MUFG Transition Whitepaper 2025

Acknowledgement

MUFG is grateful to Japan's leading companies, government authorities, and academia for their various pieces of advice and guidance during the creation of this whitepaper. The production of this whitepaper was made possible with the insights, perspectives, and advice provided through joint forums held in Japan, the U.S., and Australia, and the multiple bilateral meetings held globally. MUFG also acknowledges the contribution of Boston Consulting Group (BCG) for the background market analysis for this whitepaper.

References

For references, company name, and list of acronyms, please refer this link.

Executive Summary

MUFG Transition Whitepaper 2025: Challenges and Solutions for Expanding Japan's Carbon Neutrality Investment

MUFG announces the publication of the fourth edition of its Transition Whitepaper, a series initiated in 2022. This latest volume addresses "challenges and solutions for expanding Japan's carbon neutrality (CN) investment."

1. Changing International Dynamics and New CN Investment Challenges

A year has past since MUFG released the Transition Whitepaper 2024. Over this period, the global landscape surrounding carbon neutrality has changed significantly.

1) International Developments

Global power dynamics have undergone notable shifts, marked by policy changes following the inauguration of the second Trump administration in the U.S. and by China's expanding influence within the carbon neutrality market.

2) Rising Electricity Demand and Strategic Energy Mix Reassessment

The rapid proliferation of data centers has driven a significant surge in global electricity consumption. In response, many countries are revisiting nuclear power as a viable option and undertaking comprehensive reviews of their energy portfolios to ensure long-term stability and resilience in power supply.

2. New Analytical Focus in Transition Whitepaper 2025

This edition introduces the following enhanced approaches:

1) Broadened Global Perspective

The analysis now encompasses China, India, and ASEAN countries alongside Europe and the United States (U.S.), offering a more comprehensive regional overview and an international context for Japan's CN investments.

2) Emphasis on Energy-Intensive Industries

Beyond the traditional focus on "energy transition," this edition incorporates "energy-demand sectors," such as basic materials industries, to highlight the systemic challenges in advancing Japan's overall CN.

3) Addressing Industry-Specific Challenges

In addition to general "transition challenges," such as price pass-through, we examine "industry-specific challenges" that each sector must resolve to progress effectively toward CN goals.

This transition whitepaper provides actionable insights into the challenges and solutions required to accelerate CN investment in Japan.

Global Trends: Significant Progress in CN Investments

Despite persistent challenges in achieving CN, notable advancements in CN-related investments are evident across Europe, the U.S, and Asia. These investments are strengthening industrial competitiveness and reinforcing energy security at the national level.

1. Trends in U.S.

The U.S. has leveraged CN initiatives to revitalize its manufacturing sector and to bolster industrial capacity as part of efforts to address its trade imbalance with China. Following the inauguration of the second Trump administration, policy support has shifted toward targeted technologies aimed at maximizing domestic resource utilization and enhancing energy security.

Investment in offshore wind and electric vehicles (EV), both expected to face reduced policy support, is likely to stagnate. Conversely, solar power generation is projected to maintain strong growth, driven by sustained demand from major technology firms like GAFAM, even amid diminished policy incentives. This expansion will be complemented by policy-supported thermal generation (natural gas) and nuclear power, ensuring a diversified and resilient energy mix.

2. Trends in Europe

Europe has adopted regulation-driven strategies to accelerate renewable energy deployment, aiming to strengthen energy security and advance the industrialization of CN technologies. Despite current challenges—such as rising energy prices and constraints on price pass-through—policy support for CN technologies remains strong, and investment in this area is expected to continue progressing. At the same time, energy-intensive sectors, including materials and automotive, are under mounting pressure due to escalating energy costs and intensifying price competition from Chinese products. Addressing these structural challenges will be critical to safeguarding Europe’s industrial competitiveness in global market.

3. Trends in China

China has positioned itself as a global leader in renewable energy and EV adoption by leveraging cost advantages derived from domestic industrial development. While concerns are increasing over potential export declines due to tariff measures in Europe and the U.S., China is actively stimulating domestic demand and diversifying export destinations beyond these regions. In parallel, China is accelerating investment in emerging areas such as green hydrogen, nuclear power generation, and synthetic fuels. By aligning industrial policy with global CN trends, China is expected to continue expanding CN-related investments, reinforcing its status as a manufacturing powerhouse.

4. Trends in India

Due to population growth and economic expansion, India's energy demand is increasing. To establish an energy self-sufficient system by 2047, India is promoting the introduction of renewable energy sources, including solar power and pumped storage hydroelectric power generation. India has favorable geographical that give renewable energy an economic advantage over other power sources, making it among the cheapest in the world. Thus, the use of renewable energy is expected to grow. The production and export of green hydrogen or its derivatives using inexpensive renewable energy is also expected to accelerate. Additionally, nuclear power generation is expanding with ambitious development targets.

5. Trends in ASEAN

ASEAN has been working to diversify its power sources by setting ambitious targets for introducing renewable energy. This will help secure a stable energy supply that can respond to economic growth and population increases while promoting foreign investment and strengthening manufacturing. Although the economic advantages of renewable energy have yet to be realized in ASEAN, and many challenges remain for its expansion, renewable energy is expected to gradually increase with continued policy support from each country. Investment in thermal (natural gas), nuclear, and CCS power generation is also expected to progress.

Japan's CN Initiatives

1. Recent Developments and Future Challenges

Japan's CN investment began approximately one to two years after Europe and the U.S. However, it now faces uncertainty due to factors such as the policy changes under the Trump administration. In order to advance CN investment further, a broader range of companies will need to address challenges and actively participate in future investments.

1) Recent Developments

Over the past year, Japan outlined medium- to long-term policy directions through initiatives such as the “GX2040 Vision” and the “7th Basic Energy Plan.” Furthermore, approximately ¥2.1 trillion in public-private investment has been mobilized through support from GX Economic Transition Bonds. However, this represents only a portion of the investment required to achieve carbon neutrality and is primarily limited to investment by pioneering "first-movers."

2) Future Challenges

Countries are advancing CN policies and investments despite uncertain international circumstances. Japan must also progress its CN measures while considering international competitiveness and economic security. This requires investment from a broad range of companies, including those that have not yet committed—the second movers and beyond.

2. “Transition Challenges” and “Industry-Specific Challenges”

To expand Japan's CN investment, the following two challenges must be addressed: "transition challenges" and "industry-specific challenges." Solutions to these challenges are not uniform. Their interrelationships, order of response, and required timeframe differ across industries and sectors.

1) Transition Challenges

These are obstacles encountered when advancing the transition. Examples include increased costs due to fuel switching and uncertainty about whether the market will accept the value after transitioning.

2) Industry-Specific Challenges

These are the challenges that each industry or sector must address to maintain or enhance its competitiveness while advancing the transition. These challenges exist separately from the transition challenges.

3. Challenges Faced by Each Sector and Industry-Wide Initiatives

We mapped the relationship between the transition challenges and industry-specific challenges of each sector, along with examples of current initiatives, and classified the relationship between these two types of challenges into three categories.

1) Electricity Sector

This is a sector where anticipated growth in electricity demand requires parallel efforts to address transition challenges while balancing "S+3E" (safety, security of supply, economic efficiency, and environmental sustainability).

2) Materials Sector

This sector requires a step-by-step approach. First, domestic production lines and overall structure must be optimized in response to changing market conditions. Then, efforts can be fully committed to addressing transition challenges.

3) Maritime and Aviation Sector

This sector is under pressure to address "transition challenges" due to the introduction of international regulations.

4. The Role of Government and Finance in Expanding Japan's CN Investment

To address both transition challenges, and industry-specific challenges, it is essential to accelerate collaboration among corporates, establish government policy packages that support initiatives—including those targeting industry-specific issues—and enhance investment predictability and profitability through financial institutions. Achieving these goals requires a unified approach, with industry, government, and finance working in close coordination to drive the transition forward.

1) Industry

To accelerate CN-related investments, it is essential for companies to address both “transition challenges” and “industry-specific challenges” with a sense of urgency, leveraging inter-company collaboration.

2) Government

In addition to addressing “transition challenges”, the government is expected to develop comprehensive policy packages that also support initiatives tackling industry-specific challenges, which are essential for maintaining and strengthening industrial competitiveness.

3) Financial institutions

Leveraging their broad client base and neutral, overarching perspective, financial institutions play a pivotal role in connecting stakeholders and delivering solutions that improve investment predictability and enhance profitability.

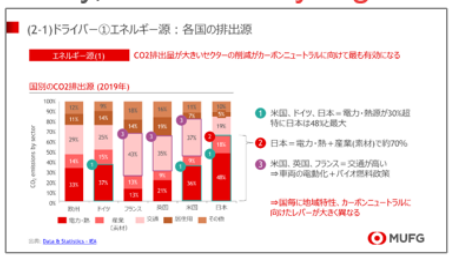
MUFG, as a leading financial partner to industry, remains committed to assisting CN investments by delivering comprehensive financial solutions.

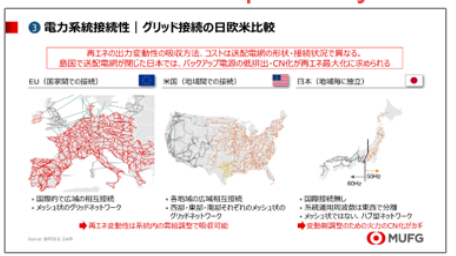
Contents

Chapter1 Review of Whitepapers 1.0-3.0 and the Purpose of Whitepaper4.0

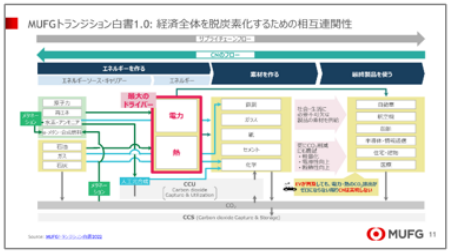
Key Messages in MUFG Transition Whitepaper 1.0

- Depending on differences in emissions sources and grid connectivity, each country/region is on individual CN pathway





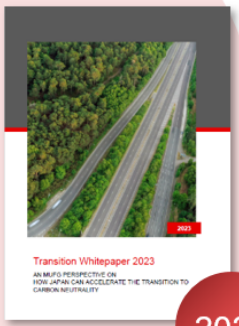
- Identifying levers for achieving CN, taking into account the vertical and horizontal linkages across industries are necessary
- In Japan, electricity and heat are key levers



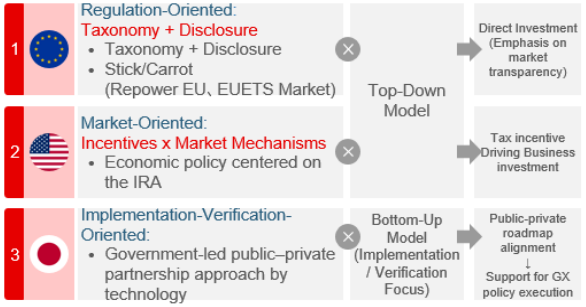
MUFG became the first Japanese bank to announce its Carbon Neutral (CN) declaration in 2021 and has published the “MUFG Transition Whitepaper” annually since 2022. When MUFG’s Whitepaper 1.0 was published, discussions on the EU Taxonomy and other environmental regulations accelerating in Europe and CN momentum was building globally. In Japan, the process of formulating a national GX (Green Transformation) strategy had begun. The whitepaper described CN-related initiatives and technological challenges. It also emphasized the importance of fostering international understanding of Japan’s unique CN pathway, which is distinct from those of Europe and the U.S. In particular, the paper focused on two key messages.

First, each country’s pathway to CN varies according to its emission sources and energy interdependency. For Japan, where electricity and heat account for most emissions, achieving CN in those sectors is most important. Second, levers for achieving CN need to take into account vertical and horizontal linkages within industries. In other words, it is not possible to selectively decarbonize only certain industries.

Key Messages in MUFG Transition Whitepaper 2.0



- Highlighting national and regional policy approaches and frameworks



- Based on the hypothesis that seven technologies play a key role in achieving CN for electricity and heat, the paper proposes a Positive Technology List:

①Wind
②Solar
③Transmission and Distribution
④Nuclear
⑤Electrification of Industry (Heat Pumps)
⑥Hydrogen/ Bio-based fuels
⑦CCUS

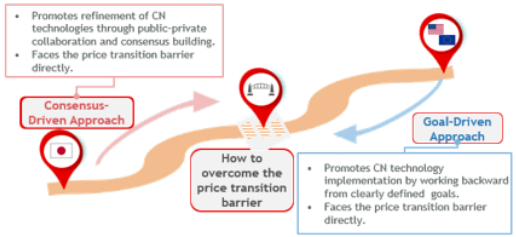
When the Whitepaper 2.0 released in 2022, the world faced an energy crisis not seen since the 1973 oil crisis, triggered by Russia's invasion of Ukraine, which led to tight electricity supply and demand and soaring energy prices. Securing stable energy supplies became an urgent priority, and the importance of energy security was reaffirmed. Against this backdrop, Europe and the U.S. began accelerating their efforts toward decarbonization. This approach aims to diversify energy sources while also serving as an opportunity to return their economies to a growth trajectory. For instance, through the Inflation Reduction Act (IRA), the U.S. government had ramped up policy support for CN technologies. In Europe, support measures were implemented to expand decarbonization investments and foster new markets, including public-private partnerships aiming to realize approximately 140 trillion yen in investments over a decade. Meanwhile, Japan had published the Basic Policy for Realizing GX, and discussions on policy support for CN technologies were underway.

Taking into account technology challenges and expectations for policy support, the paper outlined differences in policy approaches between Japan and other countries. It also highlighted seven key technology categories (1) Wind power, (2) Solar power, (3) Transmission and distribution, (4) Nuclear power, (5) Electrification of industry, (6) Hydrogen-derived and bio-derived fuels, (7) Carbon Dioxide Capture, Utilization, and Storage (CCUS) that would be critical for decarbonization of electricity and heat, which we assembled in a Positive Technology List.

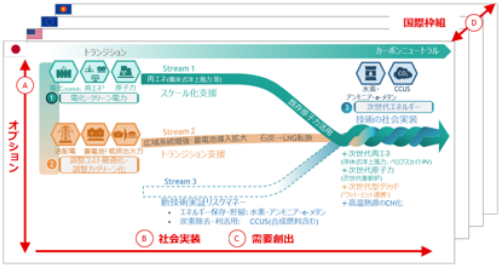
Key Messages in MUFG Transition Whitepaper 3.0

2024

- Although Japan and the Europe and the U.S. have different policies and approaches toward CN, they share common challenges - including the need to secure long-term investment visibility and to overcome the “price transition barrier”



- A pathway for Japan’s energy transition in advancing CN: technology options, social implementation, demand creation, and international frameworks



By the time Whitepaper 3.0 was published in 2024, CN-related investments in Europe and the U.S. had accelerated, making it increasingly clear which technologies were attracting capital and which were lagging. In Japan, the issuance of “GX Climate Transition Bonds” marked the beginning of a concerted investment phase.

Taking into account the challenges around new technologies and the role of public–private partnerships in advancing CN investment, Whitepaper 3.0 focused on the “price pass through barrier” faced by Europe, the U.S., and Japan. It highlighted Japan’s energy transition pathway and presented a feasible transition strategy that reflected Japan's industrial structure and market characteristics.

Key international CN Trends After Whitepaper 3.0 (2024)

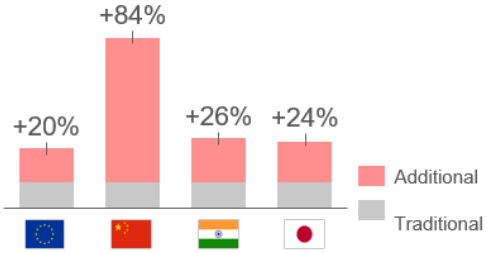
Inauguration of the Second Trump Administration

Withdrawal from the Paris agreement
Executive order to withdraw from international climate frameworks and relax fossil fuel industry regulation

Enactment of the OBBB act[1]
Shift away from the Biden administration's broad-based CN technology support

Additional tariff measures
Global trade patterns shifting — exports to the U.S. declining and supply chains moving away from China

Additional Tariff Rates on U.S. Imports[2]

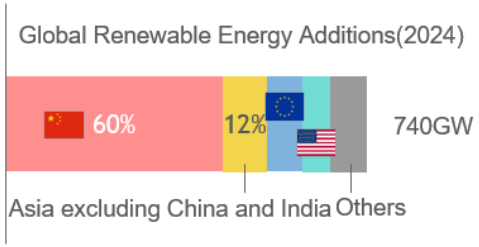


Rising Influence of China

CN technology manufacturing powerhouse
Driven by low costs, China rapidly expands exports of solar panels, wind turbines, and electrolysis equipment

Surge in renewable energy deployment
China now accounts for 60% of global renewable energy installations, making it the world's largest market

Clean fuels
Expansion of major hydrogen projects and synthetic fuel production capacity in China



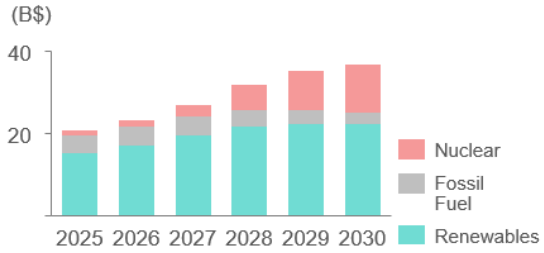
Rising Power Demand and Reassessment of Nuclear Energy

Power demand surges
Rapid growth in electricity demand driven by AI and data center expansion across many countries

Increased demand for decarbonized power sources
Growing need for low-carbon energy to meet rising power consumption

Expansion of nuclear power
Development of large-scale nuclear facilities as low-carbon energy projects accelerate

Global Investment Forecast for DC[3] Power Supply



As of 2025, one year after Whitepaper 3.0's publication, global developments on CN have again changed—driven by the second Trump administration and China's expanding presence in the CN market. This has created new tensions in international cooperation frameworks on energy policy and responses to climate change.

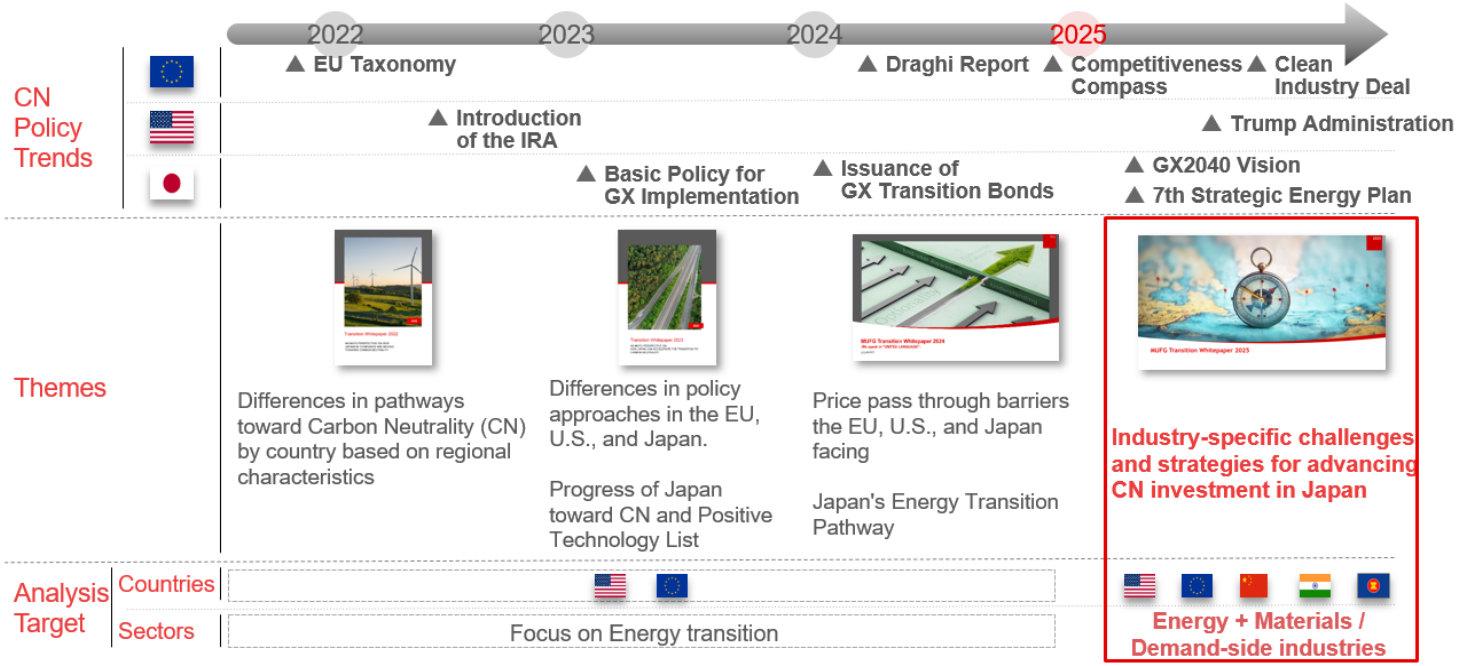
The backdrop has shifted toward increased electricity demand, mainly due to advances in AI and digitalization globally. This shift in outlook is prompting concrete revisions to the energy mix, including a renewed reassessment of nuclear power for securing a stable electricity supply.

