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How cheap is battery storage?

Ember provides the latest capex and Levelised Cost of Storage (LCOS) for large, long-duration utility-scale Battery Energy Storage Systems (BESS) across global markets outside China and the US, based on recent auction results and expert interviews.

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About

This report provides the latest, real-world evidence on the cost of large, long-duration utility-scale Battery Energy Storage System (BESS) projects. Drawing on recent auction results from Saudi Arabia, India and Italy, along with in-depth interviews with project developers, suppliers and analysts across global markets, it captures the most up-to-date picture of battery capex and the Levelised Cost of Storage (LCOS) as of October 2025. The analysis focuses on markets outside China and the United States, where competitive procurement of Chinese-manufactured equipment is reshaping global storage economics.

Summary

Ember's assessment of storage costs as of October 2025, based on recent auctions in Italy, Saudi Arabia and India and on expert interviews, shows:

- **All-in BESS project capex of $125/kWh.** Across global markets outside China and the United States, the total capex to build a long-duration (4 hours or more) utility-scale BESS project is around $125/kWh, of which around $75/kWh is for the core equipment shipped from China and around $50/kWh to install and connect the battery.

- **A levelised cost of storage (LCOS) of $65/MWh.** An all-in capex of $125/KWh leads to a cost of $65/MWh to move electricity, based on the latest real-world project parameters. This low LCOS is not only the result of cheaper batteries — longer lifetimes, higher efficiencies and lower financing costs thanks to clearer revenue models like auctions have all helped to push the LCOS down sharply.

A second year of dramatic price falls means batteries are now cheap enough to make dispatchable solar economically feasible.

With the cost of storing electricity at $65/MWh, storing 50% of a day's solar generation for use during the night-time hours adds $33/MWh to the total cost of solar. The global average price of solar in 2024 was $43/MWh. Turning this cheap daytime electricity into a dispatchable profile that is closer to an actual demand profile, would therefore result in a total electricity cost of $76/MWh.

After a 40% fall in 2024 in battery equipment costs, it's clear we're on track for another major fall in 2025. The economics for batteries are unrecognisable, and the industry is only just getting to grips with this new paradigm. Solar is no longer just cheap daytime electricity, solar is now anytime dispatchable electricity. This is a game-changer for countries with fast-growing demand and strong solar resources.

Kostantsa Rangelova
Global Electricity Analyst, Ember

1. All-in BESS projects now cost just $125/kWh as of October 2025

Battery storage has moved past its infancy, driven by rapid factory scale-up, fierce competition and oversupply that has pushed costs sharply down. Across global markets outside China and the United States, the total capex to build a large, long-duration utility-scale BESS project is around $125/kWh, comprising $75/kWh for the core equipment shipped from China and around $50/kWh for installation and grid connection.

1.1 Expert interviews and auction results suggest $125/kWh is the latest all-in BESS project capex

Outside the US and China, a BESS project is now being built for around $125 per kWh all-in, with core equipment sourced from China and engineering, procurement and construction (EPC) services and grid connection included. This represents real-world project prices, derived from recent auction results in Saudi Arabia, India and Italy, as well as interviews conducted by Ember in October 2025 with experts working on BESS projects across global markets, including Saudi Arabia, Italy, India, Australia, Mexico, Romania, Croatia, and Türkiye.

1.1.1 Core equipment costs around $75/kWh to deliver from China

Core equipment - mainly the BESS enclosures, the Power Conversion System (PCS) and the Energy Management System (EMS) - costs around $75/kWh when delivered from China, for countries with low import duties. This cost is per unit of usable battery capacity. Manufacturers typically oversize the installed capacity by at least 10%, allowing them to guarantee a 0–100% state of charge operating range.

The price of Lithium Iron Phosphate (LFP) battery cells for stationary energy storage applications has dropped to around $40/kWh in Chinese domestic markets as of November 2025. These cells are further integrated into battery enclosures, which house 5-6 MWh of cells in 20-foot containers. The enclosures account for close to 90% of the $75/kWh core equipment cost for long duration projects, with PCS and EMS costs making up around 10%.

The $75/kWh applies to larger, four-hour or longer BESS projects. Smaller projects may not get such competitive quotes from Chinese manufacturers. Additionally, total equipment costs are 10–15% cheaper for four-hour projects because several components are sized to power (MW) rather than energy (MWh), meaning the cost is spread over more storage hours. Beyond four hours, however, the marginal savings become progressively smaller.

