EXECUTIVE SUMMARY

Energy Storage Market Forecast: 2022

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Lux Research | The Deciding Factor

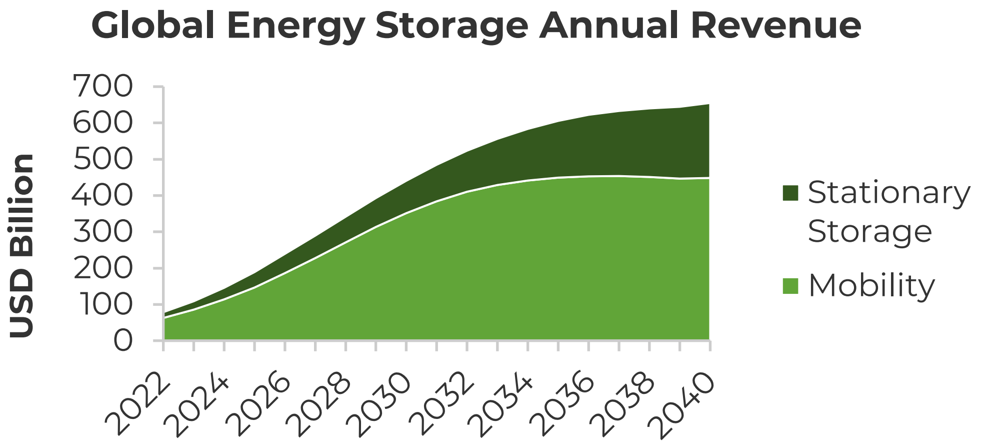
The energy storage industry is set for massive growth, provided supply chains can keep up

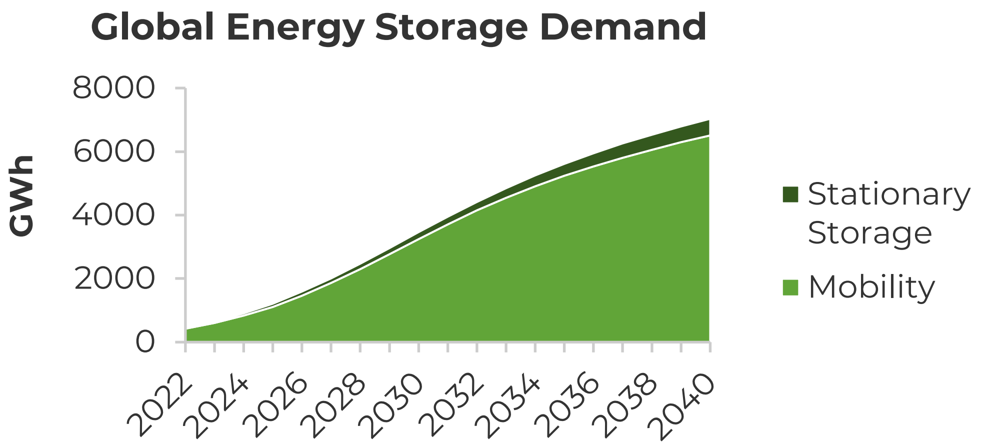
Mobility applications will drive demand for energy storage

The critical role of energy storage in the energy transition will drive dramatic growth in its demand. Usage in electric vehicles (EVs) will drive the most growth — 92% of demand in 2040 — due to large pack sizes and a large addressable market. Stationary applications will capture dramatically less energy storage demand, but significantly higher system-level costs will capture nearly one-third of revenue in 2040.

Availability and cost of raw materials will dictate the pace of growth

Dramatic cost reductions in energy storage previously came from growing economies of scale. Today, those cost reductions are maximized, and the costs of batteries are closely tied to the price of raw materials. Further, automakers are scrambling to secure cell supplies to avoid potential shortages. With few alternatives to Li-ion batteries commercially available today, a lack of growth in the Li-ion supply chain could limit growth.





Energy storage technologies are critical in the energy transition

Electrification is one of the most critical strategies to reducing global emissions. The emergence of low-cost renewables like solar photovoltaics and wind turbines means any product or process using electricity can be decarbonized. Though neither a generator nor user of electricity, energy storage sits at the heart of this transition, as it is critical to enabling electrification in two major sources of emissions: power generation and transportation.

