S&P Global
Commodity Insights

# Top Cleantech Trends for 2025

## Technologies to reduce emissions and confront climate change

2025

## Credits

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As we move into 2025, the clean energy sector is witnessing transformative trends that are reshaping the landscape of energy production and consumption. The global commitment to emissions reduction has spurred unprecedented growth in clean energy investments, and we are seeing a surge in innovative technologies that promise to enhance efficiency, reduce costs and improve energy reliability. Additionally, geopolitical tensions, particularly concerning China's dominance in the clean technology supply chain, are influencing global energy strategies and investment decisions. Here are the key trends to watch in the coming year.

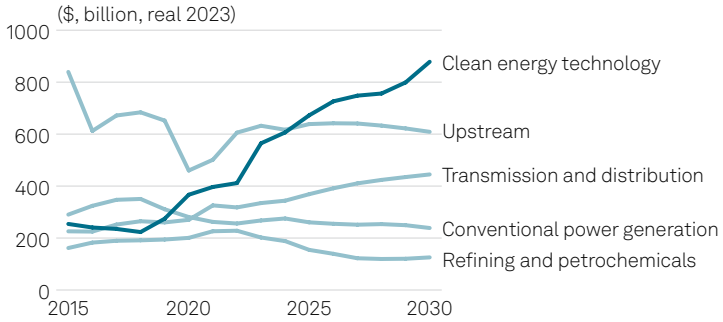
# Clean energy investment takes center stage

## Clean energy investments overtake upstream spending for the first time in 2025

In 2025, clean energy technology is set to surpass investments in upstream oil and gas for the first time. Solar PV will account for half of all cleantech investments and two-thirds of installed megawatts. This milestone is driven by a significant increase in solar energy capacity, which is expected to exceed that of gas and potentially coal, with at least 620 GW of new solar and wind capacity coming online in 2024 — equivalent to the entire power systems of India, Pakistan and Bangladesh combined. Additionally, battery energy storage systems (BESS) will surpass pumped hydro storage in installed capacity.

This massive build-out will require an estimated $640 billion, matching the projected spending on upstream oil and gas, including LNG liquefaction and pipelines. Overall, cleantech energy supply spending - encompassing renewable power generation, green hydrogen production and carbon capture and storage (CCS) — is expected to reach $670 billion in 2025.

**Clean Energy Technology surges ahead**




Source: S&P Global Commodity Insights

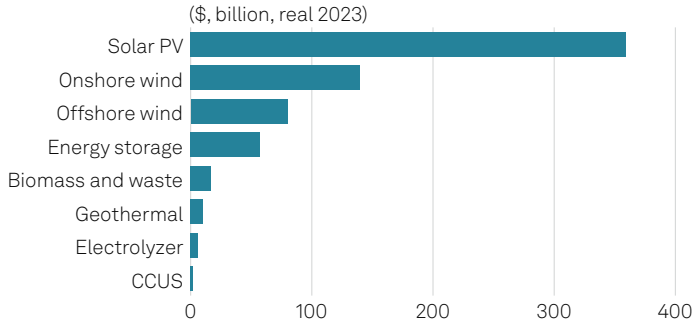
**Clean Energy Technology spending, including renewable power generation, storage, green hydrogen production, and CCS is expected to reach**

**$670 billion in 2025.**

This shift represents a geographical pivot from hydrocarbon-producing nations to regions with rapidly growing power demand and a transition from centralized energy projects to more distributed investments. Approximately one-third of cleantech spending will focus on distributed solar installations under 5 MW and behind-the-meter energy storage. However, this total investment still falls short of the levels needed to meet climate goals, particularly the goal of tripling renewable capacity by 2030.

Moreover, capital efficiency varies by region, with China projected to add nearly twice as many gigawatts per dollar spent compared with the United States. This trend underscores the evolving dynamics of the energy market as it shifts toward sustainable solutions.