Meanwhile, in Japan, while private investment by companies, particularly in high-emitting sectors, has shown some progress, the growing uncertainty in the international situation has made it difficult to predict future policy directions and energy price trends. Consequently, an increasing number of companies are adopting a cautious stance toward new investments. Under these circumstances, the trend of CN investment in Japan can be said to be approaching a major turning point.

---

1. One Big Beautiful Bill Act; 2. Tariffs are shown as of the reciprocal tariff measures in effect at the time of the Executive order issued April 9, 2025; 3. Data Center
Source: Nikkei; Global Data Website;REN21 Website; IEA Website

Summary of Chapter1 (Review of MUFG Transition Whitepapers 1.0–3.0 and Objectives of Whitepaper 4.0)

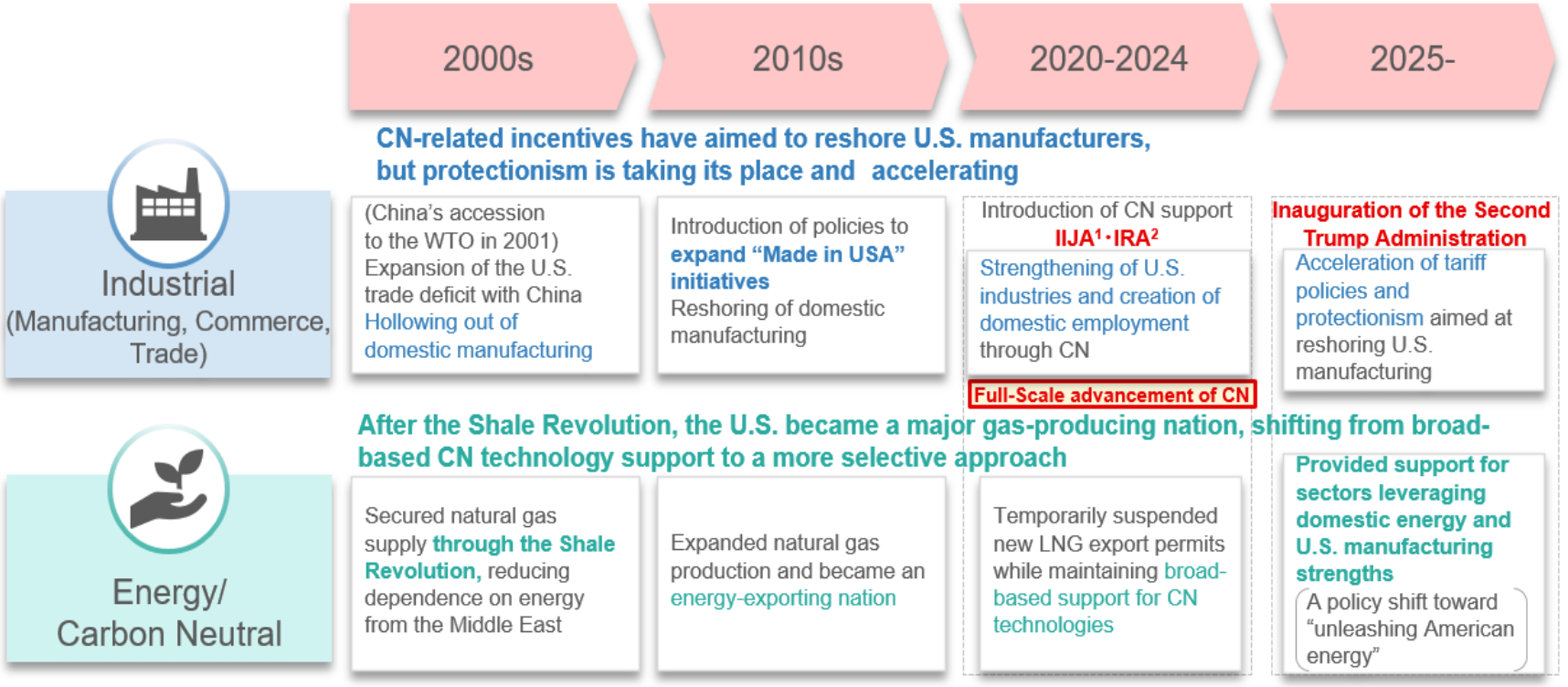


In response to these shifts, this MUFG Transition Whitepaper 2025 (Whitepaper 4.0) reevaluates the path toward CN outlined in previous editions and aims to clarify the CN investment challenges Japan must address. It is intended to provide a foundation for discussions on how best to tackle these challenges and further accelerate CN investment amid a rapidly changing international environment. We also expand our analysis to include industrial and policy trends in China, India, and ASEAN alongside Europe and the U.S., creating a more complete review of CN strategies and investment trends. In addition to the energy transition analysis seen in previous papers, we drill down into the challanges facing energy-consuming industries such as the materials sector. This creates a more comprehensive analysis of the transition from the perspectives of both energy supply and energy demand. Finally, we suggest some practical ideas to support Japan’s journey toward sustainablility.

With this in mind, Chapter 2 provides an overview of the policy trends in the U. S., Europe, China, India, and ASEAN over two decades, focusing on the dual axes of "industry" and "energy/CN." It also summarizes investment trends in clean-related technologies and the impacts of recent policies. In Chapter 3 reviews policy trends and investment directions in Japan, and then identify two main challenges the country faces in advancing its transition: "transition challenges" inherent in the process of transitioning to CN, and "industry-specific challenges" that each industry must overcome to enhance its competitiveness. This paper analyzes the structure of these challenges and propose directions for solutions, focusing on key emission sectors. Furthermore, we will outline the roles of governments and financial institutions in supporting the resolution of challenges faced by industry.

Contents

Trends in Industrial and CN Policies in the U.S.



---

1. IIJA: Infrastructure investment support for renewable energy and clean hydrogen hubs;
2. IRA: Tax credits for CN technology investment, production, and deployment

Trends in Industrial and CN Policies in the U.S.

This chapter will examine the trends in the U.S., Europe, China, India, and ASEAN. First, is the U.S.

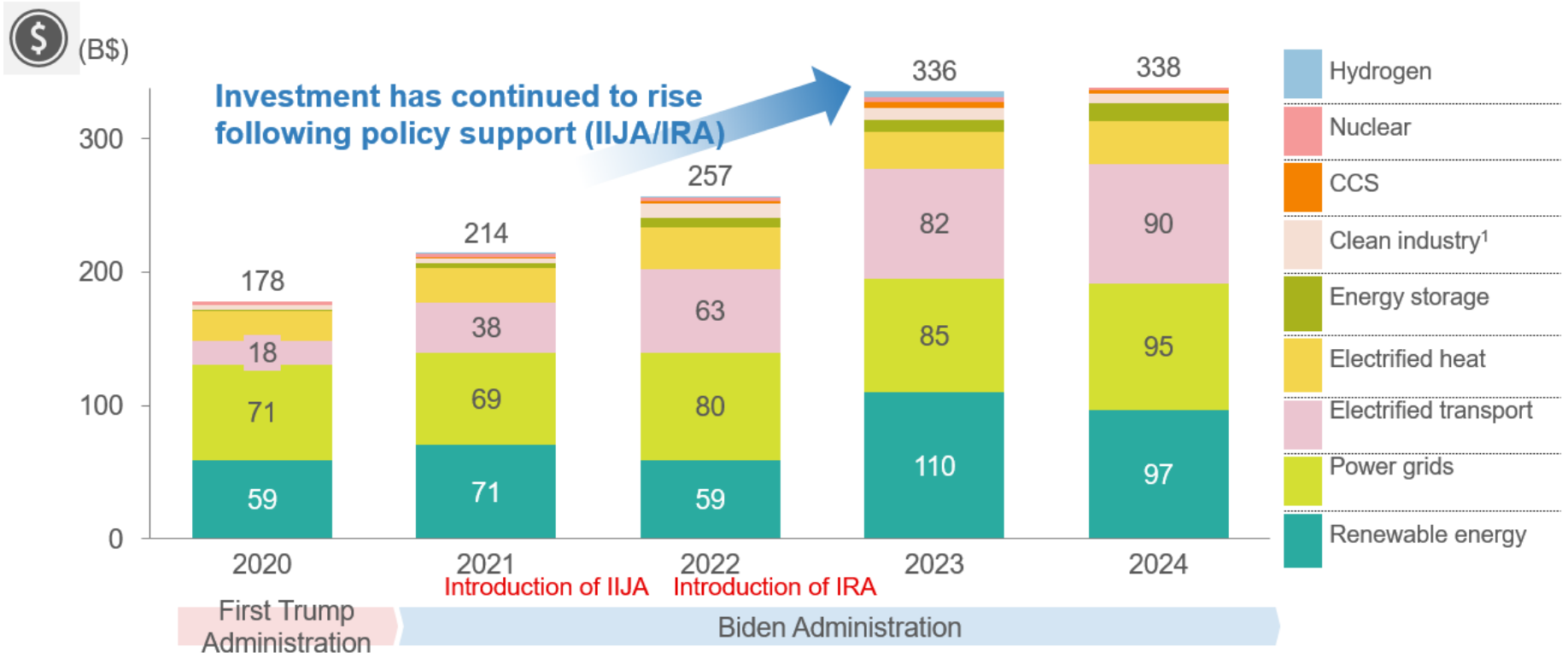
Since China's accession to the World Trade Organization (WTO) in 2001, U.S. industrial and energy/CN policies have faced two structural challenges: bringing manufacturing back onshore and a narrowing trade deficit with China. The resulting hollowing out of manufacturing has led to factory closures, declining capacity utilization, job losses, and outflows of skilled workers. These trends have constrained economic growth and fueled political instability. What is more, critical sectors—including autos, steel, machinery, electrical equipment, and pharmaceuticals—have become increasingly dependent on overseas production. Against this backdrop, the U.S. government has launched a series of initiatives under the "Made in USA" banner aimed at revitalizing domestic manufacturing and rebuilding the country's industrial strength.

Under the Biden administration, the U.S. took an integrated approach to advancing industrial and CN policies. Following extensive intra-party negotiations, it enacted two major pieces of legislation: the Infrastructure Investment and Jobs Act (IIJA) (November 2021) and the Inflation Reduction Act (IRA) (August 2022). While the IIJA primarily focused on infrastructure development, it also allocated substantial funding to energy and climate-related activities. The IRA, meanwhile, promoted clean energy adoption and climate change mitigation. Between them, the Acts provided extensive incentives—including tax credits, subsidies, and investment support—to accelerate the deployment of clean technologies. In doing so, they aimed not only to advance decarbonization but also to address the structural challenges facing domestic manufacturing.

In January 2025, the political environment shifted. The second Trump administration issued Executive Order 14154: Unleashing American Energy, which directed federal agencies to immediately suspend or review funding approved under the IIJA and IRA. The order stated that unlocking America's untapped natural resources would serve the national interest by restoring U.S. prosperity. This reflected the administration's intention to maximize use of domestic resources, ensure a low-cost and stable energy supply, and revitalize domestic manufacturing.

Although both the Biden and Trump administrations have shared the overarching goal of strengthening U.S. industries, the current administration, under the slogan "Make America Great Again," is concentrating policy support on sectors that leverage the country's own energy resources and industrial strengths. A key factor underpinning the shift has been the country's emergence as a major natural gas power through the shale revolution. Once heavily dependent on energy imports, the U.S. became the world's largest producer of natural gas in 2011 and a net exporter of liquefied natural gas (LNG) by 2017. This not only secured the nation's energy advantage but provided an abundant low-cost supply of gas to serve as a heat source and feedstock for industries such as chemicals, fertilizers, and hydrogen production. This created an economic foundation for manufacturing reshoring. Thus, while under the Biden administration, natural gas was positioned as a transitional fuel on the road to decarbonization, under the Trump administration, it has been defined as a permanent baseload fuel.

Investment Trends by Clean Technology Type in the U.S.



That said, over the past five years, total investment in clean technologies has risen steadily, with a notable acceleration under the IIJA and IRA. In 2023 and 2024, investment amounted to $336 billion and $338 billion respectively.

By technology category, transport electrification—e.g. electric vehicles (EV)—has been the primary growth driver, with continuous expansion over the past five years. As of 2024, the segment accounted for just over a quarter of total clean-technology investment. Similarly, investment in transmission and distribution infrastructure has continued to rise.

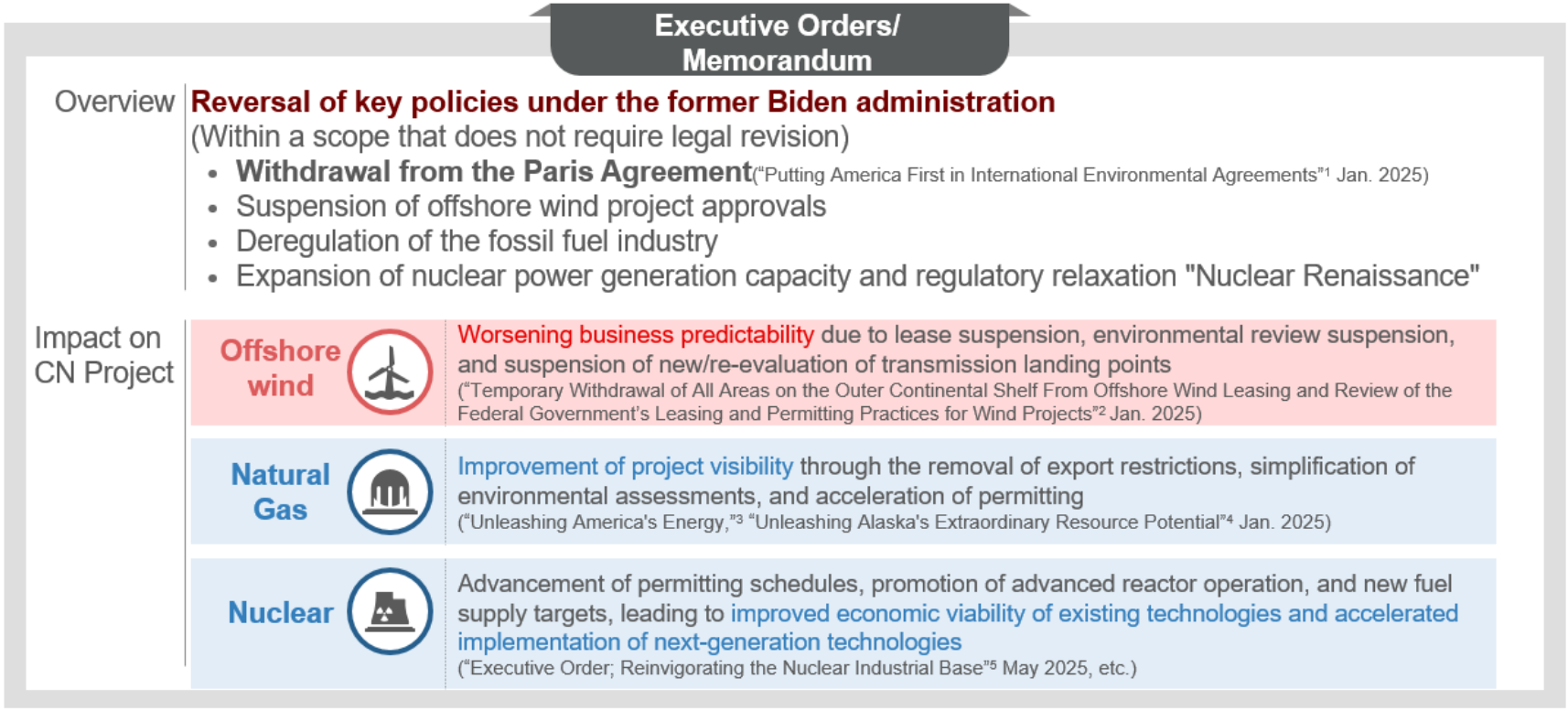
Due to stricter import restrictions on solar components and delays in wind project permitting, investment in the renewable energy sector temporarily declined in 2022. But following IRA implementation, it rebounded and has since stabilized at around $100 billion annually.

Although its share of total investment remains relatively small, energy storage has emerged as a rapidly growing segment. The increasing investment in this area indicates active capital deployment for equipment and infrastructure to enable renewable power production.

---

1. Projects related to clean steel, clean ammonia, circular economy, and bioplastics that aim for net zero in industrial sectors through the use of CN technologies.
Source: BloombergNEF. Note: Start years differ by sector, but all sectors are present from 2020 onwards. Most notably, power grids start in 2020. CCS refers to carbon capture and storage.

Policy Shifts by the Second Trump Administration: Executive Orders



Through Executive orders, CN-related technologies can be divided into those where investment promotion is supported and those where it is constrained

---

1. Putting America First In International Environmental Agreements; 2. Temporary Withdrawal of All Areas on the Outer Continental Shelf from Offshore Wind Leasing and Review of the Federal Government's Leasing and Permitting Practices for Wind Projects; 3. Unleashing American Energy; 4. Unleashing Alaska's Extraordinary Resource Potential; 5. Reinvigorating the Nuclear Industrial Base

Policy Shifts by the Second Trump Administration: Executive Orders

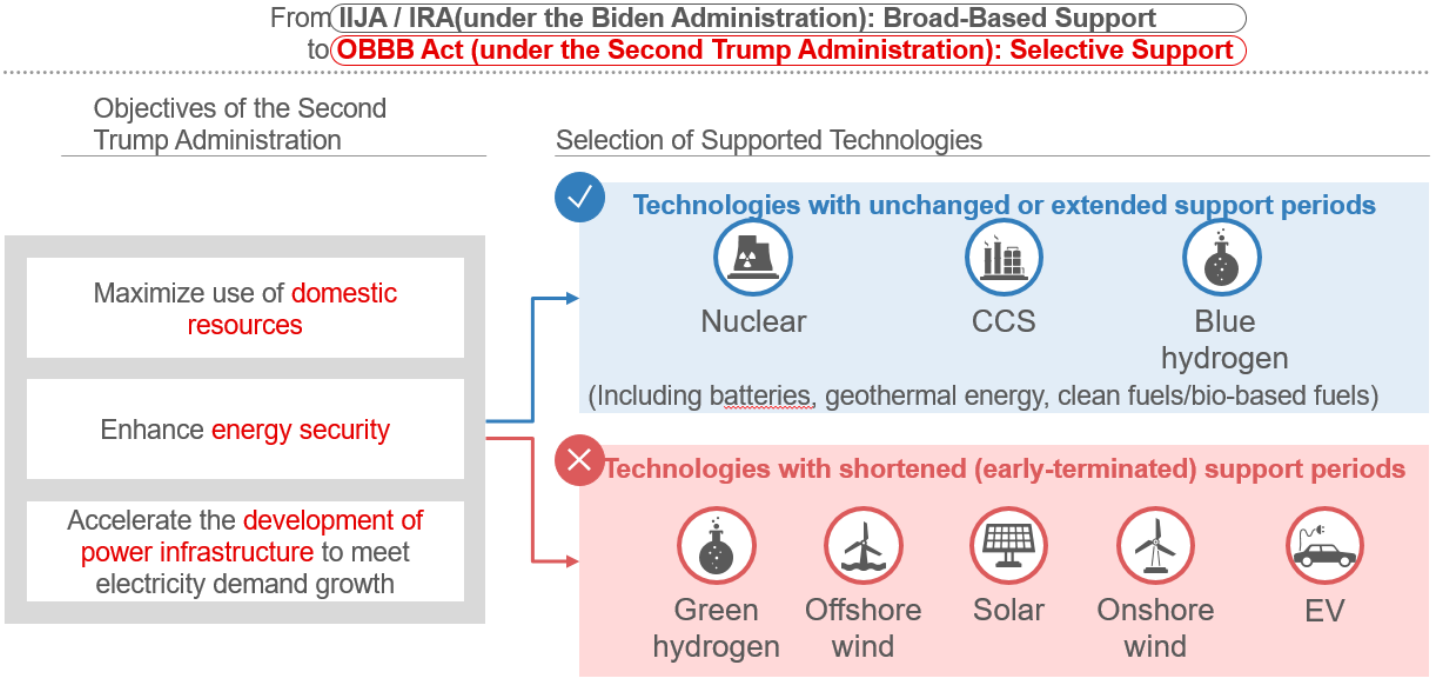
The Trump administration has issued a series of executive orders to move the U.S. away from the Biden administration's CN policies. Among the most symbolic came in January 2025, when the administration made an executive order entitled *"Putting America First in International Environmental Agreements".* The order formally withdrew the U.S. from the Paris Agreement. This was followed by a sequence of orders, including to suspend offshore wind permitting, deregulate fossil fuel industries, and promote and deregulate nuclear power.