- **Power Generation (14% of global emissions):** Our grid today is optimized for distributing power from large, controllable power plants, which can be mostly turned on and off based on expected demand. Tomorrow's zero-carbon grid will be built around significantly more distributed sources of generation that are not controllable. Energy storage plays a key role in integrating these intermittent renewables. At low penetration rates of renewables, short-duration storage manages small fluctuations in the frequency and voltage of the grid. At higher penetration rates, longer-duration storage can shift solar power generated during the day to be used at night or even store energy generated during the summer to be used in the winter.
- **Transportation (16% of global emissions):** Most methods to transport people and things today use liquid hydrocarbon fuels due to their high energy density, historically low costs, and widespread availability. Decarbonizing transport requires the use of batteries. Hybrid vehicles use small batteries to harvest the energy lost during braking to reduce fuel consumption, battery EVs (BEVs) run solely on stored power in batteries, and fuel cells use batteries to manage throttle output and harvest energy during braking.

The key to these developments was the Li-ion battery. Developed initially for consumer electronic devices like cameras and phones, its combination of high energy density and low cost made it the technology of choice for storing energy for both grid and mobility applications.

Questions about Li-ion batteries no longer start with "if" but "how"

The last decade in the energy storage space was dominated by questions of whether consumers would adopt EVs and if prices would fall enough to make adding large amounts of renewables and grid storage economical. Today, few ask questions focused on "if" batteries will be used, as the answer is a resounding "yes."

Instead, the biggest questions the industry faces today are about "how?" How fast will demand for Li-ion batteries grow? How fast can all parts of the supply chain keep up with this growth? How can companies minimize their exposure to delays caused by supply chain issues?

In this report we review key trends and events surrounding the answers to these questions, review how they impacted our previous forecasts, and ultimately present our newest forecasts for energy storage demand.

Raw Materials Extraction	Materials Refining	Active Materials and Electrolytes	Li-Ion Cells	Module and Pack Assembly
Extracting raw materials for batteries	Refining minerals for battery production	Synthesizing active materials and others for cell assembly	Producing battery cells	Producing complete battery packs for use in end-applications

Methodology

Stationary storage is divided into three sectors: residential, behind-the-meter commercial and industrial, and front-of-the-meter utility. Energy consumption varies across the three categories, and the market sizes are similarly distinct given the same energy demand.

- **Residential:** Residential energy storage systems are almost always tied to rooftop solar installations. We assume a 5-kW system size across geographies.
- **Commercial and industrial:** Commercial and industrial energy storage is primarily used for backup and demand charge reduction. Our model assumes a 100-kW battery and a 4-hour duration.
- **Utility:** Utility scale takes up the largest market share of stationary storage with the most possible applications. Systems range from single MW to over 100 MW and typically have a discharge duration between 2–4 hours.

Image credits (top to bottom): Tesla, Stem Inc., NGK Insulators

Methodology

To model stationary storage technology adoption, the forecast model utilizes a logistic function to simulate an S-curve. The function uses the following input parameters:

- **Past Deployments:** The existing energy storage infrastructure provides the starting point for the forecast, and it also provides insight for potential disruptions. In 2019, the energy storage market stagnated, in part due to large deployment numbers in 2018, and a lack of supportive regulations to integrate new assets.
- **Historic Energy Mix and Projected Penetration of Renewables:** Energy storage growth is intrinsically paired with the penetration of renewables. Grids will continue growing nondispatchable capacity for renewables while retiring traditional fossil fuel generators. The rate of change of the grid determines the timing for a specific energy storage market.
- **EV Fleet Size:** Fleet size by 2040 will determine additional energy needs not immediately predicted by historic power production patterns or stated capacity goals of renewables. Electrification of the transport sector and the additional load it creates are considered in our forecasts.
- **Replacement Rates:** The model assumes a 10-year retirement rate of energy storage assets, primarily based on Li-ion capabilities. Regions with slower growth will see replacement rates start to dominate the projected demand.