**Investment in new clean energy technology, 2025**



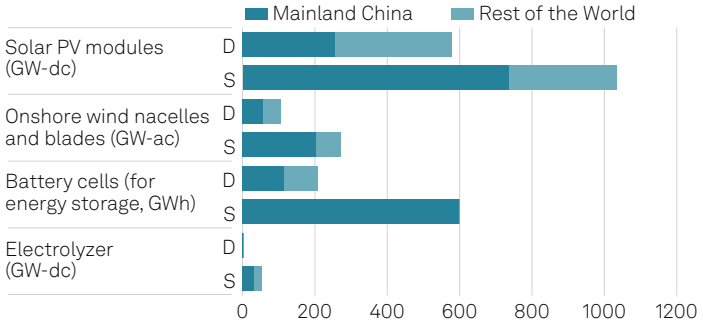

Source: S&P Global Commodity Insights

# Tensions in cleantech supply chains

## Chinese oversupply continues to shake international cleantech markets

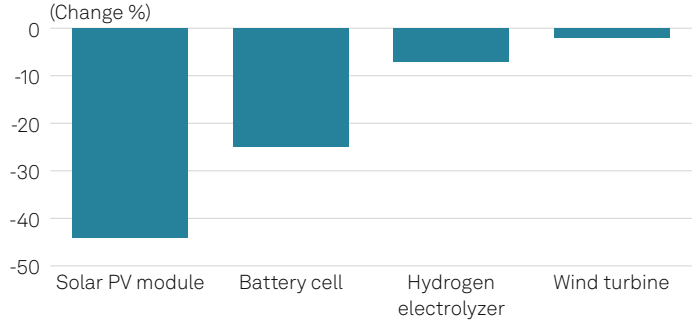
The oversupply of cleantech equipment from China is exerting significant pressure on international markets, particularly in the solar, wind and battery sectors. Over the past two years, the rapid expansion of cleantech supply chains has outstripped market demand, leading to substantial price declines in 2023 and 2024. While these price drops are expected to moderate in 2025, the effects of oversupply will still be felt, especially in energy storage systems where fierce competition continues to suppress prices. In the wind energy sector, Western turbine manufacturers are likely to prioritize profitability over sales volume, making significant price reductions unlikely. In contrast, overcapacity and fierce competition among Chinese manufacturers will keep their prices low, driving them to expand into international markets owing to the price differential with Western competitors.

**Annual cleantech installations (demand) and key equipment manufacturing capacity (supply), in 2025**



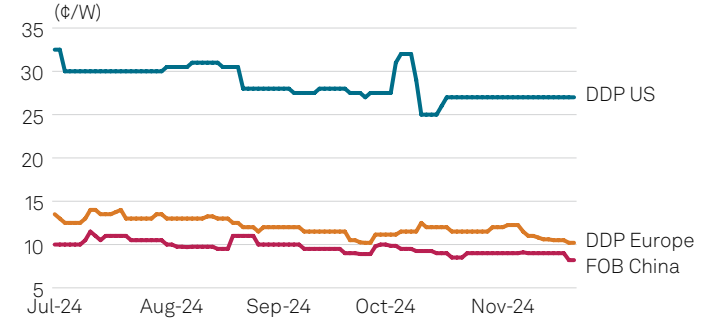

Note: D = demand, S =supply
Source: S&P Global Commodity Insights

**CET Component price change, global average 2023 to 2025**




Source: S&P Global Commodity Insights

**Platts Solar Module Assessment (5-50MW)**




Source: S&P Global Commodity Insights

The landscape is shifting, particularly within the solar photovoltaic module supply chain, which has seen a slowdown in growth as of 2024. In response to the oversupply challenge, China has initiated rationalization efforts aimed at controlling manufacturing expansions and increasing barriers to entry for new competitors. Many planned expansions in the first half of 2024 have been delayed or scrapped altogether, reflecting a strategic pivot in the industry.

As we look ahead to 2025, a weakening domestic economy in China is likely to complicate the maintenance of its oversized supply chain. This is compounded by slowing solar PV demand in international markets and the implementation of higher tariffs and local sourcing incentives, particularly in the United States and Europe, which will further challenge Chinese manufacturers. The United States will remain the most attractive market for module manufacturers, as the price gap from the global average continues to widen, creating new opportunities for growth amid the ongoing market adjustments.

## Favorable policies fuel cleantech manufacturing growth in new regions amid global oversupply

In recent years, government programs like the US Inflation Reduction Act and India's production-linked incentive have promoted domestic clean energy technology production to create local jobs and enhance supply chain resilience. However, European policy initiatives to support cleantech manufacturing have been largely ineffective. The wind industry is an exception, as leading European turbine manufacturers maintain their legacy supply chains. Yet, facing cost pressures from cheaper Chinese competitors raises uncertainty about their future. Some manufacturers have already consolidated European operations, shifting focus to new capacity in the Asia-Pacific region. Despite higher costs, these European supply chains remain a key differentiator for original equipment manufacturers amid growing scrutiny on localization and supply chain resilience, potentially allowing them to persist and expand, particularly in the offshore wind sector.