These actions have led to polarization. At one end of the spectrum, offshore wind has suffered most, with the January 2025 order halting new leasing, new project approvals, and the reassessment of existing offshore wind facilities. As a result, the predictability and visibility of business operations—a prerequisite for project financing and supply chain investment—have deteriorated significantly, creating deep uncertainty for developers and investors in offshore wind projects. At the other end of the spectrum, natural gas and nuclear power have seen a decisive policy tailwind. On natural gas, executive orders and directives from the Department of the Interior have led to the lifting of LNG export restrictions and streamlining of environmental assessments and permitting procedures. This has reversed the Biden-era suspension of export permits to non-Free Trade Agreement (FTA) countries, dramatically improving the policy and business predictability required for LNG operators to secure long-term sales contracts and project financing.

On nuclear energy, the administration has announced measures to accelerate licensing processes, promote the deployment of advanced reactors, and strengthen domestic fuel supply targets. These steps are expected to support extensions of operations at existing plants and investment in maintenance and refurbishment. They will also stimulate investment in next-generation nuclear technologies, including those still in demonstration phases.

In aggregate, the second Trump administration has shifted from the previous all-encompassing CN policy framework—which broadly supported all clean technologies—to a more selective, targeted strategy implemented through executive action. The administration is concentrating support and investment promotion in sectors that enhance energy security and industrial competitiveness, while sending a clear signal of restraint toward high-cost, policy-dependent sectors such as offshore wind.

Support for CN Technologies under the OBBB (One Big Beautiful Bill) Act



Through the One Big Beautiful Bill (OBBB) Act, the Trump administration has reinforced its policy shift toward a targeted approach, focusing on selectively supporting technologies deemed strategically important. The transition is guided by three overarching policy objectives aimed at revitalizing U.S. industry: maximizing the utilization of domestic resources, enhancing energy security, and promoting the development of power infrastructure—the latter intended to cater to the surging electricity demand associated with rapid expansion of artificial intelligence (AI) and data centers (DCs).

Technologies receiving continued or extended policy support include nuclear power, carbon capture, utilization, and storage (CCS/CCUS), and blue hydrogen, alongside battery storage, geothermal power, and clean fuels and biofuels. These contribute to grid stability and the decarbonization of fossil fuels, and are viewed as practically deployable technologies. As such, they remain eligible for support measures under the IIJA and IRA frameworks. Conversely, green hydrogen, offshore wind, and EV-related technologies—which were heavily promoted under the Biden administration—have been subject to accelerated phaseouts or reductions in support. These sectors continue to face challenges in cost competitiveness and grid integration, and have seen tax credits and subsidies originally established under the IRA shortened.

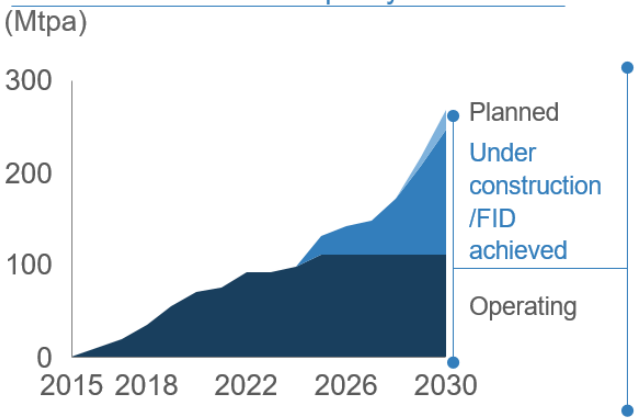
Against the backdrop of rising energy prices and fiscal constraints, the administration has sought to allocate limited public resources strategically, prioritizing technologies that most effectively advance national interests in industrial revitalization and energy security.

Source: IRS (as of July 9 2025); Congress.gov website

Progress: Trends in Natural Gas

Under the Trump administration, export restrictions of natural gas (by the Biden administration) have been lifted, environmental assessments simplified, and project approvals accelerated

U.S. LNG Production Capacity[1]



Capacity is expected to increase rapidly toward 2030

Major LNG Development Projects Progressing in 2025

Project	Progress in 2025	Production Capacity[2]
1 Corpus Christi LNG (Texas)	Manufacturing facility expansion permit (Jun)	29.1Mtpa
2 Louisiana LNG (Louisiana)	FID (Apr)	27.5Mtpa
3 Alaska LNG (Alaska)	Executive order explicitly accelerates development (Jan)	20.0Mtpa
4 CP2(Calcasieu2) LNG-Phase1(Louisiana)	FID (Jul)	14.4Mtpa
5 Commonwealth LNG (Louisiana)	Non-FTA[3] Export authorization from DOE (Sep)	9.3Mtpa

Multiple LNG development projects advanced in 2025

Some transition technologies have been more influenced by Trump administration policies than others. Natural gas stands out as an area in which approval processes for new and existing LNG facilities have been substantially accelerated. As a result, the U.S.'s LNG production capacity is projected to expand rapidly toward 2030, reaching about double the capacity of currently operational plants. Output from projects that are under construction or have reached Final Investment Decision (FID) is expected to come online around 2028, driving national LNG production capacity to approximately 300 million tons per annum (Mtpa) by 2030.

The year 2025 has seen major project milestones. The Louisiana LNG Project, for example, achieved its FID in April 2025, with a projected production capacity of 27.5Mtpa at full operation. Two other projects—the Alaska LNG Project and Commonwealth LNG Project—exemplify the Trump administration's impact. The Alaska LNG Project has been explicitly designated for accelerated development under the executive order "Unlocking Alaska's Extraordinary Resource Potential." In September 2025, the U.S. and Japanese governments issued a joint statement confirming their intent to pursue LNG offtake contracts from Alaska and to facilitate stable, long-term U.S. energy purchases totaling approximately $7 billion annually. The following month, Tokyo Gas signed a letter of intent to procure LNG from Alaska, underscoring Japan's growing engagement in the initiative. At the Commonwealth LNG Project, export permits for non-FTA countries had been suspended under the Biden administration, were reinstated. This highlights the U.S. government's renewed commitment to leveraging its domestic energy resources and reasserting its position as a leading global energy exporter.

---

1. Production capacity aggregated by pipeline; classified into: pipelines currently in operation; pipelines under construction or that have reached FID; and pre-FID pipelines with publicly announced development plans; 2. Expected production volume at full commercial operation for the project; 3. Free Trade Agreement
Source: Rystad Energy, Wood Mackenzie, Public Company data

Progress: Trends in Nuclear

By Executive order, the U.S. aims to expand nuclear power generation capacity to 400 GW by 2050 (four times the 2025 level). The plan targets the construction of 10 new plants and a 5 GW increase in output at existing facilities by 2030, with 20 tons of nuclear fuel already secured

Acceleration of Restarts and Expanded Output of Existing Reactors(Target: +5GW Total)

1. Palisades
   - Michigan (800MW)
2. Cranes Clean Energy Center
   - Pennsylvania (800MW)
   - Microsoft signed a 20-year PPA, supporting the restart of operations
3. Duane Arnold Energy Center (DAEC)
   - Iowa (600MW)

Approval for Construction and Operation of 11 Small Test Reactors

1. MSR-1 (Molten Salt Reactor)
   - Texas(1MW/Unit)
   - To be built at Abilene Christian University
2. Aalo-1 (SMR)
   - Texas (10 MW/Unit)
   - Pilot plant to be built at Texas national research institute
3. Integral Molten Salt Reactor
   - Texas (200 MW/Unit)
   - To be built at Energy Solutions' closed site
4. PWR-20 (PWR)
   - Texas (20 MW/Unit)
   - To construct 30 micro reactors for the state's DC

Google and Amazon (AWS) Enter Nuclear Power PPA[1]

1. Susquehanna
   - Pennsylvania
   - AWS and Talen Energy signed a 17-year (through 2042) 1.92 GW power supply agreement for Susquehanna power plant
2. Hermes-2
   - Tennessee
   - Google, in partnership with Kairos Power, aims to introduce up to 500 MW of nuclear generation by 2035

※Locations of the other seven projects remain undisclosed at this time

Similar to natural gas, nuclear power has been explicitly prioritized, with President Trump signing four Executive orders promoting what he calls a “nuclear renaissance.” These directives set a long-term national target of achieving 400GW of nuclear generation capacity by 2050—around four times the current level. The administration has established policy objectives to commence construction of 10 new reactors by 2030, increase output from existing facilities by 5GW, and to secure an initial stockpile of 20 tons of nuclear fuel.

An example of efforts to lift generation at existing reactors is the Cranes Clean Energy Center, which recently restarted the former Three Mile Island Unit 1 reactor. While Unit 2 of the same plant suffered a core meltdown in 1979, the recently restarted Unit 1 was shut down in 2019 for economic reasons. The restart was ahead of schedule and supported by a 20-year long-term power purchase agreement (PPA) with Microsoft, which will ensure both business predictability and revenue stability. Indeed, a key driver of nuclear demand is the electricity needs of data centers. Aside from Microsoft, Google has partnered with Kairos Power on new generation systems, positioning nuclear energy as a promising and stable power source for the digital economy.

Progress is also evident in the new build segment, amid accelerating construction of small modular reactors (SMRs) and next-generation reactors. Eleven experimental reactor projects have already received construction and operation permits. These include test projects such as the Molten Salt Reactor (MSR-1) and Aalo-1 SMR, both aimed at validating next-generation nuclear technologies.

---

1. Privately led use of nuclear power, driven mainly by rising electricity demand from DCs rather than direct Executive orders.

Source: Public company data; NRC Website; DOE Website; US selects 11 projects for program to fast-track small nuclear test reactors | Reuters

Progress / Stagnation: Trends in CCS Projects

IRA: Tax credits for carbon capture and storage (CCS) are maintained

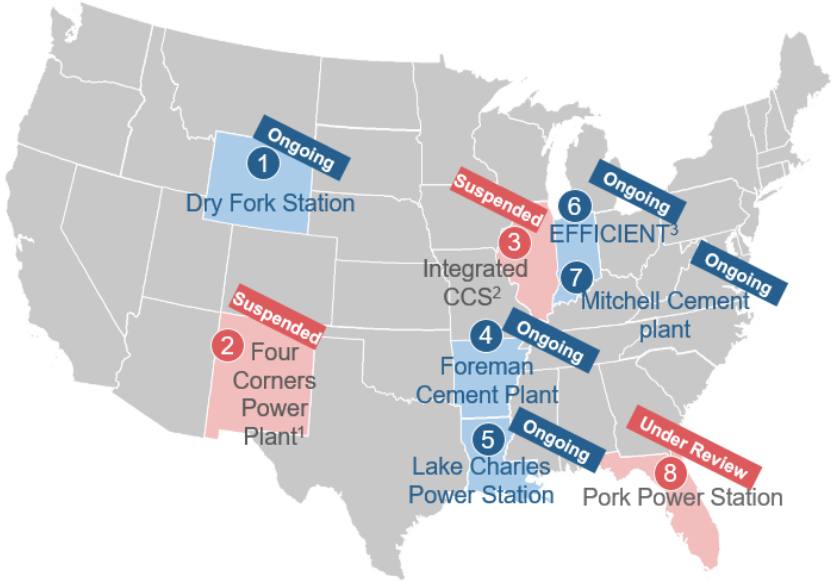
Five of the eight Carbon Capture Demonstration Projects Program adopted by the Biden administration will continue receiving support, while three have been suspended or are under review for suspension due to poor economic viability

Funding opportunity for large-scale pilots announced at the end of 2024 is currently reviewing applications submitted by Jul 2025

(as of Oct 2025)

: Ongoing FEED support

: Suspended / Under Review FEED Support



In the CCS sector, the OBBB Act maintains the details of the 45Q tax credit introduced under the IRA. At the same time, support at the individual project level has not been uniformly positive. As of October 2025, within the U.S. Department of Energy's (DOE) CO_2 Capture Demonstration Program, which funds front-end engineering design (FEED) studies, five of the eight projects selected under the Biden administration continue to receive federal support, and additional funding is planned to help FEED-stage projects progress to large-scale pilots, commercial demonstrations, and, ultimately, networked CCS systems.

By contrast, support for the remaining three projects has reportedly been terminated or is under review due to weak project economics. This suggests that, although CCS is positioned in federal policy as a "strategic technology for decarbonizing fossil fuel use," actual project progress or stagnation remains highly sensitive to state-level conditions and the circumstances of individual developers.

Note: The hub locations on the map indicate approximate positions based on publicly available information; 1. Included in the projects for which support was discontinued as announced by the DOE on October 2, 2025; 2. Integrated Capture, Transport, and Geological Storage, Funding terminated in May 2025 due to low economic viability; 3. Edwardsport Flex Fuel Integrated Capture for Indiana's Energy Transition

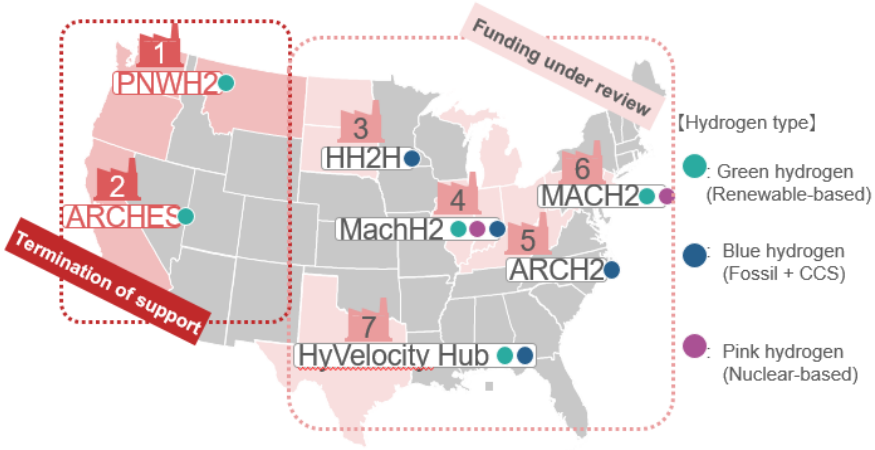
Source: DOE (1/3); DOE(2/3); DOE (3/3); Latitude Media Website

Progress / Stagnation: Trends in Hydrogen Hubs

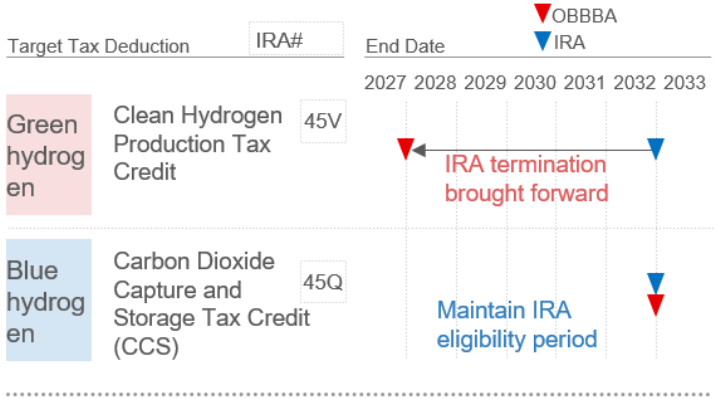
- Green hydrogen: Early termination of clean hydrogen production tax credits under the IRA
- Blue hydrogen: Tax credits for carbon capture and storage (CCS) maintained under the IRA

Support for Clean Hydrogen Hubs Selected by the Biden Administration to be Discontinued

The U.S. Department of Energy has discontinued support for two large-scale hydrogen hubs, and reports indicate that the remaining five are also under consideration for discontinuation (as of Oct 2025).



The OBBB Act Maintains the Tax Credit for Blue Hydrogen Linked to CCS



Support for specific clean hydrogen hubs has been discontinued, but the OBBB Act maintains the IRA's application to blue hydrogen, maintaining a policy of favoring blue hydrogen over green hydrogen

The hydrogen hub initiative, launched to accelerate the commercialization of hydrogen at seven locations across the U.S., is facing headwinds as it is either being canceled or under consideration for cancellation. Not only has the DOE discontinued support for two projects focused on green hydrogen (hydrogen derived from renewable energy), but as of October 2025, it is also considering discontinuing support for the remaining five projects, including plans for blue hydrogen (hydrogen produced from natural gas with CO2 captured and stored using CCS to reduce environmental impact).

Similarly, the end date for the clean hydrogen tax credit (45V) has been brought forward, putting green hydrogen in a difficult position from a tax credit perspective. On the other hand, as mentioned above, the OBBB Act maintains the tax credit system (45Q) for the CCS field, so blue hydrogen can continue to be eligible for tax credits when utilizing CCS, and compared to green hydrogen, it can be said to be a technology with higher policy priority.

---

1. The hub locations on the map indicate approximate positions based on publicly available information. Hub names are abbreviated, and sites shown in multiple colors represent multiple hydrogen production methods.
Source: PNWH2; ARCHES; Reuters ; Latitude Media Website

Stagnation: Trends in Offshore Wind Power

- Suspension of new or renewed assessments for leasing, environmental review, and transmission approvals
- Early termination of clean power production and investment tax credits under the IRA

Withdrawal and Termination of Support
for a Total of 12 Offshore Wind Projects **(as of Aug 2025)**

Withdrawn Prior to Implementation (Planned Support Amount)

1. Sparrows Point Steel Marshalling($47M)
2. Bridgeport Port($10M)
3. Wind Port at Paulsboro($20M)
4. Arthur Kill Terminal($48M)
5. Davisville($11M)
6. Norfolk($39M)
7. Humboldt ($427M)

Support Terminated Mid-Process (Planned Support Amount)

8. Redwood Marine Terminal($8M)
9. Salem Wind Port($33M)
10. Lake Erie($11M)
11. Radio Island($2M)
12. Portsmouth Marine Terminal($20M)

Starting July 2025, government agency heads (ministers) will intervene in the decision-making process for all existing projects

Approval of New Offshore Wind Projects Suspended

By Executive order, new approvals for offshore wind projects are suspended in all waters surrounding the United States

Unlike hydrogen, offshore wind power is blowing headwinds across the board. On his first day of office, President Trump indefinitely suspended new offshore wind leasing in federal waters, followed by a freeze on environmental reviews and new re-evaluations of transmission and landings. In addition, the exemption of Clean Power Production Investment Tax (PTC/ITC) based on IRA has been brought forward, and institutional support has been reduced.