Methodology

Electrification of the transport sector has driven the vast majority of demand for energy storage. In this forecast we've considered demand from road-based transportation including the following vehicle types:

- **Light-duty vehicles:** Light-duty vehicles are primarily privately owned passenger vehicles but include smaller commercial vehicles, Class 2 and under.
- **Medium-duty vehicles:** Medium-duty vehicles (MDVs) are primary commercial vehicles between Classes 3–6.
- **Heavy-duty vehicles:** Heavy-duty vehicles (HDVs) include Class 7 and Class 8 trucks, which are used for commercial purposes. This category includes vehicles used in both shorter regional and long-haul routes.
- **Buses:** This category includes intracity buses used to move people within cities as well as intercity buses that travel longer distances between cities.

Image credits (clockwise from top left): Tesla, General Motors, Proterra, Peterbuilt

Methodology

We also use logistic functions, or S-curves, for mobility applications as they are commonly used to predict the timing and magnitude of technology adoption. The following factors are used to calculate S-curve parameters:

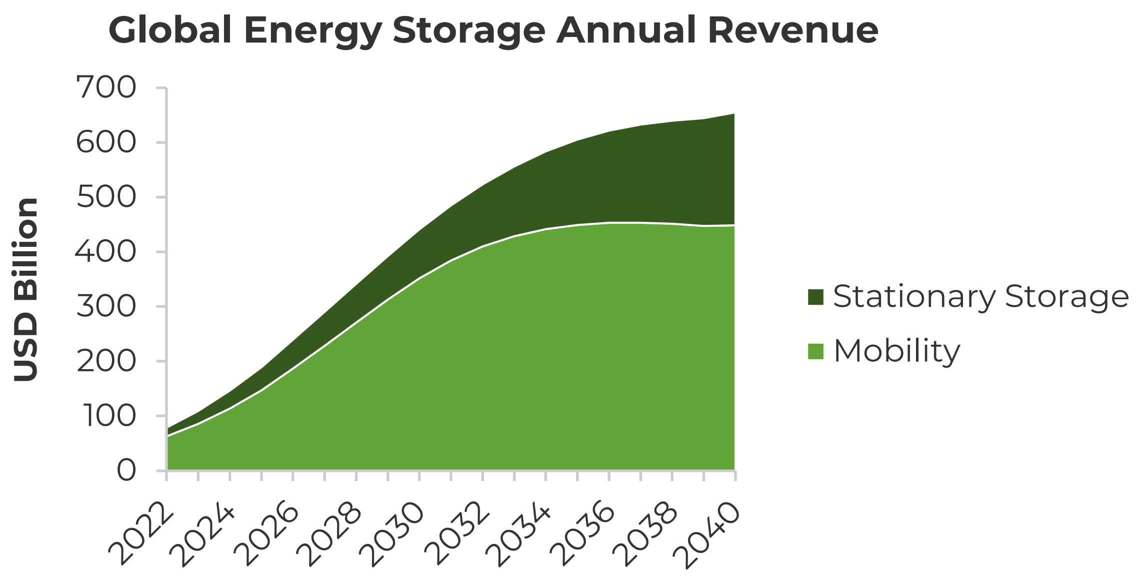
- **Historical Vehicle Sales:** Many regions are already seeing meaningful EV penetration above 10% as market penetration increased significantly during the COVID-19 pandemic. Our S-curves consider the calculated S-curve parameters from historical adoption.
- **Powertrain Costs:** Vehicle costs are a significant factor in customers purchasing vehicles. We consider both upfront costs for each powertrain in our forecasts as well as total cost of ownership (TCO). In light-duty vehicles, upfront costs are more important, while in commercial applications (MDVs and HDVs), TCO is weighted more heavily.
- **Regulations and Subsidies:** Regions with the strongest financial subsidies and regulations surrounding the adoption of EVs have seen the largest adoption to date, making this an important metric to consider in forecasts. The main types of regulations we consider are financial subsidies for EVs, bans of vehicles with internal combustion engines (ICE), and fuel efficiency standards.
- **Consumer Sentiments:** While most consumer surveys should be taken with a grain of salt, considering respondents may not be familiar with EV technology, there is no denying that consumer interest in EVs is accelerating and impacting demand.