**Projections indicate that China's share of the battery cell manufacturing market will decline to**

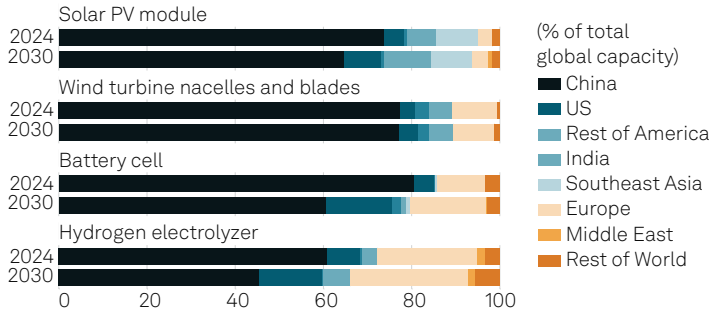
**61%**

**by 2030.**

The ongoing antidumping investigation in the US into cell exports from four Southeast Asian countries, which announced high preliminary tariffs on Nov. 29, 2024, for exports from all four countries, has the potential to significantly reshape the global PV manufacturing landscape. In response, India is aggressively ramping up its PV manufacturing capacity, targeting exports to the US market to take advantage of the trade tensions between the US and China. This investigation has also spurred a wave of capacity announcements across the Middle East and North Africa region, particularly in Saudi Arabia, positioning it as a new hub for Chinese PV and battery manufacturers.

As we look toward 2025, manufacturing growth in China is expected to slow down in response to current overcapacity issues, leading to a more diversified cleantech manufacturing footprint by 2030. Projections indicate that China's share of the PV module manufacturing market will decline to 65%, while its share of the battery cell manufacturing market is expected to drop to 61%, driven by joint venture investments from the automotive sector. Despite these shifts, risks to the manufacturing outlook outside of China remain owing to the competitive pricing, scale and dominant market position of Chinese suppliers.

**CET manufacturing capacity, 2024 vs 2030**




Source: S&P Global Commodity Insights

# Cost declines in mainstream technologies hinder scaling of new solutions for decarbonization

As mainstream clean energy technologies continue to experience cost declines, the prospects for higher-cost new technologies to scale effectively are diminishing. While favorable financing conditions and robust investor interest have spurred innovation and early-stage funding in recent years, many companies will face challenges in 2025 as they seek additional funding for their next growth stages. Transitioning from pilot projects to first-of-a-kind and then to first-few-of-a-kind implementations is inherently difficult, and the current economic environment adds to these challenges.

The looming oversupply in solar, wind and energy storage markets makes it increasingly difficult for new technologies to compete on price alone. But the window of opportunity is also narrowing for technologies not directly impacted by oversupply. Despite recent drops, interest rates in Europe and the United States are unlikely to return to the low or negative levels seen over the past decade, contributing to lower investor enthusiasm. In addition, political and geopolitical uncertainties further complicate future business models and potential offtake agreements

However, the need for innovative solutions remains critical to addressing some of the toughest decarbonization challenges, particularly in long-duration energy storage and hard-to-abate sectors such as transportation, industry and buildings. As a result, the scale-ups of next-generation technologies will be closely monitored, including geothermal, advanced nuclear, hydrogen, direct air capture, grid-enhancing technologies and various forms of energy storage, as they attempt to gain a foothold in the competitive cleantech landscape.

# Storage transforms the power markets

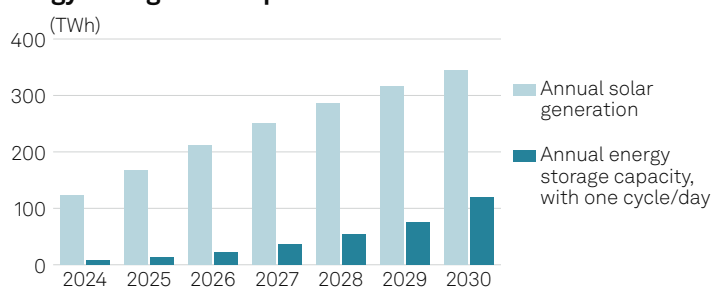
## Battery energy storage becomes essential in a low-priced electricity market

As the energy landscape evolves, battery energy storage is becoming increasingly vital for improving project economics and countering the effects of low wholesale electricity prices in regions with high renewable penetration. Despite significant declines in solar PV hard costs, the reduction in capital expenditures has not led to robust project development, primarily owing to low power purchase agreement expectations and an unprofitable merchant market stemming from a widespread drop in electricity prices across Europe.