In August 2025, the Department of Transportation (DOT) decided to either withdraw or halt funding for 12 offshore wind power projects that had been supported under the Biden administration. A total of US$680 million will be allocated to support other projects.

Source: U.S. Department of Transportation Website; U.S. Department of the Interior Website; The White House Website

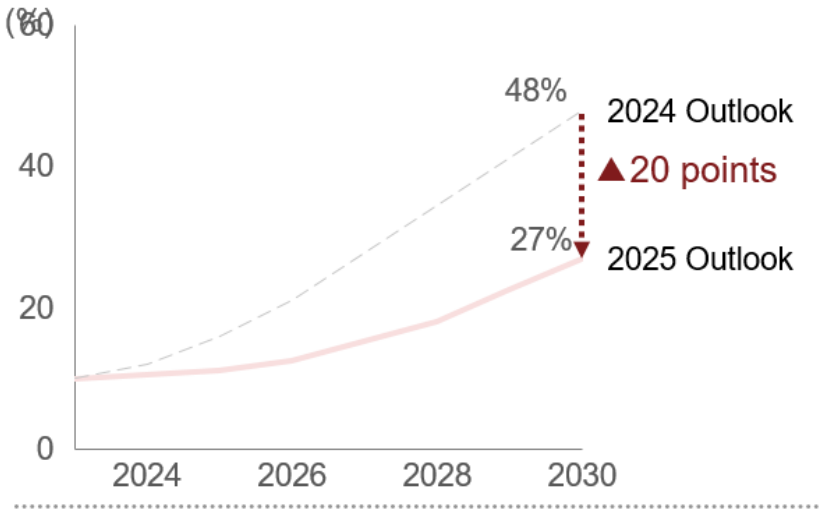
Stagnation: EV Production and EV Sales under Pressure

Early termination of clean vehicle tax credits under the IRA

Reduction/Reconsideration of EV Investment in the U.S. (Oct. 2025)

Ford	Delayed mass production of EV models despite investment exceeding $1.5B (2025/8)
GM	Sold EV battery plant for approximately $2.1B (2025/5), 3,300 job cuts at battery plants (2025/10)
Nissan	Delayed EV production at U.S. plant (2025/10)
BORG WARNER	Withdrew from EV charging business and downsized battery system operations (2025/5)
Panasonic Energy	Delayed production ramp-up at factory that had seen $4B of investment (2025/7)

Change in U.S. Share of EV Sales[1] Outlook



EV adoption in the U.S. is projected to fall significantly behind expectations

The EV sector is also facing difficulties. The Trump administration has announced an accelerated phase out of the Clean Vehicle Tax Credit (30D) established under the IRA, leading to widespread caution across the industry.

Companies across the supply chain—from automotive OEMs to battery and charging infrastructure providers—have scaled back or delayed projects. There have seen postponements in EV model launches, downsizing of production plans, and even asset sales and business withdrawals. Among examples, Nissan had planned to begin production of two EV models at its Mississippi plant between late 2028 and the first half of 2029. In October 2025, the company suspended the plan and instead shifted focus toward expanding hybrid vehicle production. As a result of these moves, forecasts for EV sales have been revised down from 48% of the total to 27% of the total by 2030.

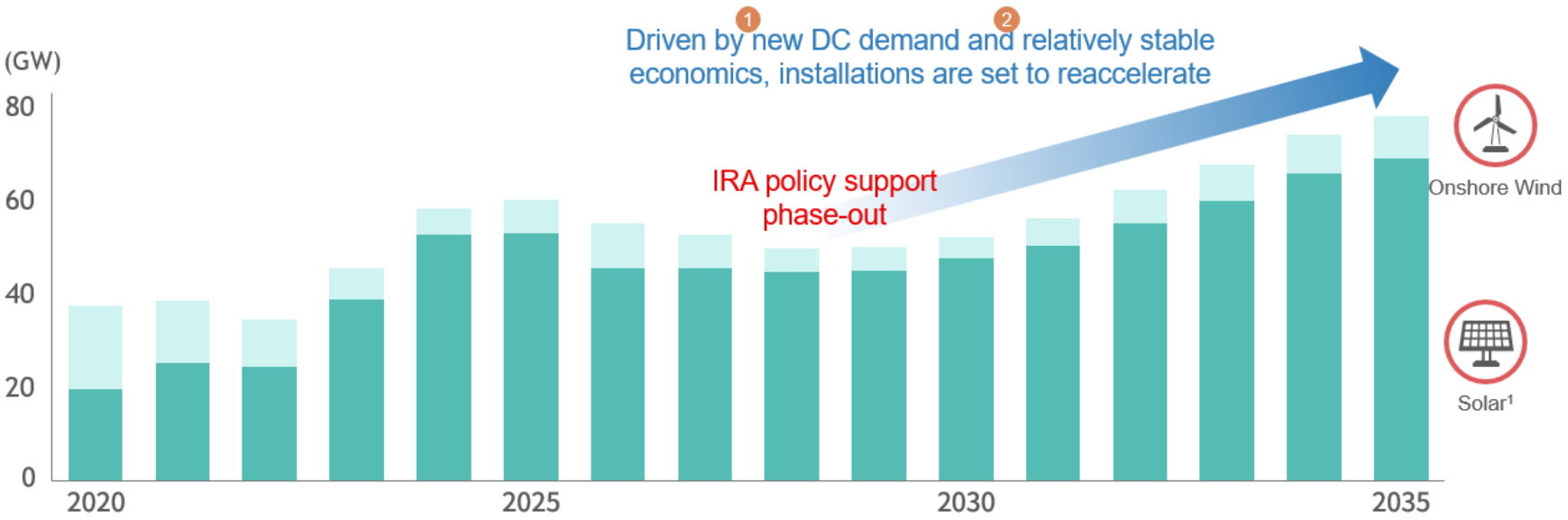
---

1. Share of EVs (passenger vehicles) in total vehicle sales
Source: JETRO Website; BloombergNEF. "Electric Vehicle Outlook 2025" (Note: Passenger vehicle sales); Public company data

Forecast for New Installations of Solar and Onshore Wind

Early termination of clean energy production and investment tax credits under the IRA

Forecasts for New Solar and Onshore Wind Installations in the U.S. (October 2025)

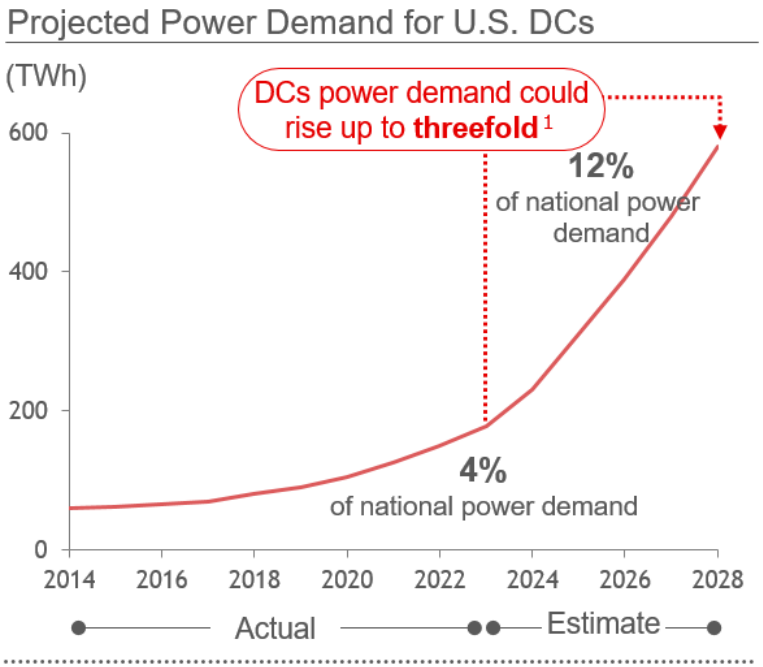


According to BloombergNEF (BNEF),new solar and onshore wind installations—particularly solar—are expected to maintain an upward trend supported by clean electricity production and investment tax credits under the IRA (Sections 45Y and 48E). However, with the IRA incentives ending earlier than anticipated, the market is likely to enter a period of limited growth beginning in 2026. Growth is projected to resume in the 2030s, reaching around 66GW annually by 2035.

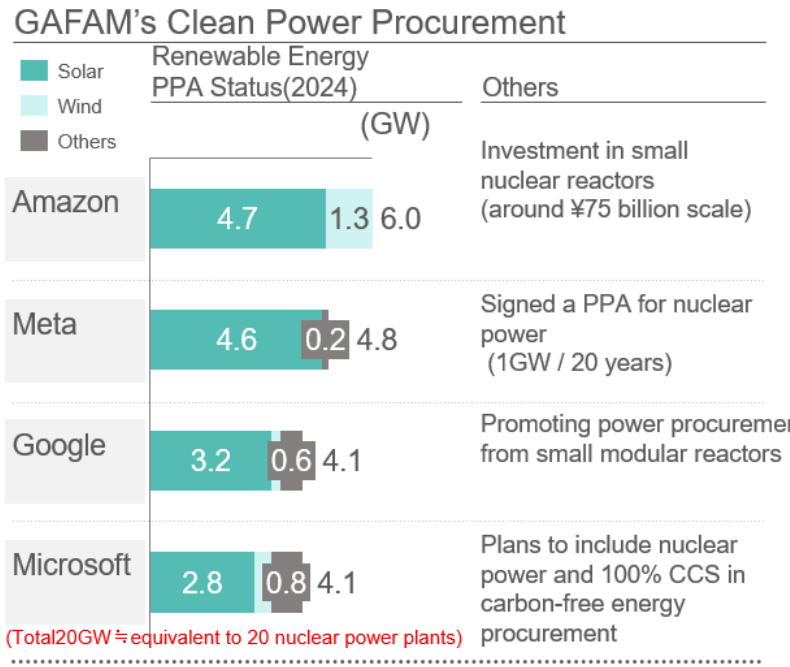
The main drivers of this post-IRA recovery will be twofold: rising electricity demand driven by the rapid construction of new data centers and the relative cost advantage of renewables compared with other power generation sources. Given these factors, investment in U.S. solar and onshore wind is expected to continue, though at a modestly slower pace.

1: Including Utility Solar, Residential Solar, Commercial Solar
Source: BloombergNEF "Trump Slams the Brakes on US Wind and Solar Growth" Note. Solar here refers to photovoltaic solar. Solar capacity is in direct current.

New DCs Demand and Power Procurement by GAFAM



Data center demand is projected to expand significantly over a short period



GAFAM are expanding clean power procurement—primarily solar—in response to data center electricity needs

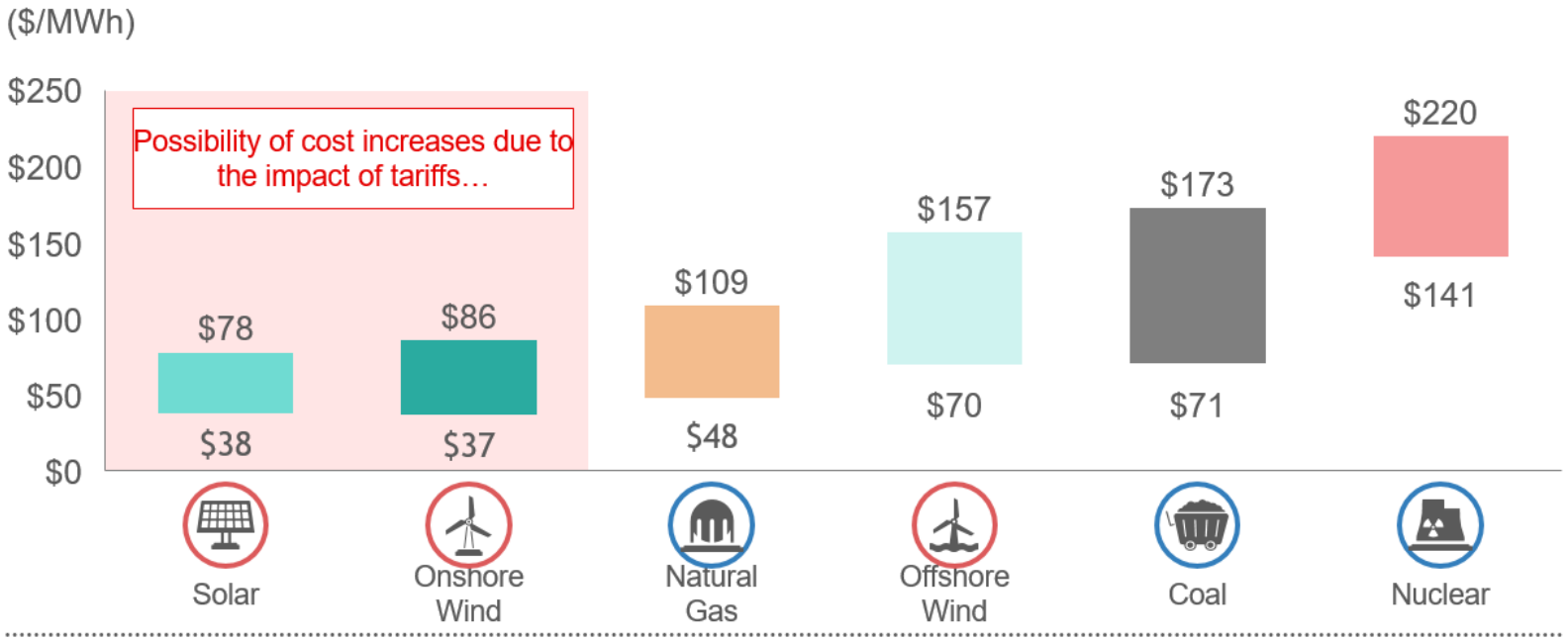
A major driver behind the expansion of renewable energy in the U.S. is surging electricity demand from data centers. In 2023, power consumption by data centers accounted for approximately 4% of total national electricity demand, but this share is set to triple to around 12% by 2028.

In anticipation of this rapid growth, major technology companies—collectively known as GAFAM (Google, Apple, Facebook, Amazon, and Microsoft)—are securing clean energy sources. Firms have signed multi-gigawatt PPAs, primarily for solar energy, and are diversifying by investing in or contracting power from nuclear and fossil fuel plants equipped with CCS technologies. Thus, the expansion of demand from data centers is accelerating the procurement and diversification of clean power sources, positioning digital infrastructure as a pivotal force in shaping the next phase of the U.S. clean energy transition.

---

1. Among multiple scenario analyses conducted, the results of the maximum scenario are shown.
Source: Lawrence Berkeley National Laboratory; BloombergNEF; Public company data; Note: Charts are for offsite publicly disclosed power purchase agreements (PPAs) that are online. "US DoD" in the left chart stands for US Department of Defense and "Air P&C" stands for Air Products and Chemicals. Data through December 2024.

Generation Costs as of June 2025 (LCOE)



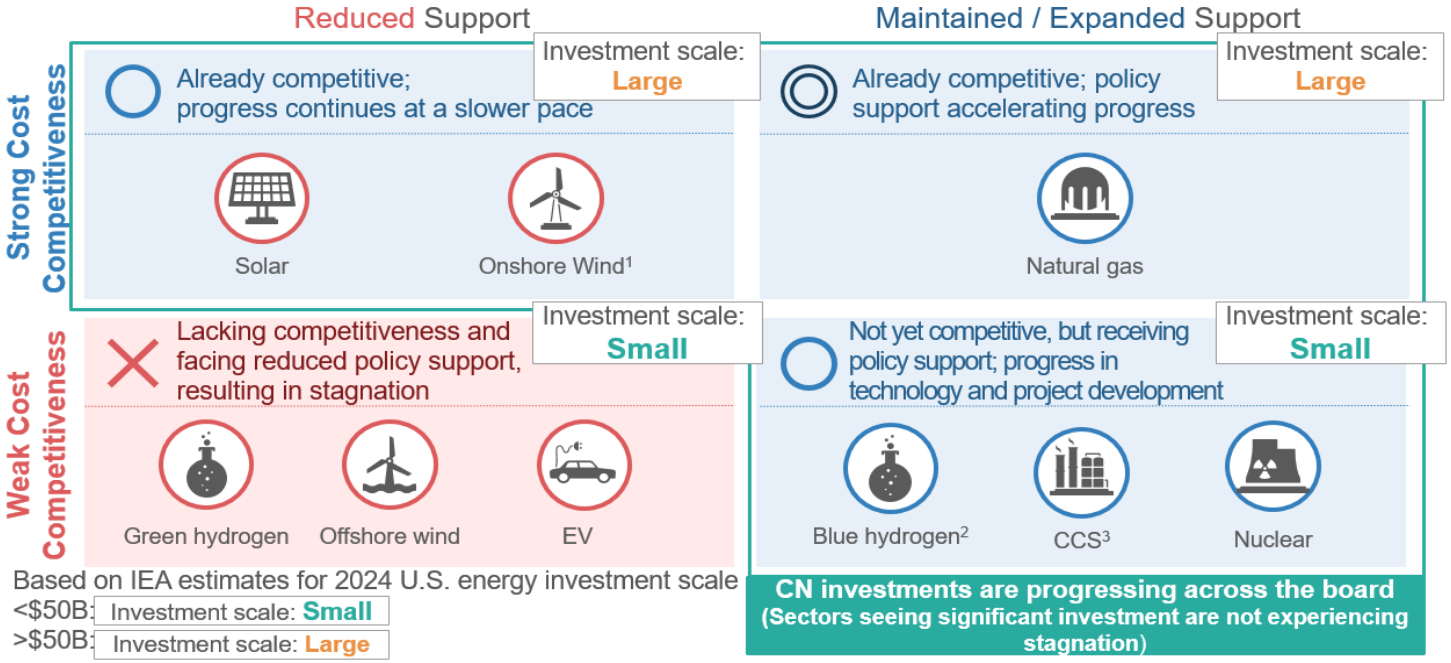
Solar and Onshore wind remain competitive clean power sources

Drilling down into renewables costs, research shows that as of June 2025, the lowest-cost options are solar power ($38–78/MWh) and onshore wind ($37–86/MWh)—both of which fall below the cost range of natural gas ($ 48–109/MWh) on a levelized cost basis. Natural gas is the most economical of the fossil fuels.

Although some renewables costs may rise due to the high tariffs imposed by the second Trump administration, it is expected that other power generation technologies will face similar tariff impacts. As a result, the relative cost advantage of renewables is likely to remain intact. On the other hand, it is important to note that as the amount of installed capacity increases, the shortage of transmission grids and storage facilities becomes more severe. Additionally, the supply chain for solar and wind equipment is extremely dependent on China.

Note: Solar/onshore and offshore wind power represent LCOE without ITC/PTC (solar/wind tax credit programs). Solar + battery storage LCOE ranges from $50 to $131, onshore wind + battery storage LCOE ranges from $44 to $123
Source: Levelized Cost of Energy+ (LCOE+) | Lazard

The Impact of the Change in Administration on CN Investments



In summary, given the expected policy support and economics for technologies under a second Trump administration, the landscape is likely to bifurcate between areas where investment is sustained or expands and areas where it stagnates. The largest upside in investment is expected in the natural gas sector, where continued and expandd policy support—including the lifting LNG export restrictions and the streamlining permitting procedures—is projected to drive a doubling of production capacity by 2030. Although nuclear power has limited cost competitiveness, it is treated as a policy priority for securing stable energy supply and supporting core domestic industrial capabilities, and executive-level policy support is being expanded. For CCS and blue hydrogen, projects are showing signs of stagnation—such as subsidy terminations linked to DOE budget cuts—yet they continue to receive support through its eligibility for the 45Q tax credit.

By contrast, solar and onshore wind, while affected by reduced policy support, are expected to sustain medium- to long-term investment, supported by declining LCOE and growing power demand. Green hydrogen, offshore wind, and EVs face heightened risks of investment stagnation, given both weaker policy support and limited cost competitiveness, undermining their economic rationale and policy priority. Offshore wind, in particular, could see a prolonged slowdown, amid suspension of new leases and freezing of environmental reviews.