Core equipment costs can reach $100/kWh or higher in markets with higher tariffs, stricter standards (such as safety certifications), or local content requirements (though in India, local PCS and EMS prices are competitive with China).

1.1.2 Installing and connecting the battery costs about $50/kWh

The EPC services and grid connection required to turn this equipment into an operational project can vary widely, but typically costs around $50 /kWh. This assumes land is provided by a tendering utility or purchased at a low cost.

The largest variation in costs comes mainly from the grid connection fee. This results in costs ranging from as little as $30/kWh with inexpensive grid connection to $100/kWh in extreme cases, with more typical values around $50/kWh, according to experts. However, when the battery storage is built at an existing solar plant or installed behind the meter, the grid connection cost becomes negligible.

1.1.3 Evidence from the auctions

There is clear evidence from three recent auctions that helps corroborate the all-in capex cost estimate of $125/kWh.

Two recent auctions in Saudi Arabia were priced at around $120/kWh. The Tabuk and Hail projects awarded equipment supply contracts in August 2025 of $179–183 million for 2.45 GWh each, or just $73-75/kWh. The EPC contracts added another $116–118 million, or $47–48/kWh.

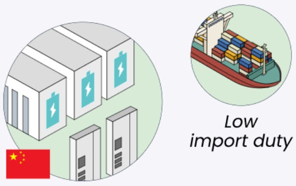
Italy's MACSE tender in October 2025 closed at €13/kWh per year. Expert interviews indicate this corresponds to a capex of around $120/kWh, with an approximate $70/$50 per kWh split between core equipment and EPC. As a sense check of the $120/kWh figure: at €13/kWh per year, it would take around eight years to recover the capex before applying a discount rate (vs a 15-year contract horizon). Italian auctions also allow some additional revenue streams, which would shorten the payback period even further.

India concluded several BESS auctions in 2025 with various scopes and clearing prices. One example is the RVUNL auction (1GW/2GWh), which cleared at 177,500 INR/MW/month. This is equivalent to $12/kWh/year, around 20% lower than the Italian auction price.

However, developers in India receive a CAPEX subsidy of 1.8 million INR/MWh (just over $20/kWh), which helps explain the lower price compared to Italy. Expert discussions suggest that current BESS prices are close to $120 /kWh. Some auctions even suggest capex below $100/kWh, although expert interviews suggest these cases reflect developers' expectations of future battery price reductions.

As of October 2025, the all-in capex for long-duration utility-scale battery storage is around 125 $/kWh outside China and the U.S.

Capital costs, $ per kWh usable energy capacity



~$75/kWh

Core equipment
Battery enclosures and Power conversion system (PCS) shipped from China

More expensive for non-China products.

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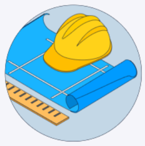

~$50/kWh

Construction and grid connection
EPC (Engineering, Procurement, Construction) and grid connection including design, project management, installation, civil works, permitting

More expensive with high grid connection fee

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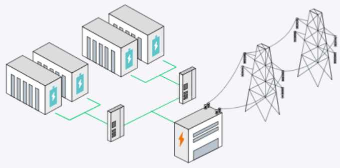

$125/kWh

Full project, connected to the grid

More expensive for smaller, short duration (<4 hours) projects

Based on evidence from auction results in Saudi Arabia, Italy and India and interviews that Ember conducted in October 2025 with experts working on BESS projects across global markets, including Saudi Arabia, Italy, India, Australia, Mexico, Romania, Croatia, Turkey and beyond.....

Saudi Arabia (August 2025) Tabuk and Hail equipment supply contracts for $179 and $183 million USD at 2.45 GWh each are 73-75 $/kWh. EPC contracts at $116-$118 million USD or 47-48 $/kWh

Italy MACSE tender from October 2025 closed at €12,959/MWh per year tariff with expert interviews indicating an underlying capital costs of 120$/kWh

India concluded several BESS auctions in 2025 with various scopes and clearing prices, e.g. INR 177.500/MW/month from RVUNL (1GW/2GWh), which is $12/kWh/year However, developers receive a CAPEX subsidy of INR 1.8 million/MWh or just over 20 $/kWh. Expert discussions suggest current BESS prices today close to $120/kWh.

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1.2 Prices have fallen sharply in the last 12 months

Batteries have seen dramatic cost reductions, with a particularly steep drop in 2024. The evidence from this analysis suggests 2025 has seen further large falls.

