to scaling clean hydrogen and expanding regional distribution / offtake networks.

Introduction to the Liftoff Technologies (cont.)

Long Duration Energy Storage (LDES)

Long Duration Energy Storage can provide critical flexibility and reliability in a future decarbonized power system. In addition, LDES could be an important solution to improve local and regional resiliency with increasing frequency of extreme-weather events, while also reducing the cost and risks around grid expansion.

The U.S. grid may need on the order of 225-460 GW of LDES capacity for power market applications for net zero systems, representing $330B in cumulative capital investment. While this requires significant levels of investment, analysis shows that by 2050 net-zero pathways that deploy LDES result in $10-20B in annualized savings in operating costs and avoided capital expenditures by 2050 compared to pathways that do not.

LDES includes a set of diverse technologies that share the goal of storing energy for 10 to 160 hours of duration of dispatch. The LDES report defines and analyzes two market segments: Inter-day LDES (10-36 hours) and Multi-day LDES (36-160+ hours).

To deploy LDES technologies at scale will require action in three areas: public and private investment to drive down cost and improve performance; market intervention and reform to compensate differentiated performance and services; and flexible and rapid supply chain formation to avoid deployment bottlenecks ahead of a potential surge in demand.


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