Overall, the outlook for U.S. CN-related investment remains positive, underpinned by robust electricity demand and the cost advantage of renewables over fossil fuels. It is expected to expand as a market-driven growth engine in the nation's evolving clean energy landscape.

1. Compared to solar power, progress is expected to be slow; 2. Support for clean hydrogen hubs selected by the Biden administration has been discontinued, but the tax credit for blue hydrogen linked to CCS under the OBBB Act remains in place; 3. The Biden administration's large-scale CCS basic design support project was partially suspended, but the tax credit for CCS under the OBBB Act remains in place.

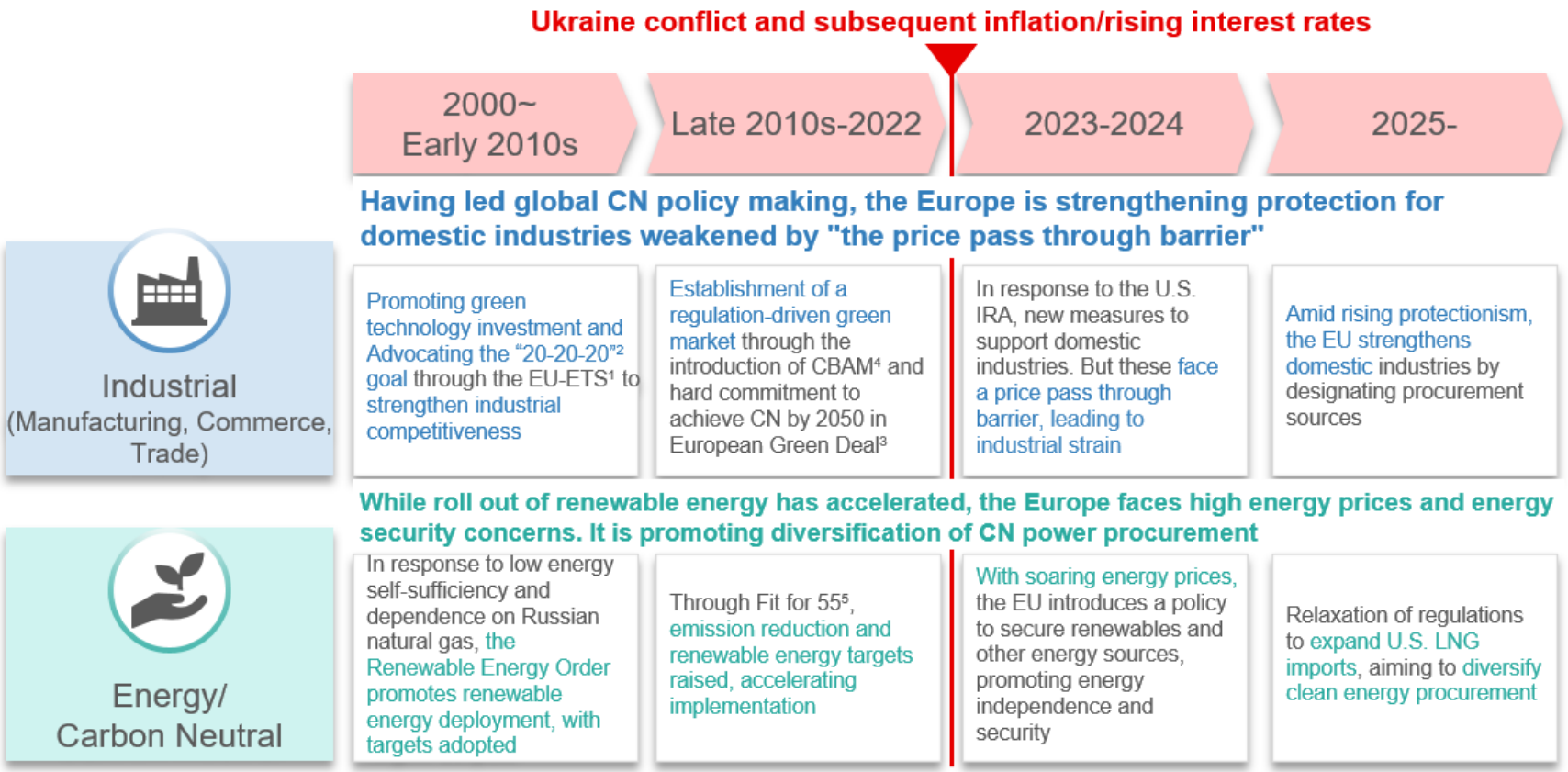
Summary

1. In response to the outflow of domestic industries since the 2000s and to reduce its trade deficit with China, the U.S. has used CN to support its industrial offering (Biden administration's IRA / IIJA).

2. The second Trump administration has significantly altered CN-related policies, clearly differentiating between supported and unsupported technologies(from an "Broad base support" approach to selective support for specific technologies).

3. While offshore wind and EVs are likely to stagnate, natural gas and nuclear power will make progress with policy support. Solar will also advance due to DC power demand and their economic viability.

Trends in Industrial and CN Policies in Europe



---

1. European Union Emissions Trading System; 2. The targets set in 2007 to achieve a 20% reduction in greenhouse gas emissions, a 20% share of renewable energy, and a 20% improvement in energy efficiency by 2020; 3. The comprehensive policy package announced in 2019; 4. Carbon Border Adjustment Mechanism; 5. A comprehensive policy package to achieve the EU's 2030 climate target (reducing greenhouse gas emissions by at least 55% compared to 1990 levels)

Trends in Industrial and CN Policies in Europe

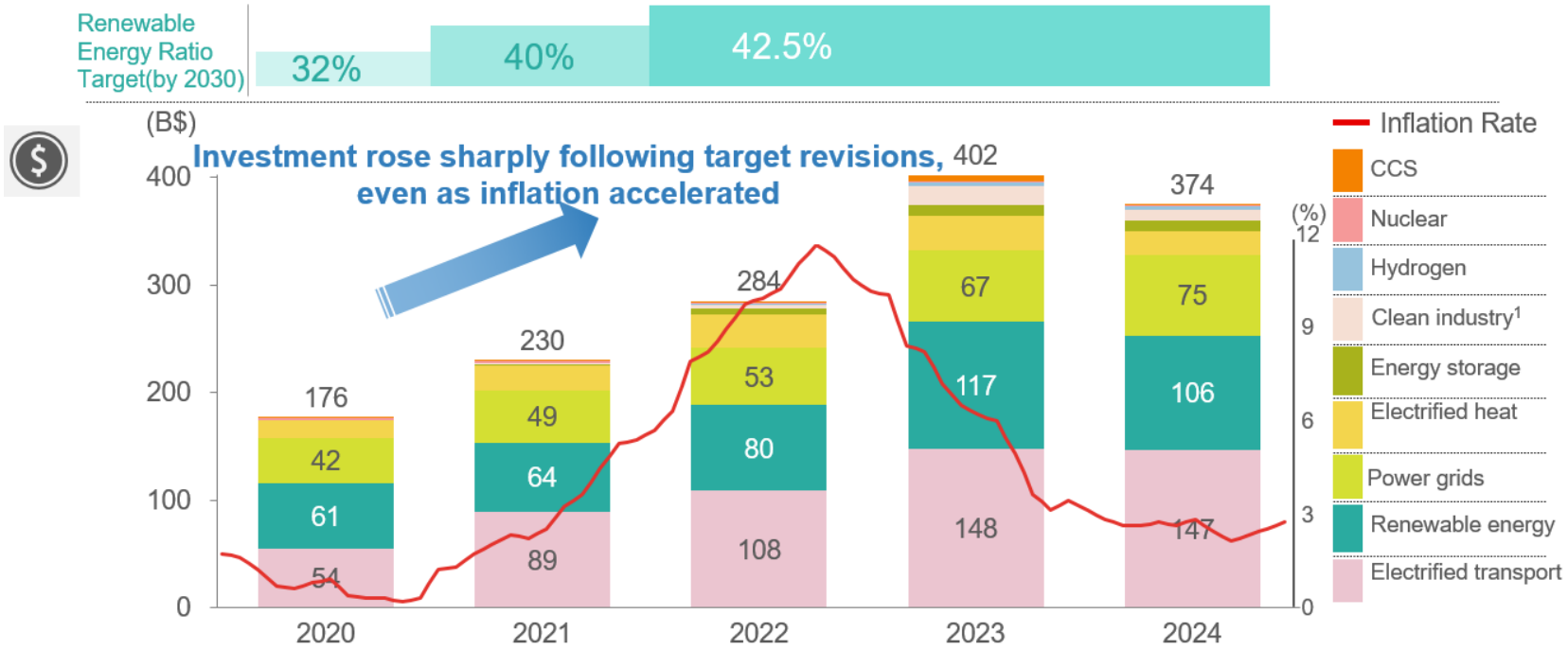
Since the early 2000s, Europe has pursued a strategy of enhancing industrial competitiveness through environmental initiatives. The region has promoted regulation-driven (rule-based) market formation and industrial development, positioning environmental policy as an engine of economic growth. In 2005, the EU introduced the Emissions Trading System (EU-ETS), establishing the world's first regional carbon market. By setting an explicit cost for emissions, the region aimed to incentivize low-carbon investment and adoption of energy-efficient technologies. In 2007, the "20-20-20" targets were adopted—setting binding goals to reduce greenhouse gas (GHG) emissions by 20%, achieve a 20% renewable energy share, and improve energy efficiency by 20% by 2020. The setting of these targets ahead of other nations helped create long-term investment visibility. The Europe successfully reframed environmental regulation as a source of competitive advantage, promoting a growth model under which environmental action drives industrial innovation and corporate opportunity.

Building on this foundation, Europe has progressively deepened its regulatory framework to promote decarbonization and shape corporate behavior. In 2019, European Commission (EC) President Ursula von der Leyen announced the European Green Deal, designating CN by 2050 as a growth strategy. In 2021, the EU made its 2050 CN goal and 2030 GHG reduction target legally binding obligations and introduced the Fit for 55 Package. This package strengthened renewable energy targets and established the Carbon Border Adjustment Mechanism (CBAM), linking industrial competitiveness with carbon accountability.

In recent years, Europe has faced rising energy prices and a "price pass through barrier," which have eroded the profitability of energy-intensive industries and triggered some contraction or relocation of production bases. In response, while maintaining its CN commitment, the EU has begun recalibrating its policies to place greater emphasis on restoring industrial competitiveness and protecting domestic industries. The underlying driver of this shift has been the energy security risks exposed by the Ukraine conflict. Europe's long-standing supply of Russian natural gas was disrupted by the conflict, highlighting vulnerabilities in its energy system. Thus, geopolitical risks, rising materials costs, and high interest rates have contributed to energy price spikes and supply uncertainty.

In response, the EU has implemented short-term measures such as regulatory easing to expand LNG imports from the U.S., while medium-to-long-term strategies now emphasize diversifying clean power sources—including nuclear energy—within Europe's CN frameworks. Through this balanced approach, Europe seeks to reconcile its decarbonization goals with energy security and industrial resilience.

Investment Trends by Clean Technology Type and Inflation Rate in Europe

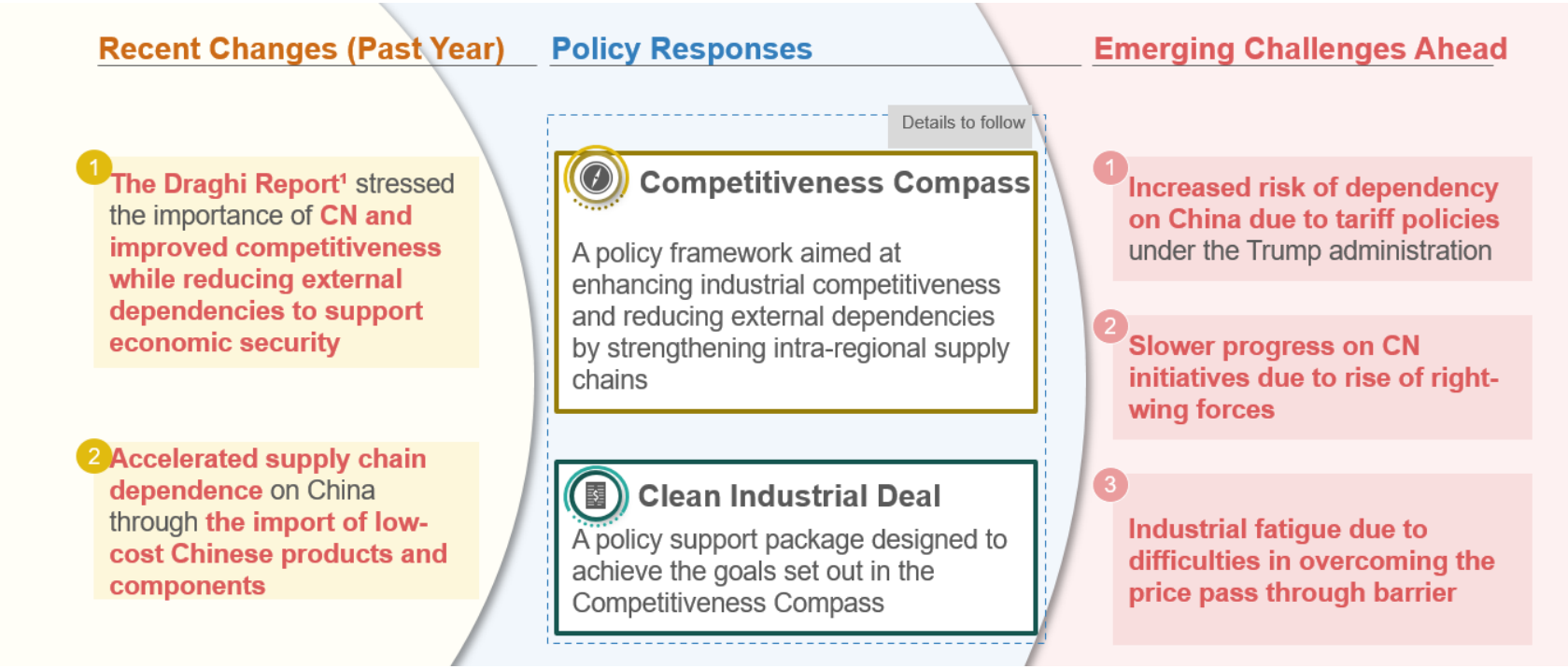


European CN investment rose steadily from 2020 to 2023, but it declined slightly from $402 billion in 2023 to $374 billion in 2024. This temporary contraction was attributed to factors including nominal adjustment effects following the easing of inflation, volatility in electricity prices, and higher financing costs. These together created investment uncertainty but did not indicate an overall loss of investment appetite. Rather, momentum now varies by sector, with investment remaining solid in policy-backed areas such as renewable energy and EV, at least partly reflecting the EC's decision to raise the 2030 renewable energy target from 32% to 42.5%. From a technological perspective, the electrification of transport, particularly through EV-related investments, has been a primary growth driver, accounting for approximately 40% of total investment in 2024. Mobility-related investment—including in battery manufacturing and charging infrastructure—play a central role in both enhancing industrial competitiveness and creating employment opportunities. Meanwhile, investment in transmission, distribution, and renewable energy has continued to expand. Notably, even as total CN investment declined between 2023 and 2024, spending on transmission and distribution infrastructure increased, reflecting the growing need for grid modernization to accommodate renewable energy expansion and accelerate the replacement of aging transmission networks.

---

1. Projects relating to clean steel, clean ammonia, circular economy, and bioplastics aimed at achieving net zero in the industrial sector through CN technologies
Source: BloombergNEF (Power grids, Poland and Rest of EU figures corrected on March 5, 2025.) IEA "World Energy Investment 2024"; EU–Japan Centre for Industrial Cooperation;

Changes and Policy Response after Publication of MUFG Whitepaper 3.0



Over the past year, Europe's industrial and energy policy has seen a clear strategic shift—from a focus on CN technologies above all else to a more pragmatic transition that seeks to balance industrial competitiveness with economic and energy security. The policy realignment has been strongly influenced by the Draghi Report, authored by former European Central Bank President Mario Draghi, which emphasized the growing importance of simultaneously achieving decarbonization and competitiveness, while reducing external dependencies. A key driver behind this shift has been the rapid influx of low-cost products and components from China, which has emphasized Europe's structural CN supply chain dependence—a trend increasingly viewed as a strategic vulnerability.

In response, the EC in 2025 introduced two new policy frameworks: the "Competitiveness Compass" and the "Clean Industrial Deal". Through these, Europe continues to advance CN objectives while adapting to shifting global and domestic conditions. However, the region now faces three pressing challenges that must be addressed in parallel: the risk of deepening dependence on China due to U.S. tariff policies; the potential slowdown of CN initiatives amid the rise of right-wing political movements; and the erosion of domestic manufacturing competitiveness caused by difficulties in reflecting higher costs in prices. These dynamics underscore Europe's evolving approach—one that seeks to balance climate ambition with economic resilience and geopolitical pragmatism.

---

1. A 2024 report on strengthening Europe's competitiveness, prepared at the request of European Commission President Ursula von der Leyen

Recent Policies: Competitiveness Compass and the Clean Industrial Deal

Recent Policies: Competitiveness Compass and the Clean Industrial Deal

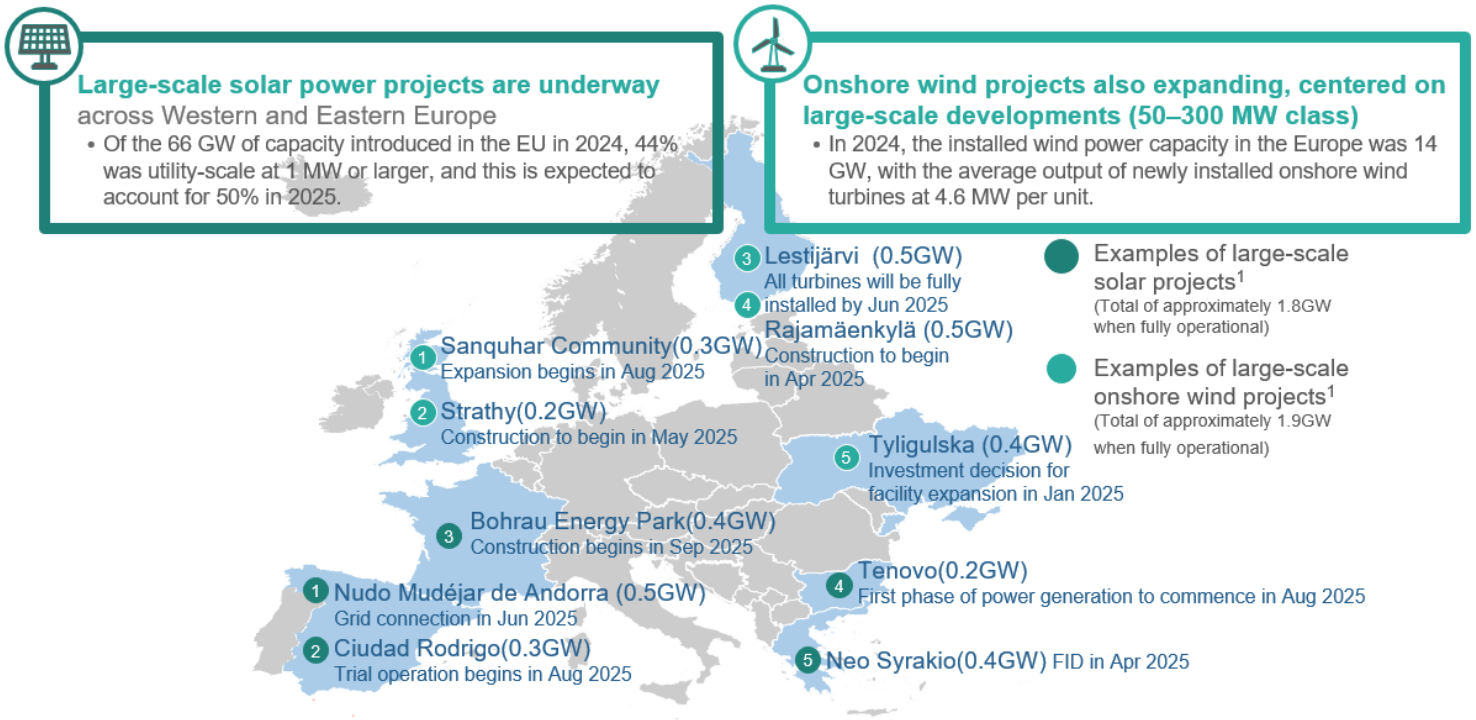
The Competitiveness Compass announced in January 2025, serves as the core policy agenda of EC President Ursula von der Leyen's second-term administration. While maintaining the traditional foundation of climate- and environment-driven industrial policy, the initiative distinguishes itself by placing energy security, supply stability, and industrial competitiveness at the center of Europe's policy framework. In essence, it institutionalizes a pragmatic transition — a balanced approach to advancing decarbonization while safeguarding the economic foundations of European growth.