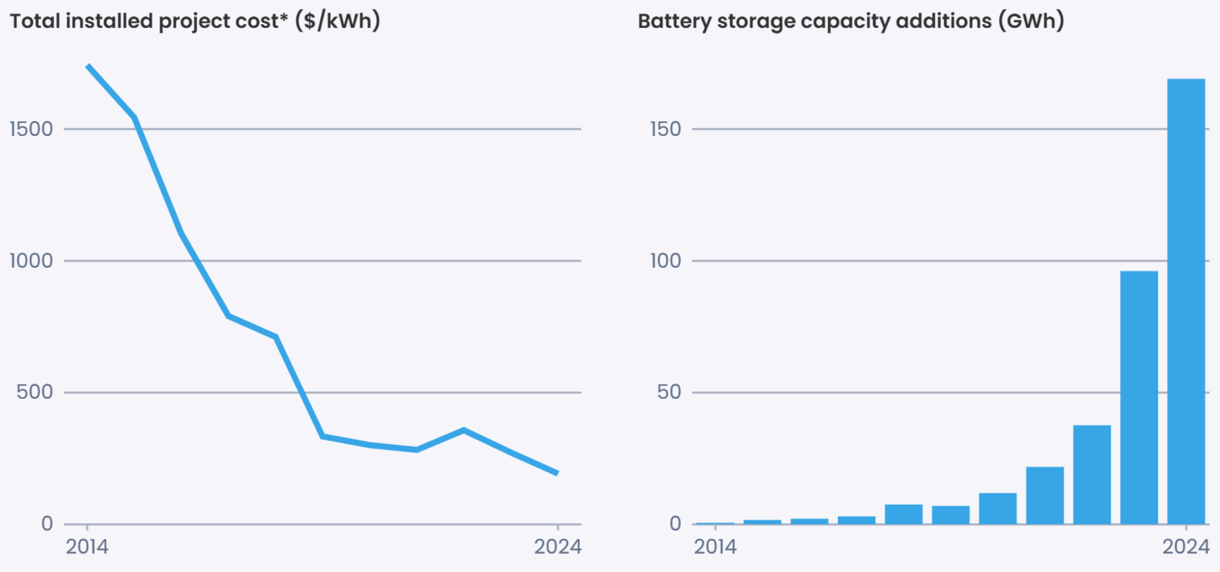
1.2.1 2024 saw a big fall in price

The cost of core BESS equipment fell by 40% in 2024 compared with 2023, reaching a record low of $165/kWh, according to BloombergNEF's global benchmark. This was driven by the rapid scale-up of assembly plants – which integrate cells into containerised systems - combined with intense manufacturer competition and continuing declines in LFP cell prices.

Installation costs are also dropping as systems become increasingly "plug and play". Integrating components such as the PCS directly into AC blocks has simplified deployment and reduced project risk, accelerating learning and further lowering costs.

This has now been a decade of rapid cost reductions. Over the last 10 years, installed costs have fallen by 20% per year on average, while deployment has increased by around 80% per year.

Battery cost fell by an average 20% per year over the last decade as annual installations rose by 80% per year



Source: IRENA • *Costs of a fully installed and commissioned battery storage project, 2024 prices in USD/kWh of usable capacity

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1.2.2 2025 has seen a further big fall in price

This research does not attempt to quantify a year-on-year change. However, based on our interviews and market evidence, BESS equipment prices — after the 40% fall in 2024 reported by BNEF — are on track for another major decline in 2025.

The $75/kWh core equipment estimate in this report reflects large-scale, competitive procurement of Chinese equipment in markets outside the United States and China, with low import duties as of October 2025. It is not directly comparable to BNEF's 2024 global average of $165/kWh, which includes markets with significantly higher costs (such as the US), a more diverse range of equipment suppliers and represents an average across 2024, not an end-of-year snapshot. Hence, the implied 55% fall from $165/kWh to $75/kWh is not representative. Nonetheless, we can expect to see a large fall when BNEF's updated global benchmark for 2025 in early 2026.

Non-equipment costs have also continued to fall, although their contribution to the total decline in BESS project capex is small.

2. Capex of $125/kWh means a levelised cost of storage of $65/MWh

This low levelised cost of storage (LCOS) is not only the result of cheaper batteries. Longer lifetimes, higher efficiencies and lower financing costs, supported by clearer revenue models such as auctions have all contributed to driving storage costs down sharply.