The decrease in electricity prices, coupled with a high penetration of renewables — especially solar — has resulted in extremely low prices for new PPA agreements, which in turn hinder the deployment of numerous planned PV projects. Starting next year , developing solar PV projects in Europe and other mature markets without integrated battery storage will become increasingly challenging owing to unfavorable project economics.

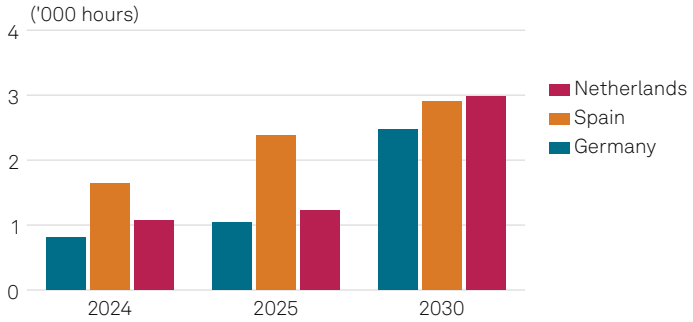
The phenomenon of cannibalization, where excessive energy production during midday hours drives prices down to mere cents per megawatt or even negative values, further disincentivizes project development. In this context, incorporating battery energy storage solutions will be essential for solar projects to remain viable and competitive, enabling developers to better manage price fluctuations and enhance the overall economic feasibility of renewable energy investments.

**Annual generation from utility-scale and front-of-the-meter energy storage in Europe**




Source: S&P Global Commodity Insights

**Hours with wholesale electricity price <10 Eur/MWh**




Source: S&P Global Commodity Insights

# Long-duration storage set to surge in 2025 as governments and grid operators prioritize energy resilience

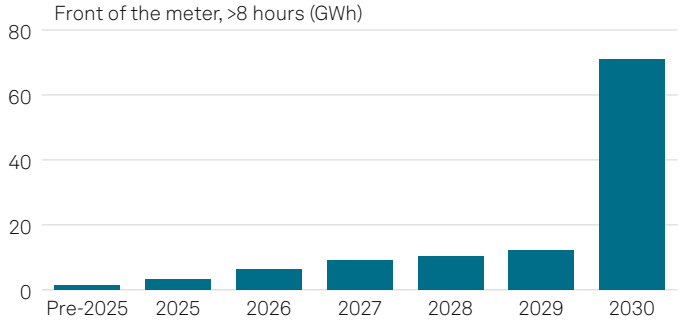
In 2025, installations of long-duration energy storage systems, defined as those with storage capabilities exceeding eight hours, are anticipated to more than double compared with the total installed capacity by the end of 2024. This surge is driven by the increasing necessity for reliable energy storage solutions, particularly as a growing share of electricity is generated from intermittent renewable sources. Long-duration storage is essential for capturing excess energy during peak generation periods and bridging the gaps when supply falls short of demand.

Despite the current challenges in establishing a viable business case for widespread deployment of long-duration energy storage systems, governments and grid operators are responding with targeted procurements aimed at enhancing grid reliability. These initiatives are crucial for building out the infrastructure needed to support a more resilient energy grid.

While lithium-ion battery technology is beginning to be utilized for eight-hour storage systems, there is a notable shift toward exploring non-lithium technologies, with large-scale commercial deployments of compressed air energy storage on the horizon. Additionally, multiday storage tenders expected by 2030 are projected to mark a significant breakthrough in the long-duration storage market. These tenders, characterized by their substantial megawatt-hour capacities, will contribute significantly to the overall installed energy storage capacity in Europe, albeit with only a limited number of projects.

However, as the market evolves, questions remain regarding the commercial and technical viability of these large-scale systems. The future of long-duration energy storage is promising, but it will require continued innovation and investment to fully realize its potential in supporting a clean and reliable energy landscape.