The Clean Industrial Deal unveiled in February 2025, provides the implementation package for the Competitiveness Compass. The plan establishes an Industrial Decarbonisation Bank with an investment support target of €100 billion. Through a combination of financial instruments, tax incentives, and regulatory streamlining, the initiative aims not only to accelerate deployment of decarbonization technologies, but also to strengthen Europe's domestic manufacturing base, rebuild supply chains, and create employment opportunities across member states.

The frameworks designate key clean technologies—including solar and wind energy, hydrogen and electrolyzers, CCS, EV, and energy storage infrastructure—as priority support areas. Meanwhile, LNG and nuclear power are assigned increased weight from the perspectives of energy security and electricity price stabilization.

Importantly, the Clean Industrial Deal introduces a technology-neutral, dual-track approach that combines deregulation with targeted investment support, enabling the EU to pursue decarbonization and enhance competitiveness simultaneously. A particularly notable reform is the simplification of state aid rules for renewable energy support, which affords member states greater discretion in granting subsidies and significantly shortens approval procedures. For example, in August 2025, France leveraged the framework to approve a fixed-price offshore wind project, accelerating deployment under the new, streamlined subsidy rules. This illustrates how the investment environment for renewable energy has improved, signaling renewed momentum for clean energy expansion under the updated policy regime.

Progress: Status of Large-Scale Renewable Energy Projects



Under the newly introduced policy frameworks, renewable energy deployment in Europe continues to expand. In particular, solar power and onshore wind installations are accelerating—not only in Western Europe's major economies, but also across a broader geographic range, including Eastern and Southern Europe, where multiple new projects are progressing in parallel. This momentum reflects the tangible impact of recent institutional reforms by the EC, including the expansion of transmission and distribution networks, streamlining of approval processes, and relaxation of state aid rules.

Looking at the composition of projects, 44% of the installed capacity of 66GW in Europe in 2024 is utility scale with 1MW or more, but more than half is less than 1MW. It can be said that the expansion of geographically dispersed power sources is remarkable. In 2024, the installed capacity of onshore wind in Europe was 14 GW, with the average output of new onshore wind turbines reaching 4.6 MW per unit.

In addition, in countries such as Spain, France, Greece, Ukraine, Finland and others, large-scale projects with a capacity of over 400 MW at full operation have also advanced to the construction approval stage, and the scale of investment is diversifying.

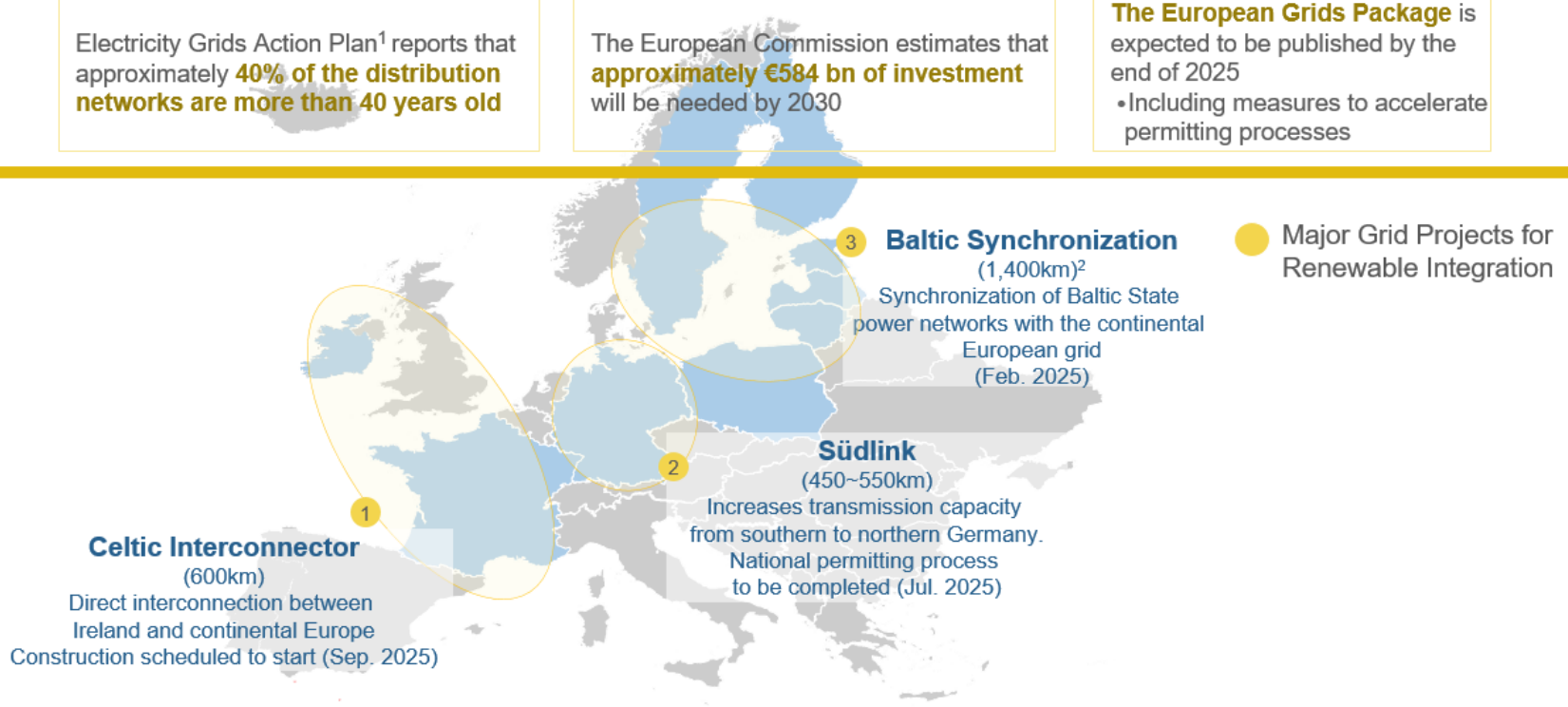
---

1. From Global Energy Monitor's published projects in Europe, five representative projects with investment decisions or construction progress after 2025 were selected in descending order of planned generation capacity. These were plotted by country.
Source: Global Energy Monitor Website; Solar Power Europe Website ; Wind Europe website; Public information

Progress: Status of Major Power Grid Projects

Many transmission networks are aging, **creating constraints on the acceleration of renewable energy expansion**
For stable renewable power supply, **Large-scale grid development projects and increased investment** are underway

- Electricity Grids Action Plan[1] reports that approximately **40% of the distribution networks are more than 40 years old**
- The European Commission estimates that **approximately €584 bn of investment** will be needed by 2030
- **The European Grids Package** is expected to be published by the end of 2025
  - Including measures to accelerate permitting processes



Note: Representative projects with progress in 2025, as listed on the European Commission's website, are plotted by region; 1. Policy to Accelerate Transmission and Distribution Infrastructure Development within the European Union, Published in November 2023; 2. New developments in the Baltic States and Poland
Source: IEA Website; European Commission Website(1/2); European Commission Website(2/2); EirGrid Website; Renewables Now Website;i

Progress: Status of Major Power Grid Projects

With the rapid expansion of renewable energy deployment, Europe faces an urgent need to modernize and expand its transmission and distribution infrastructure. Currently, approximately 40% of the EU's power grid infrastructure has been in operation for over 40 years, creating structural constraints that hinder its ability to accommodate the variability and geographic dispersion of renewable power generation. In response, the EC has redefined transmission and distribution networks as core infrastructure for achieving CN and designated them as a priority investment area.

The EC estimates that approximately €584 billion in power grid investment will be required by 2030, and it is advancing institutional reforms to facilitate this effort. Measures outlined in the Electricity Grids Action Plan include: accelerating permitting processes, strengthening Europe's domestic manufacturing and procurement capacity for equipment and components, and issuing guidance for grid modernization and digitalization. These initiatives are fully aligned with the principles of the Clean Industrial Deal, supporting member states in expanding grid capacity, reducing connection delays, and enhancing supply chain resilience within Europe.

Furthermore, by late 2025, the EU plans to introduce a comprehensive European Electricity Grid Package. This will institutionalize further reforms, including faster approval procedures, stronger cross-border interconnections, and standardization of digital grid control systems, thereby improving the efficiency and resilience of Europe's power infrastructure.

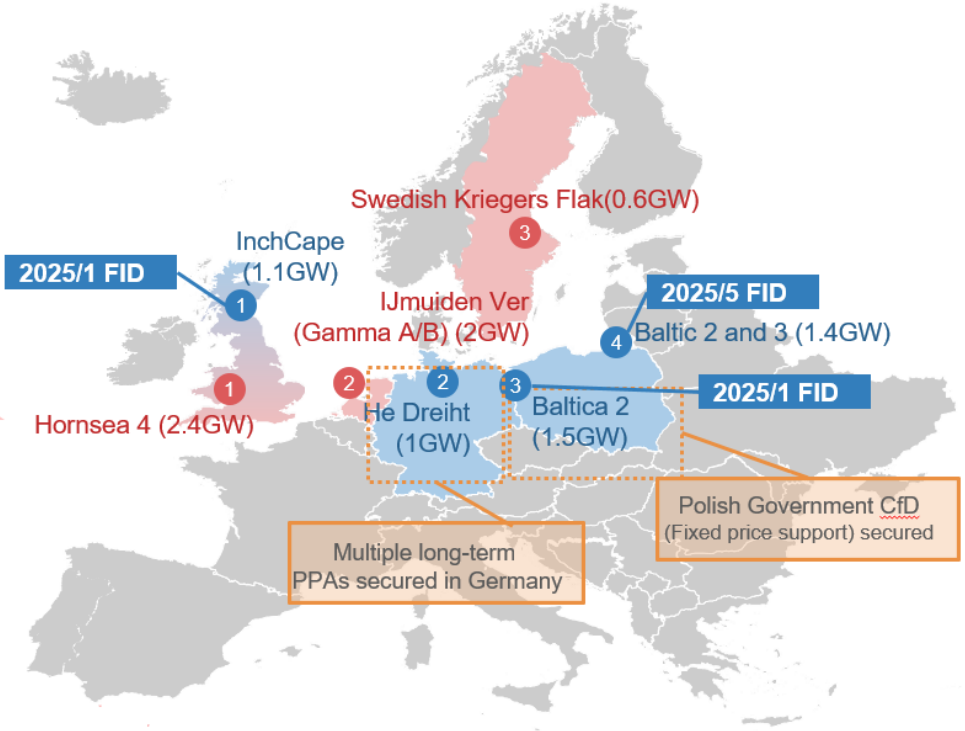
An example project is the Celtic Interconnector, a 600 km subsea transmission line linking Ireland and France, whose construction began in September 2025. Once completed, it will enable power transfers of up to 700MW, integrating Ireland's previously isolated grid with the broader European electricity market—a landmark example of regional energy interconnection and system integration.

Progress/Suspension: Status of Large-Scale Offshore Wind Projects

While progress is being made on projects such as those reached FID in 2025, there are also cancellations and withdrawals amid economic deterioration

Total new offshore wind capacity introduced in 2024 was approx.2.6 GW (+8% year on year)

- Large-scale projects announced as implemented or progressing (approx. 5GW in total, expected commercial operation in 2027–2030)
- Large-scale projects canceled or withdrawn (approx. 7GW total)

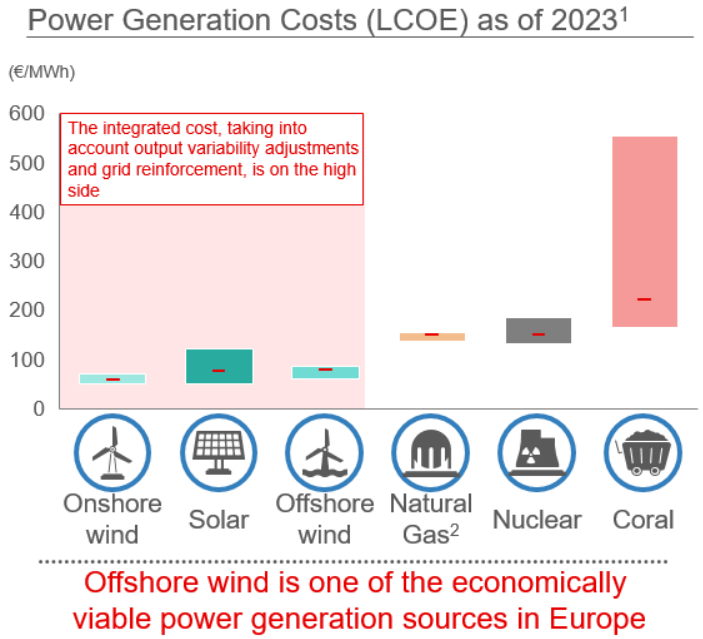


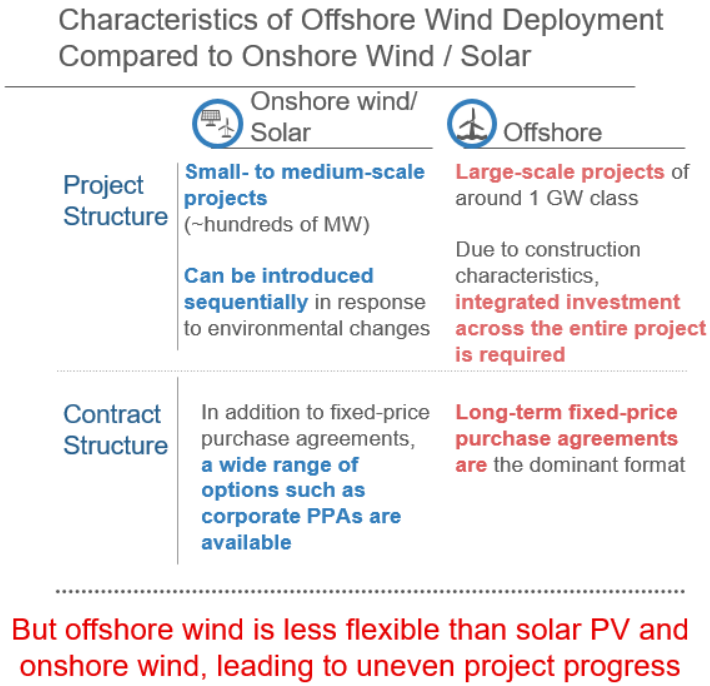
Offshore wind power continues to play a major role in European renewable energy policy. Yet, its progress remains uneven. Backed by policy frameworks such as the Competitiveness Compass and the Clean Industrial Deal, several large-scale projects are advancing. On the other hand, rising costs, volatile material prices, and inflationary pressures have undermined project profitability, forcing some developers to postpone or withdraw from planned investments.

Among the offshore wind projects making good progress is Baltic 2 & 3, which reached final investment decision (FID) in May 2025, Baltica, which secured a government-backed contract for difference (CfD) and the He Dreiht project, meanwhile, has been supported through long-term PPAs. Conversely, ultra-large projects such as IJmuiden Ver (2GW) have faced challenges and delays. These developments highlight that, while policy commitment to offshore wind remains strong, economic feasibility and financial sustainability continue to present major hurdles—not only in the U.S. but also in Europe.

Note: Based on publicly available information, we compiled representative projects in each country that have been officially announced since 2024 and plotted them by country. These are examples of large-scale projects with (planned) generation capacity of 600 MW to 1 GW or more. 2024-August.2025
Source: Wind Europe website; Public Information

Characteristics of Power Generation Costs (LCOE) and Offshore Wind Deployment in Europe





When comparing the levelized cost of electricity (LCOE) in Europe as of 2023, it becomes clear that—similar to the U.S.—onshore wind, solar, and offshore wind have all fallen below the cost range of natural gas, the cheapest among fossil fuel sources. This indicates that these renewable power sources have already achieved standalone cost competitiveness.

But when taking into account integration costs, as discussed in Whitepaper 3.0, the economics become complex. As the share of variable renewables rises, there are additional costs associated with balancing supply variability and reinforcing grid infrastructure. In particular, large-scale offshore wind projects tend to face significantly higher integration costs due to the massive grid connection investments they require.

Furthermore, although offshore wind generation costs have declined to levels comparable with solar and onshore wind, the sheer scale of these projects results in extremely high upfront investment burdens. Many projects also depend on long-term fixed-price contracts (CfDs), with limited flexibility to adjust through corporate PPAs or other market-based arrangements. Consequently, economic fluctuations—such as inflation, rising interest rates, and higher material costs—tend to have a direct and substantial impact on project profitability. For these reasons, the offshore wind market in Europe has entered a bifurcated state: projects that maintain policy support and business predictability continue to progress, while those facing deteriorating profitability are experiencing delays or cancellations.

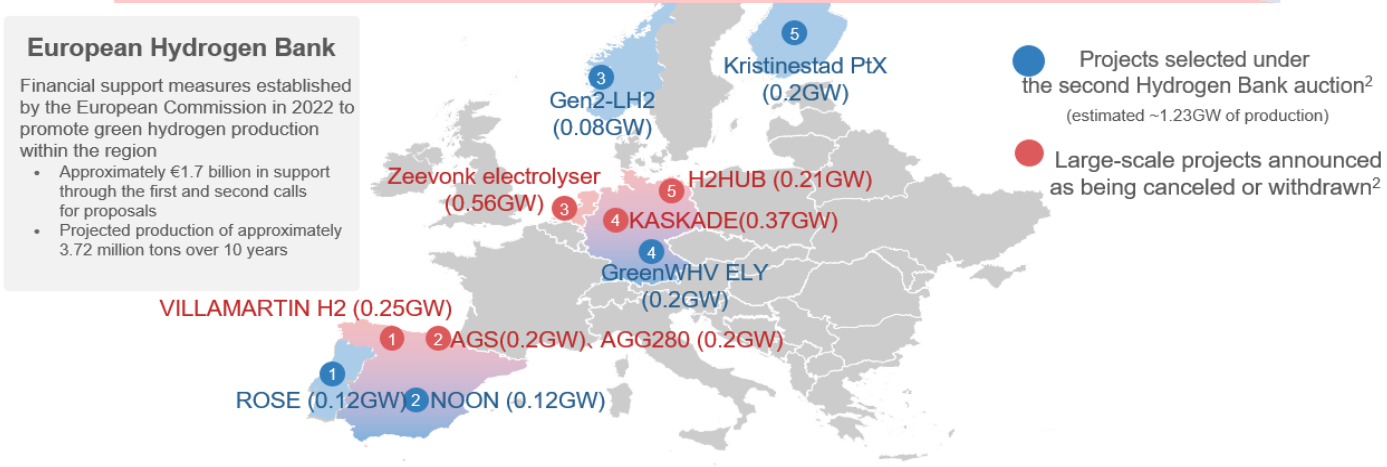
---

1. The dark red line indicates the median value, and the shaded area represents a ±25% range around the average for all of EU;
2. LCOE for combined-cycle generation (a combination of power generation by gas turbines and steam turbines)

Source: EU Website

Progress/Suspension: Trends in Hydrogen Projects

Of the 15 projects selected in May 2025 under the second EU Hydrogen Bank call, 8 will continue to receive support and are expected to **start operations within 5 years**
But 7 of the initially selected projects were excluded from support after reassessment of their maturity and economic feasibility[1]



Similar to offshore wind, hydrogen has been positioned as a core technology in Europe's CN strategy. But the sector is characterized by polarized fortunes. In terms of public sector funding, the European Hydrogen Bank by the EC serves as the central mechanism. Through its first and second funding rounds, the bank has committed approximately €1.7 billion in financial support. Its programs are expected to facilitate the production of approximately 3.72 million tons of hydrogen over the next decade, enabling Europe to develop a world-leading hydrogen market.