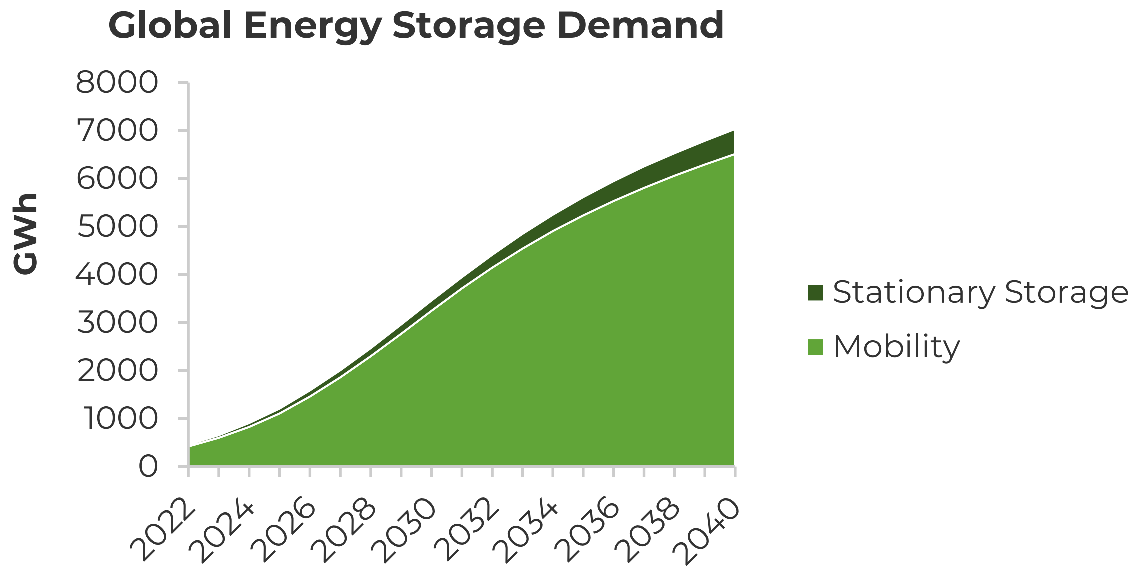
Global Energy Storage Forecast

Mobility will remain the biggest market for energy storage, making up 92% of energy storage demand (by GWh) by 2040.

The electrification of transport will remain a key driver of energy storage growth, while stationary storage deployments will be closely tied to regional energy needs. Increased revenue in stationary storage is tied to system costs, particularly for smaller behind-the-meter applications.

Technology and investment trends in energy storage will be dictated by automakers and battery manufacturers. Ongoing supply crunches have caused producers to reconsider low-cost battery materials and have created more urgency around high energy density batteries to use less material. Li-ion batteries will be the dominant energy storage technology, though stationary storage will have a more diverse distribution of technologies by 2040.