**Global additions of >8 hour energy storage**




Source: S&P Global Commodity Insights

# AI revolutionizes clean energy technology

## Renewable generation forecasting and grid planning at the forefront of AI adoption in the cleantech sector

**AI-based trading applications are increasingly popular as they can mitigate risks related to discrepancies between forecast and actual generation- that can be up to**

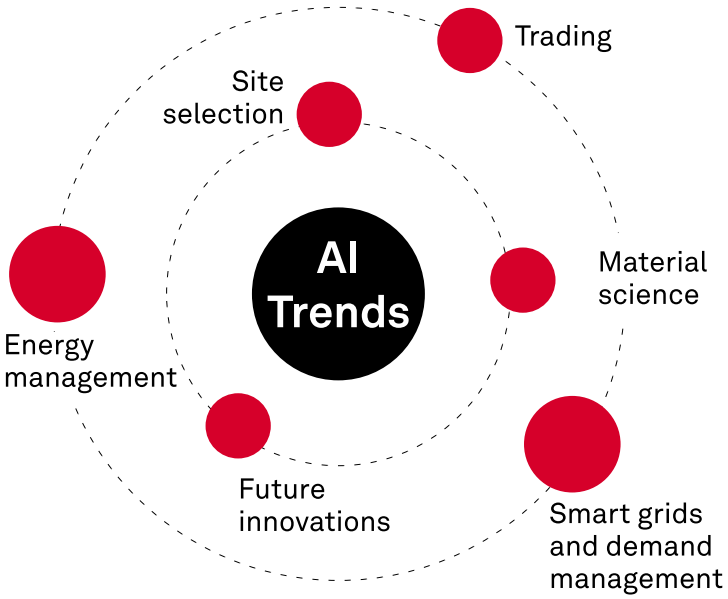
**700%**

The integration of AI into the clean energy landscape is revolutionizing how we approach renewable generation forecasting and grid planning. With its unparalleled ability to process vast amounts of data more quickly and accurately than humans, AI is emerging as a critical tool in generating novel insights that enhance energy management. A recent report from S&P Global Commodity Insights highlights that these two applications — renewable generation forecasting and grid planning — are among the early uses of AI gaining significant traction within the cleantech industry.

As the share of intermittent renewable energy sources like wind and solar increases, the need for precise generation forecasts becomes paramount. AI-based trading applications are becoming more prevalent as they can mitigate risks associated with the substantial discrepancies — up to 700% — between forecast and actual generation. By employing predictive modeling techniques and machine learning, AI is being used to develop advanced weather and generation forecasting tools, enabling more accurate price predictions and automated trading strategies.

In terms of grid planning, the growing share of renewables poses challenges to grid stability but simultaneously opens avenues for enhanced digitalization and AI utilization. Despite hurdles such as the complexity of transmission systems and data fragmentation, initial initiatives utilizing AI for grid planning are emerging. Notably, Chile's National Electric Coordinator plans to base its 2025 grid planning on Google LLC's Tapestry AI-based solution. In the United States, Southern California Edison Co. has partnered with NVIDIA Corp. to create AI-driven grid planning tools aimed at improving resilience, maintenance and incident management.

As the adoption of AI in the energy sector continues to evolve, it is expected that smaller distribution systems will be the first to embrace these technologies, paving the way for broader implementation across larger and more complex transmission systems in the future.



# Datacenters to drive 300 TWh per year of corporate clean energy procurement by 2030 with innovative hybrid strategies

As the demand for AI and digital services continues to surge, datacenters are increasingly recognized for their substantial energy consumption, rivaling the total electricity demand of entire countries.

This growing concern for sustainability is prompting a significant shift in how technology companies and other major corporates approach energy procurement, leading to an anticipated sourcing of approximately 300TWh of additional clean power annually by 2030.

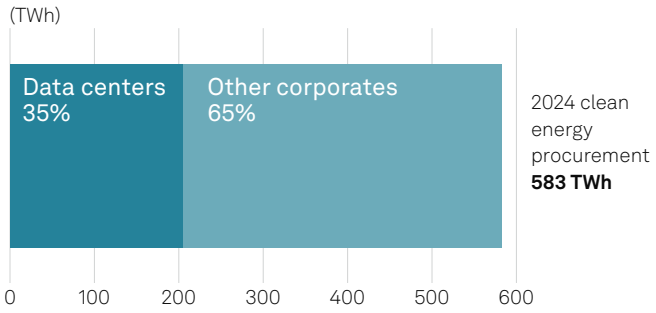
Currently, datacenters account for around 200 TWh, or 35%, of the total estimated global corporate clean energy procurement, and this figure is set to rise dramatically in the next five years.