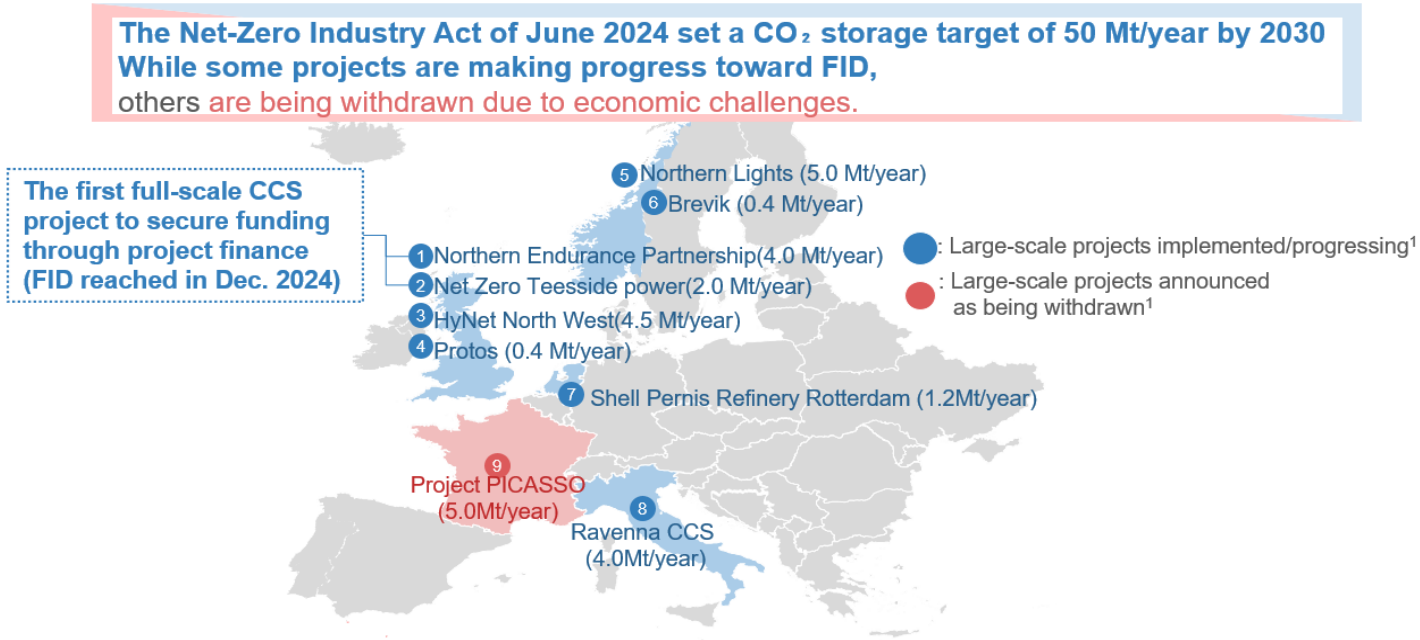
However, there have been constraints in the implementation stage, such as the withdrawal of eight large-scale green hydrogen projects (one from the results of the initial tender in April 2024 and seven from the results of the second tender in May 2025) due to regulatory uncertainty, profitability, and completion deadlines. Instead, ten small- and medium-sized projects won the tender in September of the same year, which were close to the commercialization stage. At full operation, the plant is expected to produce approximately 1.23 GW, with the aim of starting operations within five years. In other words, at present, hydrogen projects in Europe are in a phase where reliable implementation is prioritized over expansion of quantity.

This trend suggests that Europe's hydrogen strategy is shifting from a conceptual and visionary phase toward one emphasizing economic viability and risk diversification. Because fluctuating renewable power prices and rising capital costs have a direct impact on hydrogen production costs, large-scale projects face increasing challenges in securing profitability, while smaller, localized projects are progressing steadily and resiliently.

---

1. The European Commission invited ten reserve projects in September 2025 to begin preparing grant agreements and entered negotiations. As of October 2025, it remains undecided how many will be finally selected under the second call; 2. Using the auction list for the European Hydrogen Bank (EHB) second call, extract - as of October 2025 - the top five projects by production capacity for both continuing-support projects and withdrawn awards, and plot them for the relevant countries
Source: S&P Global Website

Progress/Suspension: Trends in Major CCS Projects



Europe's CCS sector is similar to hydrogen and off-shore wind in that some projects are proceeding successfully while others are not. A major turning point came with the enactment of the EC's Net-Zero Industry Act in June 2024, which mandates the establishment of 50 million tons (50 Mt per year) of CO_2 storage capacity by 2030. Thus, CCS has been positioned as a strategic industrial technology on par with renewables and hydrogen, leading to the integrated promotion of CO_2 capture, transport, and storage infrastructure across Europe.

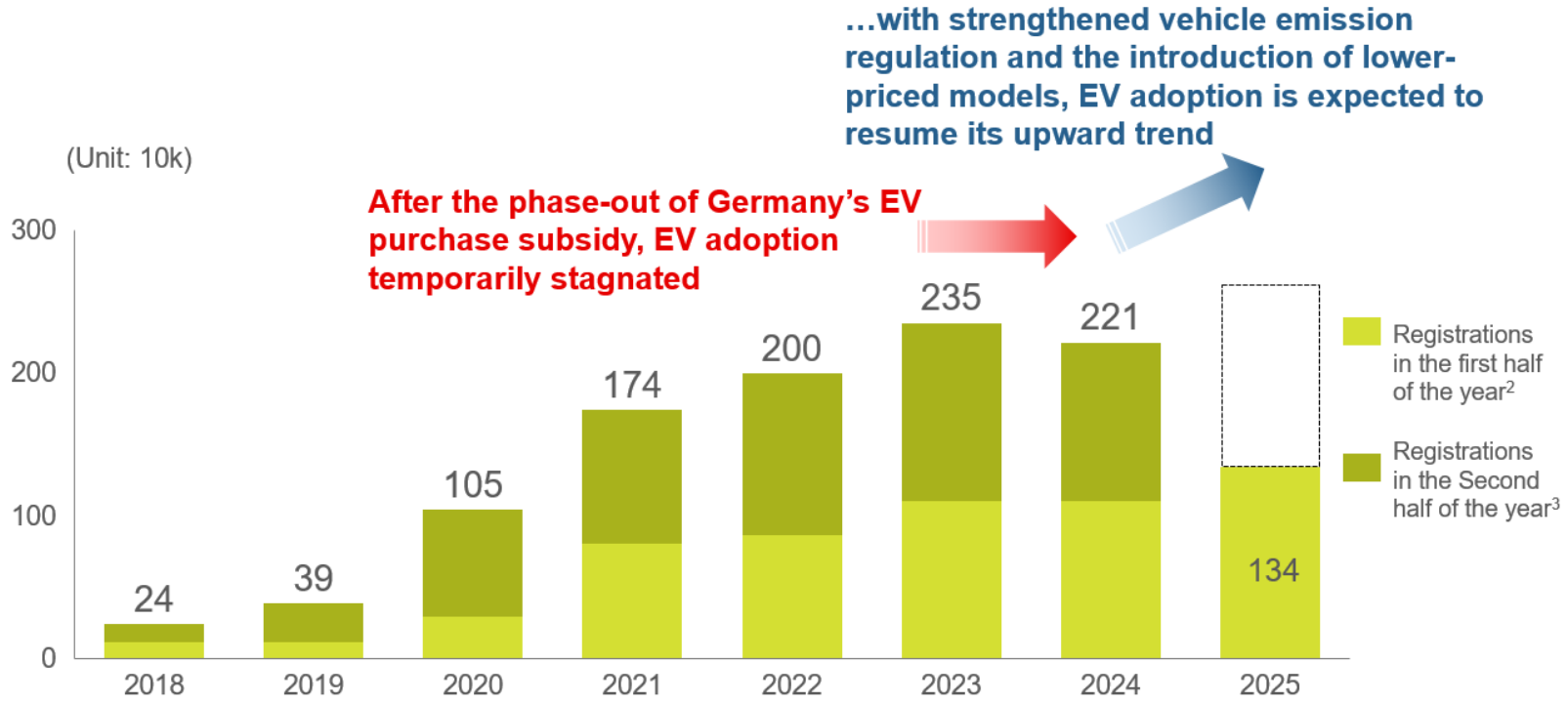
This policy shift is reflected in the progress of large-scale project financing in the United Kingdom. In December 2024, the Northern Endurance Partnership and Net Zero Teesside Power projects became one of the first full-scale CCS initiatives in Europe backed by private capital. The projects are expected to achieve annual CO_2 storage capacities of 4 million tons and 2 million tons respectively. The funding was largely enabled by a structure combining government-backed infrastructure contracts and long-term offtake agreements. Conversely, the Picasso Project in France (5 million tons) was cancelled in early 2025 due to a combination of rising material and construction costs and the failure to finalize long-term CO_2 offtake agreements. This case underscores that, beyond regulatory support, the presence of stable CO_2 demand underpinned by long-term market mechanisms is essential for project viability. It also reaffirms the importance of public–private collaboration in enhancing business predictability and ensuring steady progress in CCS development.

---

1. From the database published by the Global CCS Institute in October 2025, among CCS projects in Europe that are operational or under construction, those that have achieved project financing since 2024 or have made progress in construction or development, with a full-scale CO_2 capture capacity of 0.4 Mt per year or more, were extracted and plotted by country. Add as a source-side project connecting only to the UK's Protos network

Source: Global CCS Institute; Encyclis Website

Progress: New EV[1] Registrations



In Europe, the adoption of EVs continues to show a robust upward trajectory, in stark contrast to trends in the U.S. Supported by stringent regulations and proactive policy measures, the European EV market is expected to sustain its growth momentum. New EV registrations, which stood at approximately 240,000 units in 2018, surged nearly tenfold to about 2.35 million units in 2023. This rapid expansion reflects the combined effects of strict EU-level automotive CO_2 emission standards, national purchase subsidies and tax incentives, and steady progress in EV charging infrastructure development.

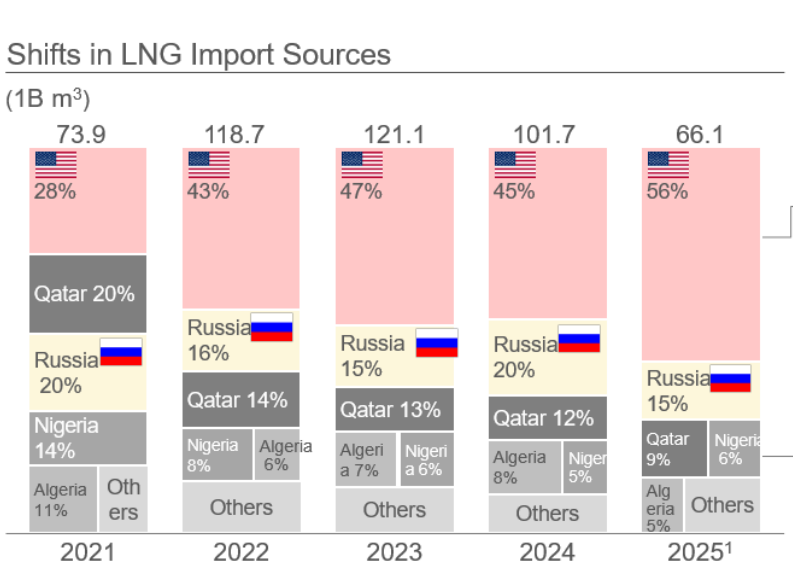
In fiscal year 2024, registrations declined slightly due to temporary factors—most notably Germany's suspension of its low-emission vehicle purchase support program. However, in fiscal year 2025, EV sales have returned to growth, driven by tightened emission regulations across member states and the market introduction of lower-priced EV models.

Indeed, registration volumes in the second half of 2025 have already surpassed those of the previous year, clearly demonstrating that comprehensive policy support has had a direct and significant impact on consumer purchasing behavior.

---

1. PHEV and BEV; 2. Figures represent totals for January to June of each year; 3. Figures represent totals for July to December of each year
Source: European Commission Website

Progress: Trends in LNG



Although dependence on Russian LNG continues, imports from the U.S. have increased sharply

Trends in Expanding LNG Procurement from the U. S.

Conclusion of long-term offtake contracts with the U.S.

- A major German state-owned energy company increased its contract volumes, securing an additional 3.0 Mtpa of LNG over 20 years.
- A major French energy company signed a 20-year offtake agreement for 1.5 Mtpa with a U.S. LNG production train prior to FID

Expansion of LNG regasification terminals and facilities in Germany

- New construction and expansion of regasification facilities at port terminals
- The EU will offset the operating losses of Germany's LNG terminals and regasification facilities with €4 billion in support between 2023 and 2033

Securing long-term imports and accelerating the expansion of LNG reception facilities

Since the outbreak of the Ukraine conflict, Europe has undergone a policy transformation and has placed far greater emphasis on energy independence and security. The focus has clearly shifted toward reducing dependence on Russia and ensuring a stable energy supply. Within this context, LNG has assumed a strategically critical role. As imports of Russian pipeline gas have declined, European countries have accelerated efforts toexpand LNG procurement. They have also moved to develop import and regasification infrastructure, which will mitigate short-term supply disruption risks and diversify energy sources over the long term.

An examination of LNG import sources since 2021 shows that, while Europe remains partially dependent on Russian supplies, imports from the U.S. have increased dramatically. By 2025, major European energy companies in Germany and France had signed a series of long-term offtake contracts with U.S. producers, making the U.S. the largest LNG supplier to Europe, accounting for more than half of total regional imports.

This structural shift in supply has driven a wave of LNG import terminal and regasification facility construction and expansion across Europe. In northern Germany, France, the Netherlands, Poland, and the Baltic states, multiple infrastructure projects are being developed, ranging in cost from several hundred million to several billion euros. The drive to diversify LNG supply sources is expected to continue in the years ahead. Furthermore, some of these new facilities are being designed for conversion into hubs for transporting clean fuels such as hydrogen and ammonia, reflecting an integrated approach that links energy security with decarbonization goals.

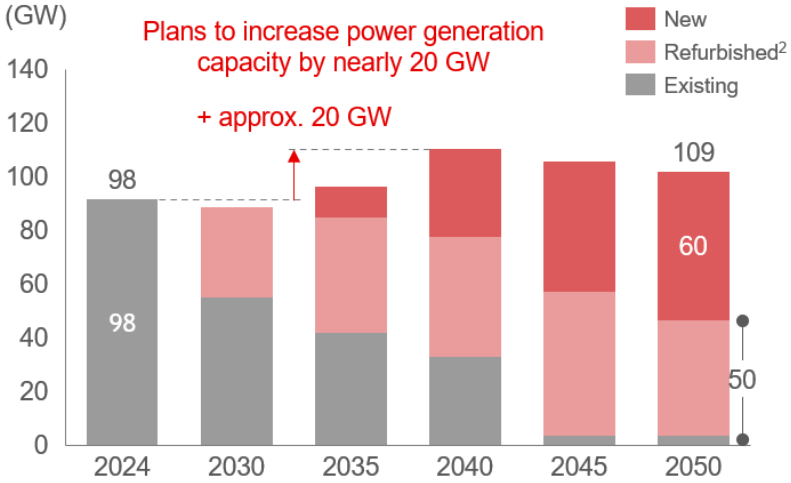
---

1. Data covering January to June 2025

Source: European Commission; Public information

Progress: Trends in Nuclear

Outlook for Large-Scale Nuclear Power Generation Capacity[1]



Reactor life extensions and new large-scale construction plans between 2025–2050 are expected to involve investments of €241 billion

Examples of Private Nuclear Power Procurement

1 Preparation of PPAs for Data Centers

- EQUINIX / ULC-Energy: In the Netherlands, a LOI[3] was signed to supply up to 0.25 GW of power to data centers (Aug 2025)
- EQUINIX / STELLARIA: 0.5 GW of power secured in advance for data center expansion within the EU(Aug 2025)

2 Establishment of 10–15-year baseload contract frameworks, now available to companies across the EU

- EDF: A total of 1.8 GW will be offered through a bidding process, with the first auction expected in 2025
  - Target customers are power consumers with annual demand exceeding 7 GWh, or retailers/generators capable of physical power delivery in France

Through PPAs and long-term baseload contracts, nuclear power supply is expanding to meet diverse private sector demand across the EU

Nuclear power in Europe is undergoing rapid reassessment and reinvestment as a clean energy source capable of offering both energy independence and stable supply. Following the outbreak of the Ukraine conflict, the EC formally reclassified nuclear as an element of the clean energy mix, integrating it into core CN strategy.

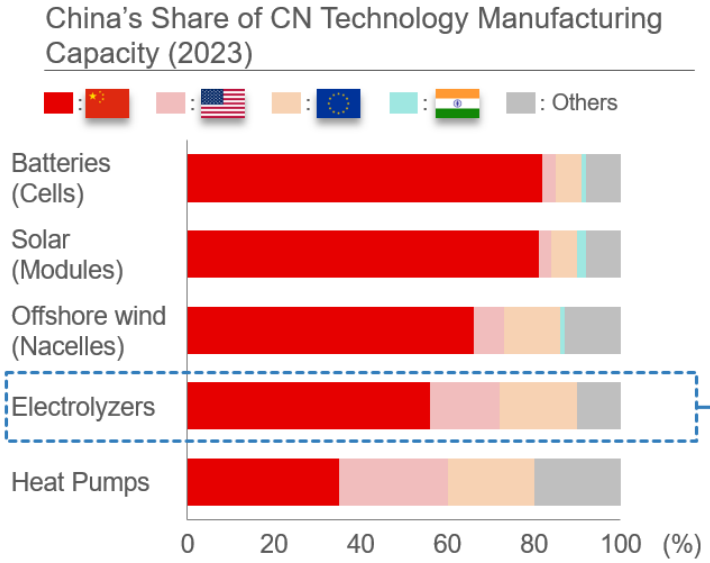
The Eighth Nuclear Illustrative Programme, published in June 2025, outlines an investment plan totaling approximately €241 billion between 2025 and 2050. The program aims to extend the operation of existing reactors and construct new large-scale units, increasing nuclear generation capacity by around 20GW between 2030 and 2040. From 2035 onward, the share of new reactors—including small modular reactors (SMRs)—is expected to grow progressively, supporting the stable maintenance of 100–120GW of generation capacity annually. Notably, as in the U.S., surging electricity demand from data centers is creating private sector demand. Major technology companies and AI developers are increasingly signing long-term nuclear PPAs, reflecting a shift toward nuclear energy as a reliable baseload source to power digital infrastructure.

Thus, the role of nuclear power in Europe is evolving to become a strategic enabler that supports industrial electrification, enhances industrial competitiveness, and advances energy security and CN objectives.