2.1 What is behind the $65/MWh LCOS

The cost of storing a unit of electricity is called the levelised cost of storage (LCOS). In this analysis, the LCOS reflects the cost of shifting one MWh to another time, such as moving daytime solar to night-time. Therefore, we do not include the cost of electricity to charge the battery. Other LCOS definitions, such as Lazard's, reflect the cost of discharging one MWh of electricity and do include the cost of charging the battery.

There are six assumptions that translate the capex into the LCOS. These assumptions can be very project-specific and difficult to generalise. We developed a live calculator that allows users to work out the LCOS based on their own assumptions.

The LCOS is $65/MWh for a project with a large, long-duration utility-scale BESS project, that shifts daytime solar to night-time hours and has guaranteed revenues. This is based on the six input assumptions listed below, which were validated through our interviews and research.

2.1.1 20-year lifetime

A 20-year lifetime is now the standard design life of the battery, as LFP technology has enabled higher cycle life. Performance guarantees can be expressed in years or cycles: in years, guarantees are often 20 or even 25 years and in cycles, they are typically 10-12,000 cycles or more (which, at one cycle per day, is more than 25 years). A 20-year lifetime at 1 cycle per day also matches Lazard's latest assumptions.

2.1.2 7% discount rate

For low-risk, contracted battery projects, experts point to a 5–7% discount rate, so we use 7% as a conservative upper limit. Contracted, fixed revenue sources are increasingly common, especially for long duration projects. Higher-risk merchant projects can face 10–15%, with Lazard's assumptions also falling within that range.

The higher the discount rate, the less valuable future revenues become and the more expensive the storage project becomes overall.

2.1.3 90% efficiency

A 90 % efficient battery (round-trip, AC to AC) is at the upper end of performance offered by leading suppliers, using high-quality PCS and optimized system integration typical of 2025 installations. It is still below the 92% efficiency in Lazard's low-end LCOS case. Older generation batteries are closer to 80-85% efficiency.

2.1.4 80% utilisation rate

Long duration systems (4 hours or more) can rarely achieve more than one cycle per day. Our modelling suggests that 80% of one full cycle per day is a conservative estimate if the battery is used to shift solar electricity from light hours to dark hours every single day in a location with relatively consistent sunshine throughout the year. Lazard's assumption of 1 cycle per day for 350 days per year represents 96% utilisation.

2.1.5 2% degradation per year

By the end of its design life, the electricity delivered by the battery will be lower due to degradation. Manufacturers typically guarantee ≤2 % annual fade, meaning after 20 years, capacity remains at around 65% of initial usable energy. Higher cycling leads to faster degradation and a shorter lifetime. In Lazard's LCOS, degradation is priced in as an additional cost for capacity augmentation after year 3, at 0.66%-1.85% of capex, but our expert interviews suggest that this is not a common practice.

2.1.6 2% operational costs

Annual operational costs for utility scale battery storage projects are typically low - around 2% of capex. We assume 2%, equivalent to $2.5/kWh/year, which covers routine maintenance, monitoring and performance guarantees, but excludes augmentation or extended warranties. Lazard's assumptions for operational costs also fall within 2% of the total installed cost in both their high and low end LCOS case.