North American datacenters are at the forefront of this transition, projected to secure about 175 TWh of incremental clean energy procurement through 2030, which will represent roughly 60% of the global increase. In contrast, Europe's datacenters are expected to account for a quarter of this incremental demand, while the Asia-Pacific region lags behind, often constrained by limited access to renewable resources near key demand centers.

In addition to scaling their clean energy procurement, datacenters are leading the charge in adopting innovative corporate procurement strategies, including hybridization and new technologies. This shift involves integrating multiple renewable sources — such as solar and wind — along with battery storage solutions to enhance energy reliability and flexibility. Datacenters are also pioneering more ambitious hourly matching or emissions matching strategies, which align energy consumption with renewable generation patterns.

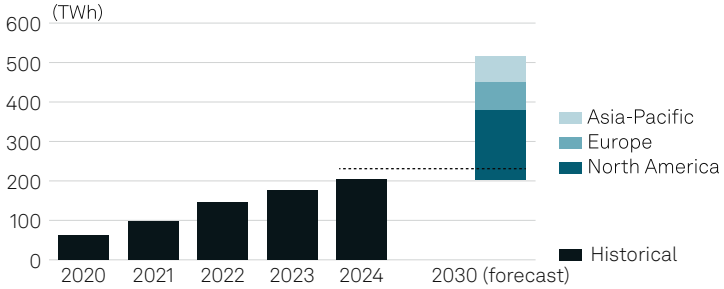
Moreover, the datacenter industry is driving the adoption of granular market instruments like time-stamped or emission-adjusted renewable energy certificates, further advancing their commitment to decarbonization.

**Total clean energy procurement market in 2024**




Source: S&P Global Commodity Insights

**Clean energy procurement from data centers- outlook through 2030**




Source: S&P Global Commodity Insights

# The quest for deeper decarbonization

## Ammonia fuels low-carbon hydrogen production via electrolysis and CCS

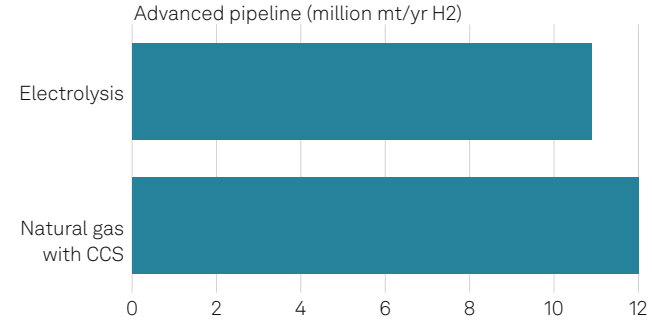
Ammonia is emerging as a crucial catalyst in the production of low-carbon hydrogen, playing a significant role in both electrolytic and fossil fuel-based CCS capacities. Globally, ammonia accounts for 50% of electrolysis and 40% of fossil fuel projects with CCS that are currently in the advanced planning phase.

One of the primary challenges facing clean hydrogen initiatives is the lack of secure offtake agreements, but the established ammonia sector provides a reliable source of both captive and merchant demand. While ammonia is predominantly used for fertilizer production, there is growing interest in its application for power generation and as bunker fuel. Although technologies in these areas are still in early development stages, first movers are beginning to establish additional sources of offtake for low-carbon ammonia.

In 2024, hydrogen and ammonia projects are expected to account for 47% of the CO2 volumes under construction or sanctioned for a final investment decision. This trend is anticipated to continue into 2025 as the industry propels itself forward with projects poised to secure an FID.

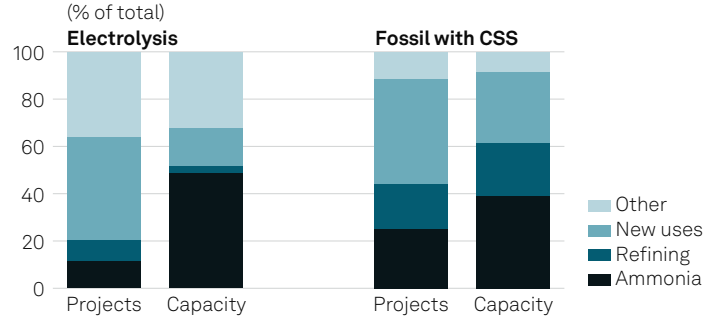
In North America, several factors are driving project advancements, including the low cost of carbon capture, government support through grants and tax credits, existing transportation and storage infrastructure, and the potential for exporting low-carbon hydrogen to Asian markets. The new Trump administration administration may further enhance government support for the industry, accelerating project timelines in 2025.