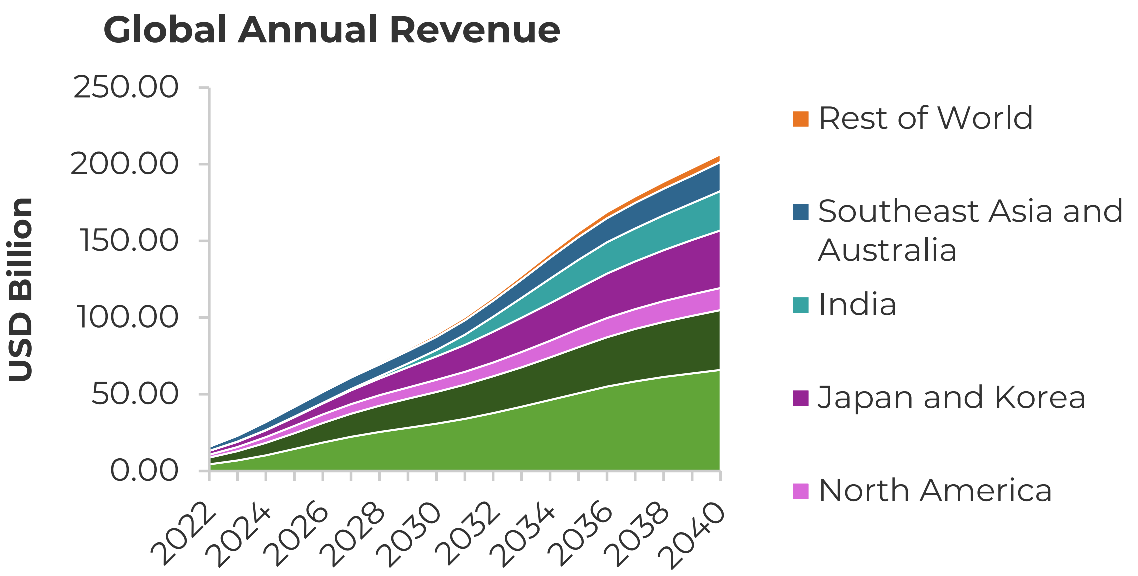


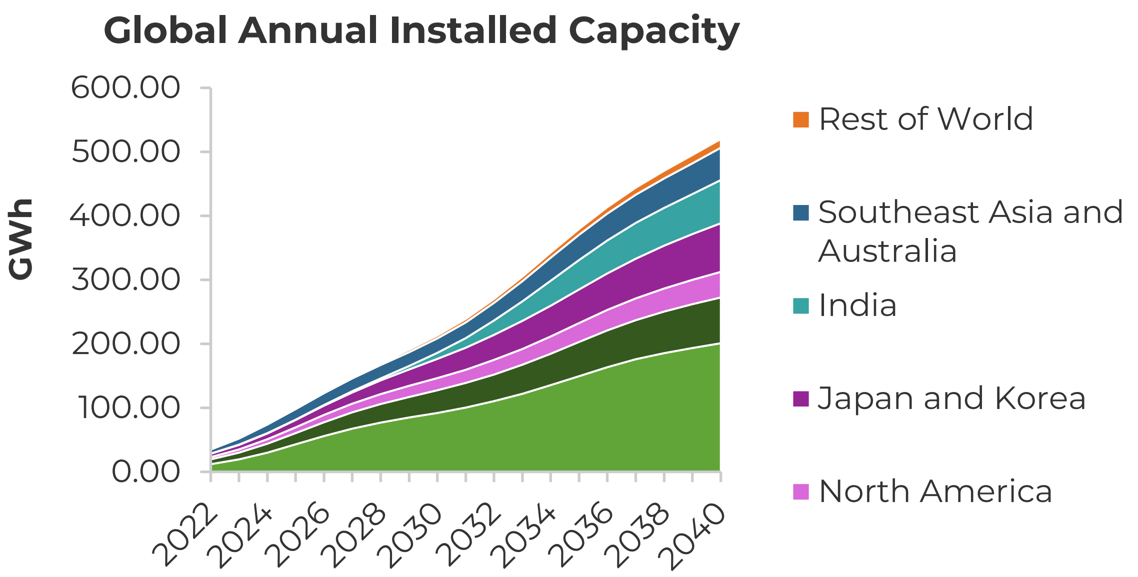
Global Stationary Storage Forecast

The global stationary storage market will be worth USD 206 billion in 2040, amounting to 520 GWh in annual deployments.

Energy storage demand is intrinsically tied to the grid energy mix or user need behind the meter. Grids integrating low levels of intermittent renewables will depend on short-duration energy storage for grid service applications to stabilize energy supply. Meanwhile, regions with higher penetration of renewables will integrate large systems for longer durations (four hours or above) and pursue more diverse revenue streams.

Policy will play a critical role in how energy storage is deployed. Countries with high penetration of renewables have already begun removing regulatory barriers that restrict battery use. Regions that define energy storage as a dispatchable power asset and build market mechanisms to make it profitable will attract more investment.