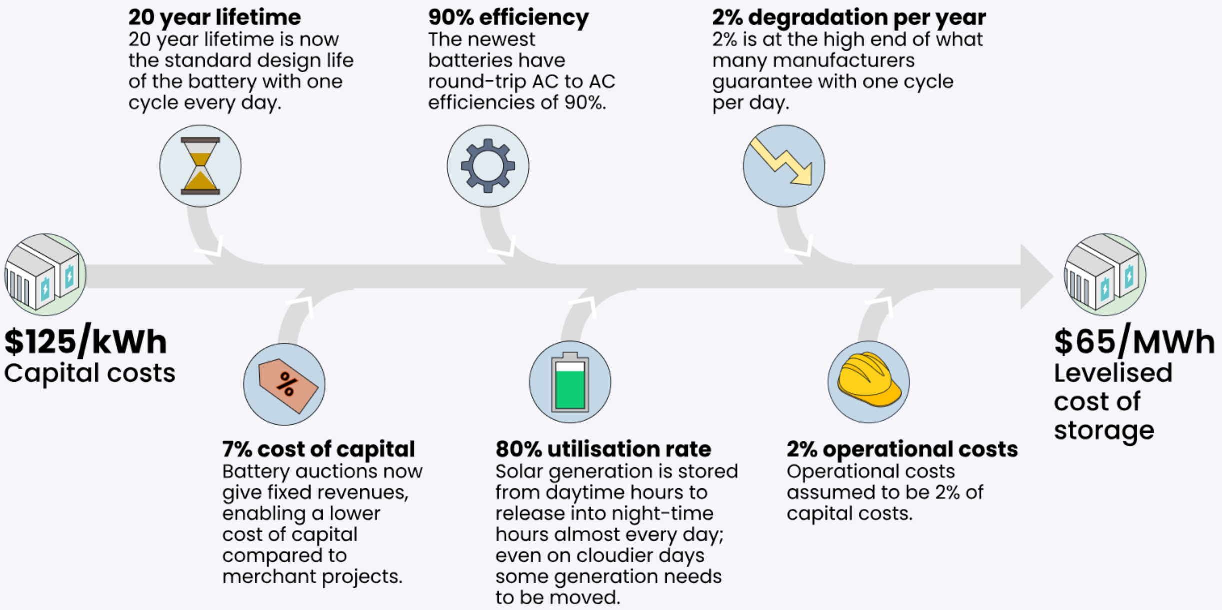
A sensitivity test shows that our assumptions remain largely conservative. Even when we align the inputs more closely with Lazard's – raising the discount rate to 11%, efficiency to 92% and utilisation to 96% — the LCOS for the same $125/kWh capex will still come out at $65/MWh. Meanwhile, Lazard's low-end total installed cost of $155/kWh for a 100MW/400 MWh battery system (i.e. $62 $ million) is significantly above the low-end capex for large BESS projects outside the US that use Chinese-manufactured equipment.

2.1.7 Other potential revenues would further lower the LCOS

The LCOS presented above does not take into account other revenue sources. In practice, shifting energy is only one part of the value a battery delivers. It also keeps the grid stable by providing services like frequency control, voltage support and emergency black-start, each creating its own revenue stream. When these services are stacked alongside energy shifting, the effective cost of moving a megawatt-hour becomes even lower.

$125/kWh capital cost outside China and the US translates into levelized cost of storage (LCOS) of $65/MWh

Based on utility-scale, long-duration battery that moves daytime solar to night-time hours with guaranteed revenues.



Our definition of LCOS is the cost of moving one MWh of electricity to another time; Other LCOS definitions are the cost of discharging one MWh of electricity, which would include the electricity cost of charging the battery.

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2.2 Longer lifetimes, higher efficiency and lower project risks have cut the LCOS by over a third

Battery prices have fallen significantly in recent years but the LCOS has fallen even faster.

This is because today's batteries perform far better than earlier generations.

We show conceptually how just three performance improvements alone reduce the LCOS by 35% — from $100/MWh to $65/MWh — even before accounting for falling battery prices.

- Longer lifetimes: Modern LFP now have a 20-year lifetime, compared with around 10 years previously. Extending the lifetime alone reduces the LCOS by $20/MWh.

- Higher efficiency: Older models operated at around 85% efficiency compared to 90% now, cutting a further $5/MWh off the LCOS.

- Lower project risk: Safety has improved significantly, reducing practical risks such as fire. Moreover, revenues are shifting from a merchant approach to an auction approach. Lowering the cost of capital from 10% to 7%, saves $10/MWh off the LCOS.

Taken together, these improvements, not just cheaper equipment, explain why the LCOS has declined so dramatically.

3. With a $65/MWh LCOS, shifting half of daily solar generation overnight adds just $33/MWh to the cost of solar

The LCOS does not apply to all solar generation, just the proportion being stored. When the LCOS is $65/kWh, shifting 50% of daily solar generation to when it's needed adds $33/MWh, to the total cost of solar generation. This means that if solar costs $43/MWh, dispatchable solar costs just $76 /MWh.

3.1 Cheap daytime solar becomes economic dispatchable solar

Solar is the cheapest form of electricity the world has ever had at its disposal. Much of it is consumed directly during the day, so only a part of it needs to be stored and only that part carries the additional storage cost.