**Clean production capacity**




Source: S&P Global Commodity Insights

**Planned end-use of advanced electrolysis projects**




Source: S&P Global Commodity Insights

In Europe, supportive policies and the recent publication of EU rules for calculating the greenhouse gas intensity of low-carbon fuels — including provisions for carbon capture and utilization (CCU) and CCS — could expedite project development, solidifying ammonia's role as a vital component in the low-carbon hydrogen economy.

BECCS accounted for

**87%**

of the engineered CDR offtake agreements by volume in 2024

# Carbon management strategies and CO2 offtake agreements shape CCUS landscape for 2025

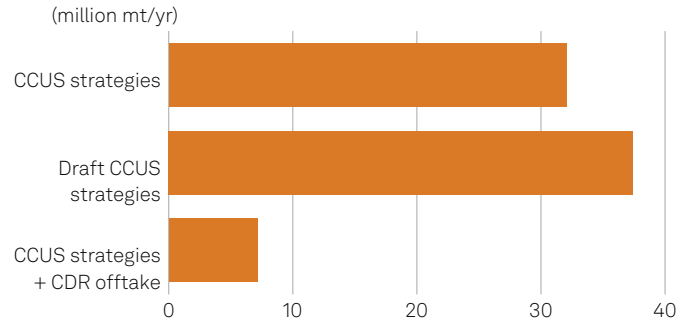
2025 it is poised to be a landmark year for carbon capture, utilization and storage (CCUS) projects, with approximately 70 million metric tons per year of CO2 capture capacity expected to secure FIDs. Recent announcements of carbon management strategies across various regions are significantly reducing uncertainty for CCUS initiatives, with over 50% of the anticipated CO2 capture capacity located in areas that have established concrete carbon management frameworks.

Within the realm of CCUS, engineered carbon dioxide removal (CDR) technologies are becoming increasingly vital for achieving climate targets. However, quality remains a challenge for existing CDR projects, driving demand for high-quality solutions such as direct air capture and bioenergy with carbon capture and storage (BECCS).

Despite the high costs associated with engineered CDR, the past three years have seen a surge in CDR offtake agreements, reflecting growing corporate interest in these technologies, alongside enhanced government policy support. Notably, BECCS accounted for 87% of the engineered CDR offtake agreements by volume in 2024, positioning it as an attractive sector for scaling CDR efforts owing to the larger scale of these projects compared with other engineered CDR initiatives.

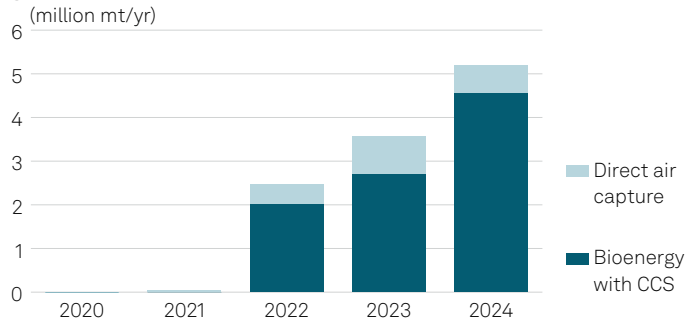
Overall, the convergence of ambitious carbon management targets and record-setting CO2 offtake agreements is creating a favorable environment for CCUS projects, setting the stage for significant advancements in carbon capture technology and deployment in the coming years.

**Planned FID in 2025 by incentive**




Source: S&P Global Commodity Insights

**Engineered Carbon Dioxide Removal Purchases Tracker**




Source: S&P Global Commodity Insights

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# What's next for cleantech?

The year 2025 promises to be a pivotal year for the clean energy sector, highlighted by a significant rise in corporate clean energy procurement from datacenters and advancements in AI for renewable generation forecasting and grid planning. These trends will enhance sustainability and drive growth in the renewable energy market.

Favorable policies will facilitate cleantech manufacturing expansion despite global oversupply, while long-duration storage installations are expected to double, ensuring grid reliability. As these developments unfold, they will reshape energy production and consumption, paving the way for a more resilient and sustainable future.