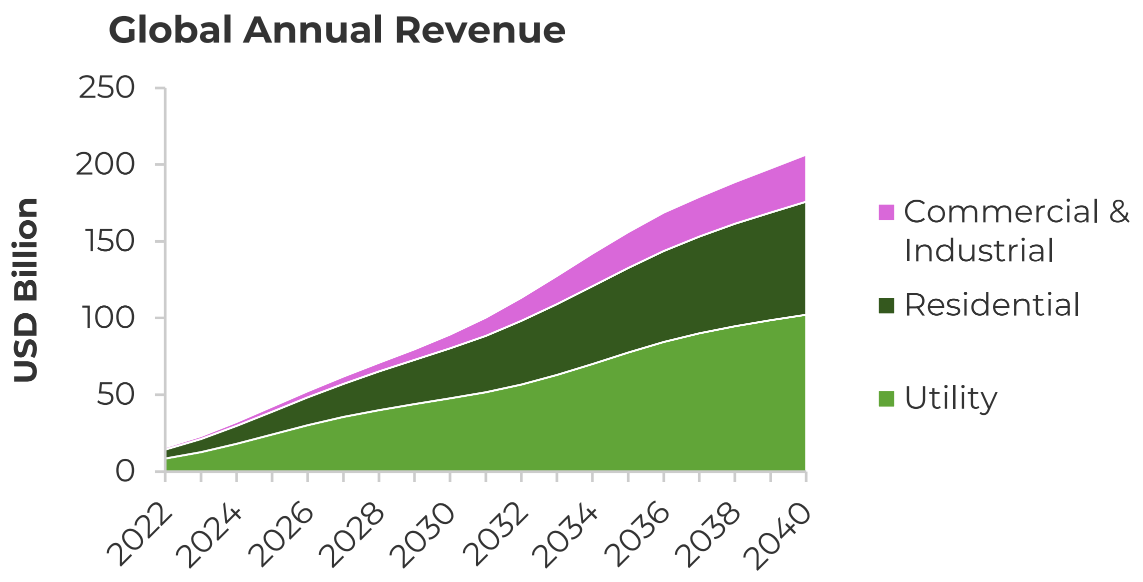


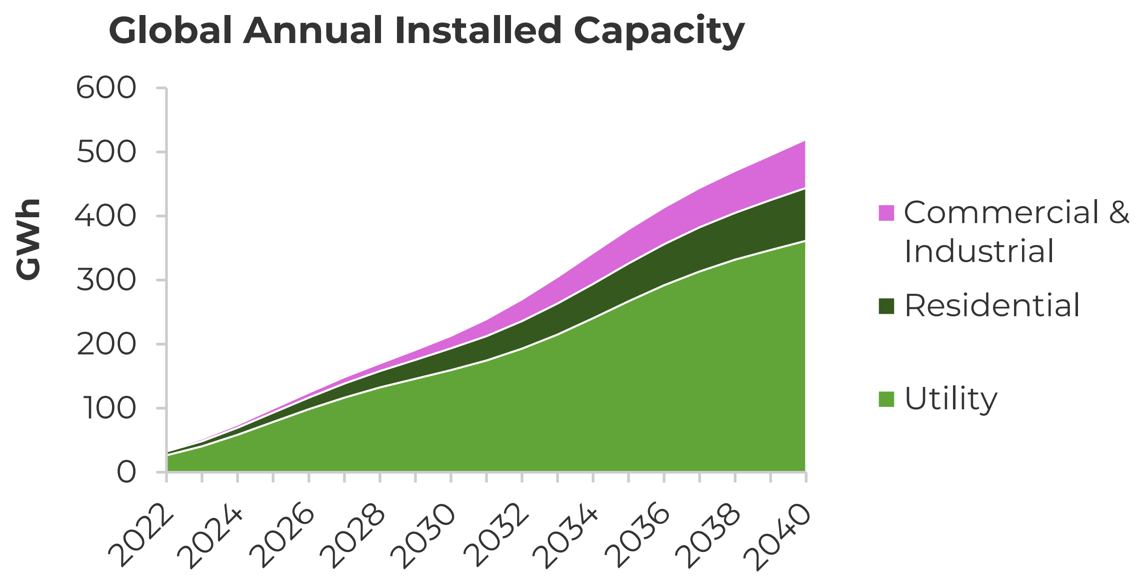
Global Stationary Storage Forecast

Utility-scale energy storage will account for 70% of total demand by 2040, and revenue will reach over USD 206 billion across sectors.

Behind-the-meter storage growth is largely driven by falling Li-ion cost; however, it is no longer only deployed for backup and reliability, but can serve as a valuable distributed asset. Residential energy storage will be more attractive in regions like Australia where feed-in tariffs are expiring, and residential systems are more economically competitive.

Utility-scale installation sizes keep increasing, with Vistra's Moss Landing system reaching 1,600 MWh. Energy storage will be vital as grids deal with congestion and intermittency while working to retire fossil fuel generators. Though Li-ion remains the most popular battery choice, the landscape in 2030 will fit technology to applications served.