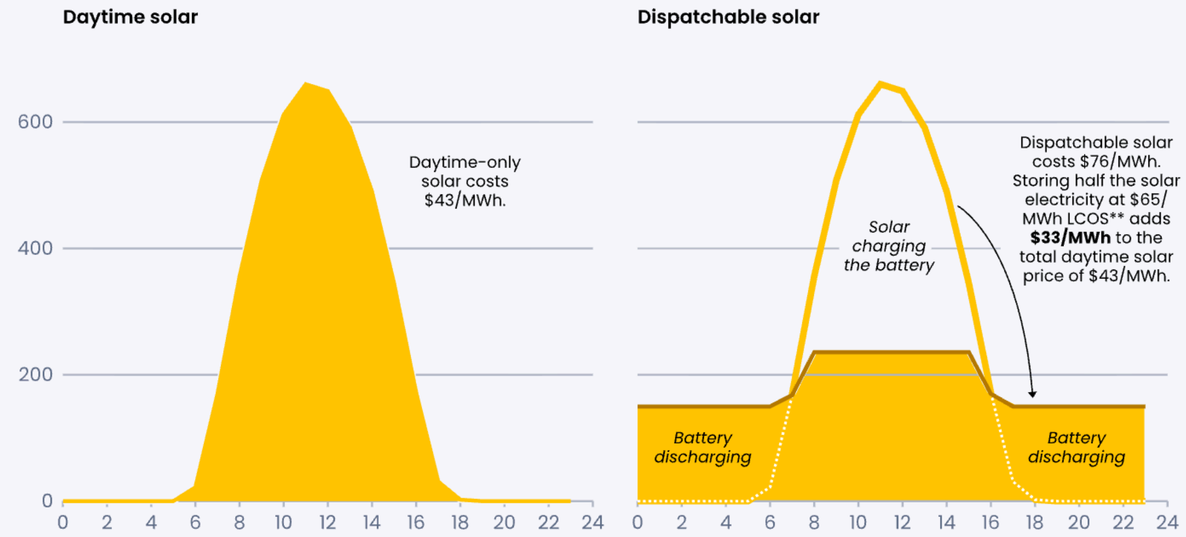
Storing around 50% of daytime solar is enough to keep solar electricity flowing through the night. At $65/MWh LCOS, storing half the output roughly adds $33/MWh to the cost of solar. Using the global average price of solar in 2024 of $43/MWh, according to IRENA, means the total cost of dispatchable solar is $76/MWh.

This is not the same as baseload solar. Delivering constant power every hour of the year, including cloudy weeks and seasonal lows, requires solar overbuild and more battery storage. But shifting half of daytime solar is a major step. It aligns solar generation more closely with a typical demand profile, meaning solar can meet a much larger share of the evening and night-time demand and significantly increase its contribution to the power mix.

In regions with ultra-low-cost desert solar, oversizing and storing a larger share of solar is even more compelling.

It costs just $33/MWh to transform daytime solar into dispatchable solar

Example hourly solar profile, kW*



Source: Ember
*Solar profile based on average day in Rajasthan, India with 1,000 kW (DC) fixed-axis solar PV, using JRC PVGIS data
**The $65/MWh LCOS is based on Ember's price assessment for October 2025 for utility-scale long duration battery storage projects outside of US and China, using core equipment from China

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3.2 Cheap batteries will enable solar to meet the majority of global energy growth

In the next decade, 80% of global energy demand growth is projected to come from "regions with high-quality solar irradiation", according to the IEA's latest World Energy Outlook. In this Age of Electricity, most of the energy demand growth is electricity demand growth.

For these countries, combining solar with storage is now the most affordable path to meet soaring demand, improve energy security and reduce dependence on fossil fuel imports. This report shows how dispatchable solar can be achieved for around $76/MWh, which is cheaper and quicker than building a new gas power plant, especially if the country relies on more expensive LNG imports.

Battery manufacturing capacity is already scaling far ahead of demand,, with supply exceeding demand by a factor of three in 2024. While China currently dominates global battery production, this has triggered a wave of investment in new manufacturing capacity across Asia, Europe, the Middle East and the US as countries seek to diversify supply chains and enhance energy security.

Today, most grid scale batteries are LFP, using no nickel or cobalt. A shift towards sodium-ion technology has also begun, which will also cut out lithium, leaving no critical minerals in the battery.

Countries can deploy storage at speed today while also building their own clean-energy industries for tomorrow. Even when core BESS equipment is imported, roughly 40% of total project value (about $50/kWh out of $125/kWh) remains local through engineering, civil works, grid connection and other EPC activities. There is further potential to onshore value by building the core BESS equipment domestically using imported Chinese solar cells.

Cheap batteries do not just complement solar — they unlock its full potential. Solar is no longer just cheap daytime electricity; with storage, it becomes dispatchable, anytime electricity. Together, solar and batteries are on track to meet much of the world's energy demand growth over the next decade.

Supporting information

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