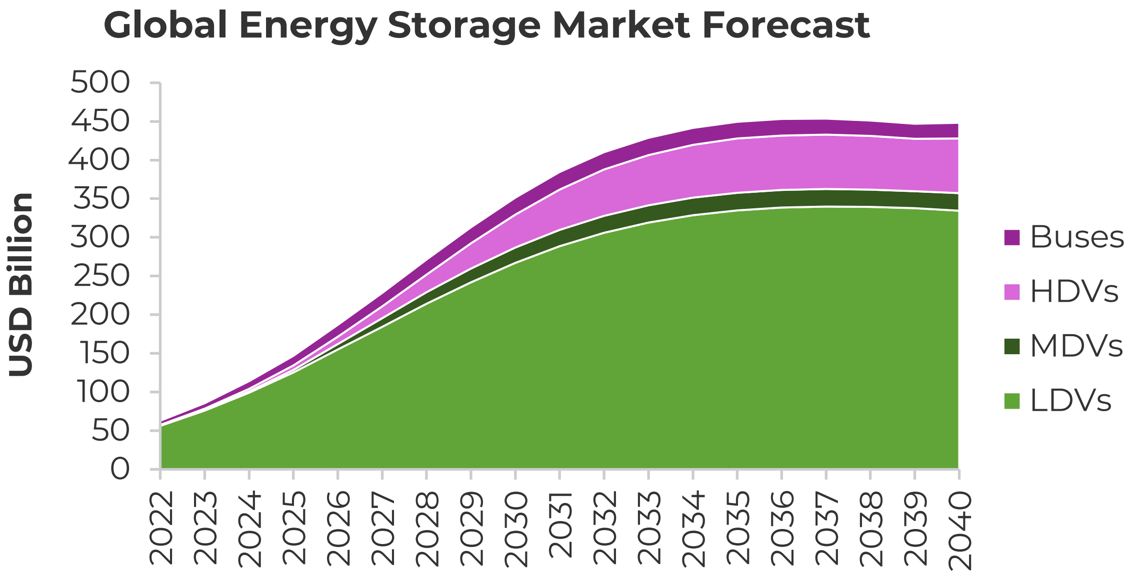


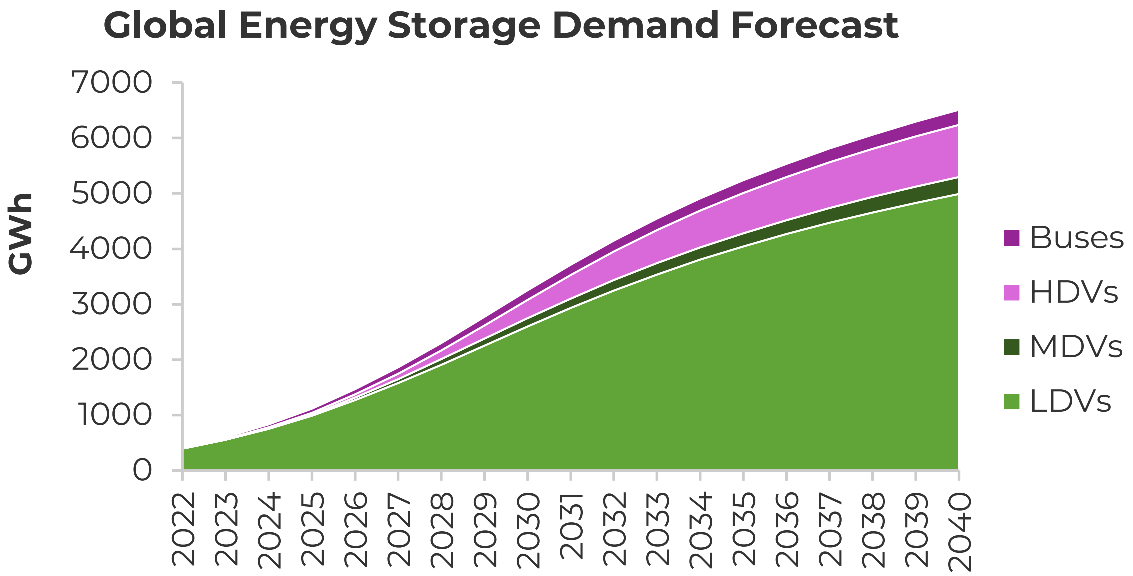
Global Mobility Forecast

Lux expects demand for energy storage to grow from an expected 423 GWh in 2022 to 6,513 GWh in 2040.

Mobility applications will remain the biggest market for advanced energy storage in the future. The large market for light-duty vehicles (LDVs) is the biggest source of demand, as a combination of consumer interest in EVs and a regulatory push to eliminate emissions intersect in the 2020s.

Commercial vehicles, including MDVs, HDVs, and buses, are smaller in number but represent a greater share of emissions. Adoption in these segments is more frequently driven by the TCO; as gas prices remain volatile, many fleet owners are expected to adopt EVs, regardless of the regulatory environment.





How do you integrate a large number of vehicles into the grid?

Integrating small numbers of EVs into the electrical grid will not threaten grid stability. Much like integrating solar photovoltaics, challenges in integrating vehicle charging to the grid emerge as high rates of penetration are achieved. As EV sales increase rapidly, the grid in some regions will begin to feel strain from these vehicles — strain that will only increase in the future.

Without managing EV charging, infrastructure will limit growth. Two new pieces of EV infrastructure are important in managing this new electrical load:

1. **Vehicle-to-grid (V2G) charging** enables vehicles to not only accept power from the grid to charge their batteries, but also to discharge batteries to provide grid services and compensate owners for its use. Historically vehicles were not designed for V2G, but today, Hyundai, Ford, and Nissan have released vehicles capable of and designed for V2G charging. Market reforms, like Federal Energy Regulatory Commission Order 2222 in the U.S., will further unlock the value of EVs as a grid asset.
2. **Battery swapping** schemes allow vehicles to quickly gain range without pulling large amounts of power from the grid. Stored batteries in a charging station can slowly charge or even participate in grid services with excess capacity, eliminating the spike in demand that fast charging brings. Costs for battery swapping scheme are roughly equivalent to those of fast charging, and the biggest barrier is a lack of automakers committed to producing swapping-enabled vehicles.

Commodity prices will impact the pace of electrification

Consumers are typically very short-sighted in their purchasing decisions of vehicles. Rather than making a TCO-based decision considering historical trends in fuel prices as many fleet owners might, they tend to respond to short-term indicators. Gas prices fall, and correspondingly, the sale of large, less-efficient vehicles increases. As gas prices increase, interest in hybrid and EVs increases.

Currently, both batteries and crude oil are highly volatile commodities. At the pump, consumers saw historically low prices in 2020, with historical highs in 2022. High gas prices have accelerated interest in EVs, but we're likely going to see battery prices increase for the first time this year due to increasing raw materials costs — specifically lithium, nickel, and cobalt. Clients should keep a close eye on the prices of these materials, as they will impact the pace of adoption.

440%

Increase in lithium carbonate prices between July 2021 and July 2022

59%

Increase in U.S. gasoline price between June 2021 and June 2022

Sources:

Stationary storage growth is tied to a slower moving electricity market and uncertain business models

Growth of stationary storage markets will largely depend on the grids they serve. Behind-the-meter deployments are less dependent on the overall energy mix, but incentives for users to install their own systems will come from regions with evolving grids along with market reforms that unlock new revenue streams. Utility-scale energy storage will remain the largest market sector, but widespread integration will require commercial acceptance of non-Li-ion battery technologies and shifts in both regulations and business models.

Apart from regional grid structures, there are other factors contributing to demand in stationary storage:

1. **Timelines for deployment must be shorter.** Historically, the time between a project announcement and field operation could be two years or more. As project developers and system integrators gain experience, that time has decreased; however, strains on Li-ion battery supply for stationary storage has once again kept timelines long. Alternative technologies like flow batteries will somewhat solve the security of supply challenge, but commercial immaturity will cause a similar delay.
2. **Projects will become more bankable as clearer business models emerge.** Across all stationary storage technologies, bankability — how readily investors will finance a project — will improve when markets provide clearer paths for revenue. In some instances, that means defining energy storage as its own category in energy markets and lowering barriers for systems to charge and discharge. For technologies with a shorter deployment history, more defined business models will allow for greater confidence in revenue opportunities.

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