---

1. Based on the draft of the 8th Nuclear Illustrative Programme (PINC), dated June 2025;
2. For existing reactors requiring new life-extension investments after 2025, assuming such investments are implemented; 3. Letter of Intent
Source: Global Energy Review 2025; Equinix enters into multiple advanced nuclear deals to power data centers | Reuters; Public company data

Emerging Challenge: Europe's Technology Dependence on China



CN technology manufacturing capacity is concentrated in China, raising concerns over dependency risks under potential U.S. tariff policies

To protect regional industries, the EU is adding stricter procurement requirements

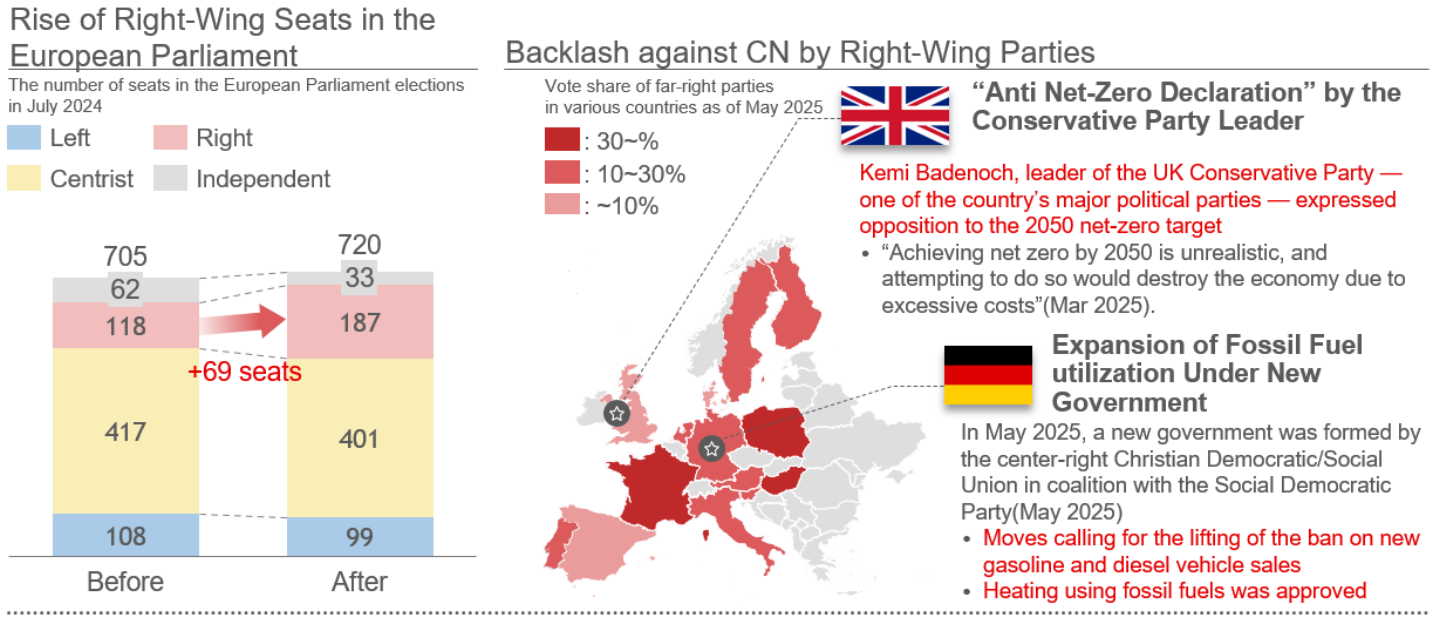
A key structural concern in Europe is its deepening dependence on China, which has established a dominant position in CN-related manufacturing. As of 2023, China accounted for 50–80% of the global market in sectors such as batteries, solar modules, offshore wind equipment, and electrolyzers, and about 30% in heat pumps. By contrast, Europe and the U.S. each account for around 20% each, lagging significantly in both production capacity and cost competitiveness. Consequently, while Europe has made policy-driven progress in various CN technologies, its heavy dependence on China for manufacturing capacity and component supply poses a challenge to the EU's stated goal of achieving strategic autonomy.

The tariff policies introduced under the second Trump administration have created additional short-term risks, particularly for European firms relying on Chinese-made components. Higher tariffs could raise procurement costs for products such as batteries, further eroding the competitiveness of European manufacturers. In response, the EC has begun implementing measures to increase domestic manufacturing ratios and revise procurement regulations. An example of the challenge has emerged in the European Hydrogen Bank's funding scheme. In its first funding round, it was revealed that approximately 60% of the selected project developers assembled their core electrolyzer stacks in China. Learning from this experience, the second and subsequent rounds of funding now include explicit requirements for a minimum share of EU-based manufacturing.

---

1. Start date of public offering
Source: IEA Advancing Clean technology Manufacturing; European Hydrogen Bank; Nikkei Inc.

Emerging Challenge: Rise of Right-Wing Forces in Europe



In the European Parliament and member states, CN-skepticism is gaining ground, leading to looser fossil fuel regulation and delays or revisions to net-zero targets

Another emerging challenge for Europe is the rise of CN-skeptical right-wing parties. In the European Parliament elections of July 2024, left-leaning and centrist parties lost seats, while right-wing factions gained 69 seats. The shift reflects growing public frustration over inflation, rising energy prices, and concerns about industrial competitiveness, all of which have fueled a backlash against climate policies across member states. Capitalizing on this sentiment, right-wing parties have expanded their support base by advocating for regulatory relaxation, greater use of fossil resources, and domestic industry prioritization.

Even in EU member states where governments had previously championed CN technologies, the rise of right-wing forces is creating growing headwinds. As of May 2025, far-right parties have secured more than 10% of the vote in recent elections in many countries.

Country-level developments underscore this trend. In the United Kingdom, for instance, the Conservative Party leader has suggested revisiting the 2040 net-zero target and has expressed openness to continued fossil fuel use. Similarly, in Germany, the new administration has reversed a planned ban on sales of new gasoline and diesel vehicles and signaled an expanded role for fossil fuels, prompting concerns that the country's CN policy momentum may be weakening.

Source: European Parliament Website; Statista; Public Information

Emerging Challenge: Weakening of Demand-Side Industries (German Companies 1/2)

Competitiveness Compass / Clean Industrial Deal

	2024		2025	
Materials	BASF	Closure of a chemical production line in Germany (Aug 2024)	Conti-nental	Closure or sale of five industrial material plants in Germany (Jan 2025)
	EVONIK	Plans to cut more than 1/5 of workforce and sell several sites (Dec 2024)	Bayer	Plans to relocate or sell Frankfurt-based operations by the end of 2028(May 2025)
Automotive	Volks Wagen	Closure of at least three plants in Germany (Oct 2024)	Porsche	Reduction of approximately 3,900 jobs by the end of 2029 (Mar 2025)
	ZF	Plans to cut up to 14,000 jobs in Germany, mainly in EV-related operations (Jul 2024)	Audi	Closure of Belgium plant by the end of 2025 (Feb 2025)
	BOSCH	Plans to reduce approximately 10,000 workers in Germany (Dec 2024)	Daimler Truck	Plans to reduce approximately 5,000 workers in Germany (Jul 2025)

Among demand-side industries in Europe, which the government aims to protect and strengthen, German companies are planning domestic plant closures and restructurings

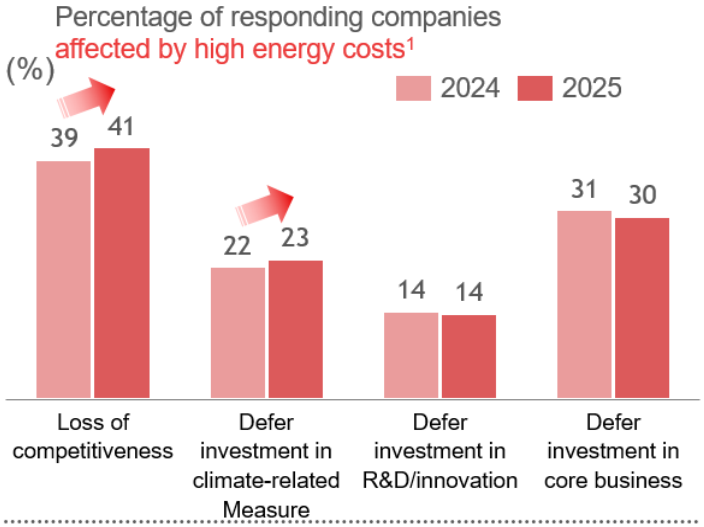
Europe is also grappling with demand-side strains. Germany, while pushing ahead on the supply side—expanding renewables, reinforcing transmission networks, and deploying CN-related technologies—has seen mounting pressure on industry. Challenges have intensified, including persistently high energy costs, eroding international competitiveness, and barriers to passing higher costs through to customers.

Although the government has emphasized protecting and strengthening key sectors such as materials and automotive, since 2024 major companies have announced a series of domestic plant closures and restructurings, a trend that has continued into 2025. Behind this are elevated energy prices, competition from lower-priced Chinese products, and the difficulty of passing decarbonization costs on to end products.

Source: Public company data

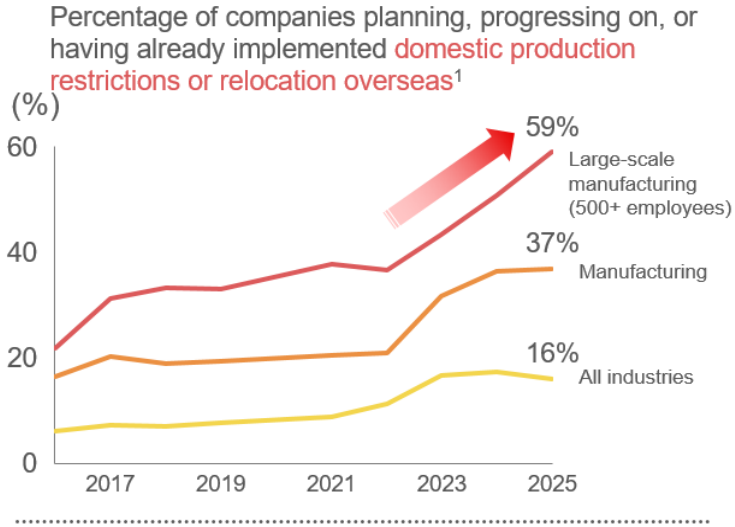
Emerging Challenge: Weakening of Demand-Side Industries (German Companies 2/2)

Impact of High Energy Costs



Due to persistently high energy costs, companies are expected to see the same level of competitiveness loss and investment delay in 2025 as in 2024

Trends in Domestic Production Constraints and Overseas Relocation by German Companies



Nearly 60% of large-scale manufacturers are planning to, or have already begun to, restrict domestic production or relocate overseas; a trend expected to continue

According to a 2025 survey conducted by the Association of German Chambers of Industry and Commerce (DIHK), the proportion of German businesses reporting that rising energy costs negatively affect their competitiveness has remained elevated at the same high level as in 2024. Within this group, the share of respondents citing “loss of competitiveness” and “postponement of climate-related investment” as specific consequences has increased compared with 2024, underscoring a deepening strain on industrial performance.

The same survey also revealed that nearly 60% of large manufacturing companies—those with over 500 employees—reported that they are planning, in the process of, or have already implemented measures to reduce domestic production or relocate operations abroad, raising serious concerns about the risk of industrial hollowing-out.

This trend has been gradually progressing since 2016, but it has accelerated sharply since 2022, triggered by the energy crisis and rising interest rates. These pressures are not limited to the materials and automotive industries; similar signs of weakening demand-side activity are now emerging across a broader range of industrial sectors.

---

1. Based on responses to a corporate survey conducted by the Association of German Chambers of Industry and Commerce (DIHK). The number of respondent companies in 2025 was 3,600. Results for 2020 in the graph on the right are not disclosed; Source: Energiewende-Barometer

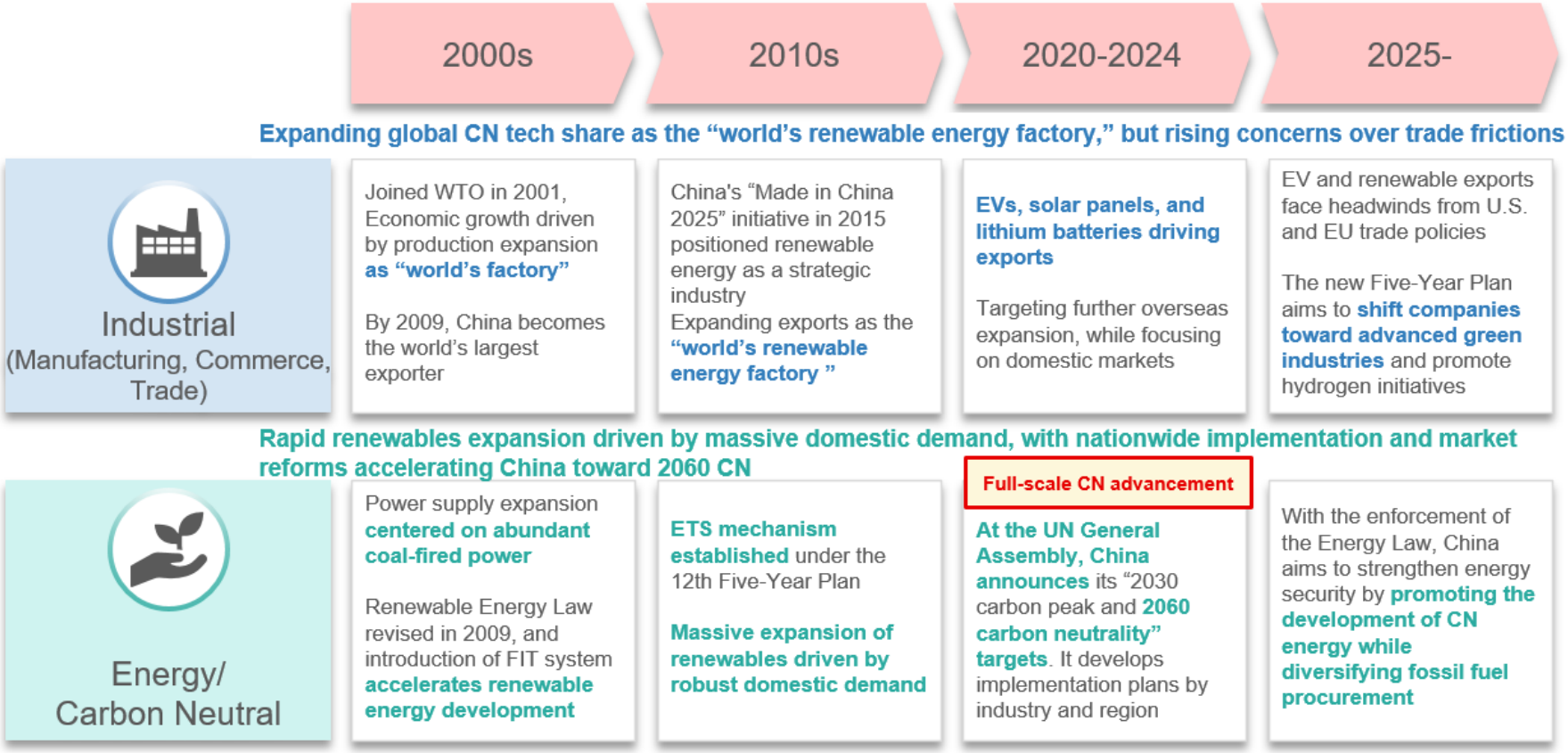
Summary

1. At the European Commission level, to achieve energy autonomy and promote the industrialization of CN technologies, the focus is on expanding renewable energy deployment and shaping markets through regulatory measures. While currently paying attention to industrial competitiveness, the Commission continues to maintain its support policies for CN technologies.

2. Through the "Competitiveness Compass" and "Clean Industrial Deal", the EU has continued providing broad support for CN technologies. Progress has been seen not only in renewables and EVs, but also in offshore wind and hydrogen, as well as in the adoption of LNG and nuclear power.

3. Meanwhile, at the member state level, rising energy prices and price competition with Chinese products are undermining industrial competitiveness, making the transition likely to proceed amid significant challenges.

Trends in Industrial and CN Policies in China



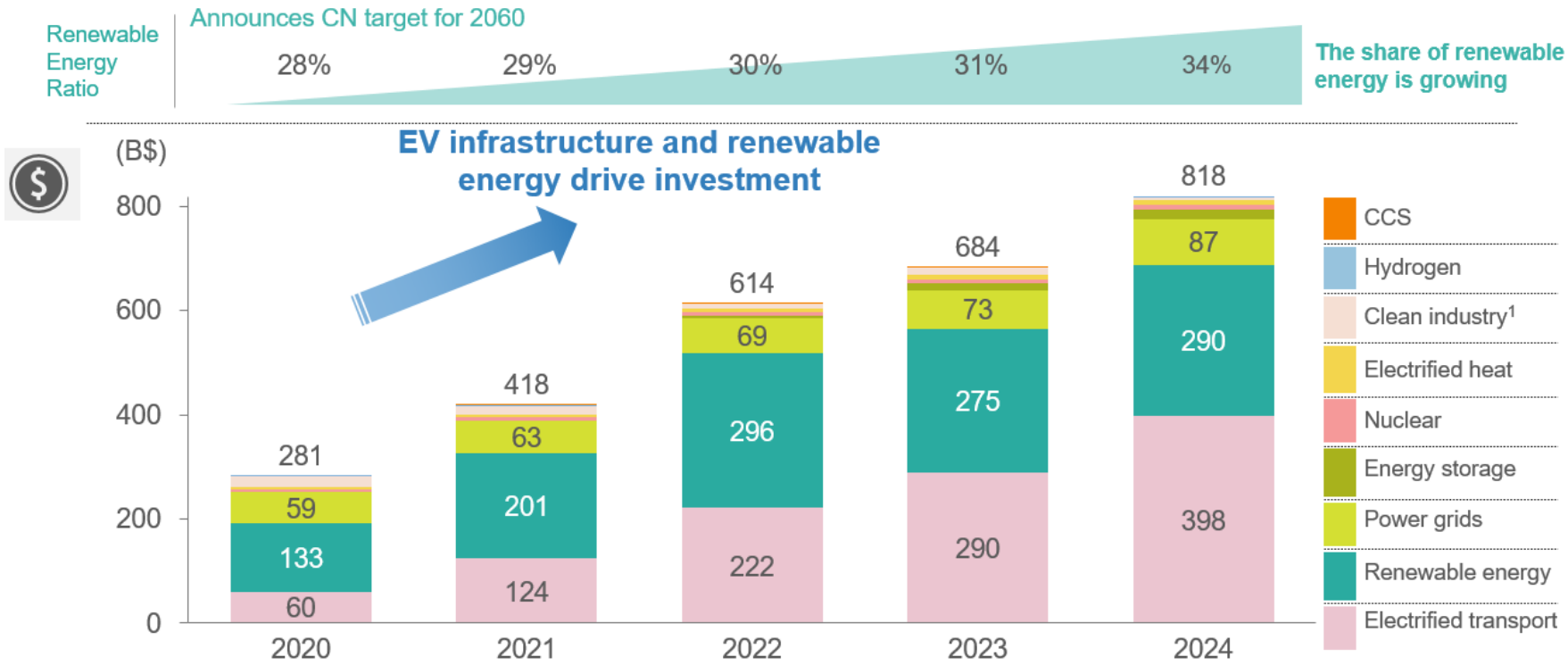
Trends in Industrial and CN Policies in China

Over the past 25 years, China's industrial, energy, and CN policies have consistently positioned low-carbon development not only as an environmental measure but as a core driver of industrial competitiveness. In the early 2000s, amid rapid economic growth, China saw a sharp increase in electricity and energy demand, resulting in heavy dependence on coal-fired power generation. As issues such as air pollution, reliance on imported fossil fuels, and constraints on power supply became more apparent, China in 2005 enacted the Renewable Energy Law, marking the country's first comprehensive legislation to promote renewable energy. The law set forth measures to encourage the development and utilization of renewables, mandate grid connection and purchase of renewables, and prioritize technological advancement in renewable industries. Critically, it established the institutional foundation for China's renewable energy expansion, positioning renewables as a strategic sector essential for energy system transformation, supply stability, and industrial development.

In 2009, a revision to the Renewable Energy Law integrated renewables into national planning frameworks and introduced a feed-in tariff (FIT) levy system to accelerate deployment. As a result, by the early 2010s, China saw significant growth in domestic production of solar and wind equipment, the expansion of global market share, and the emergence of low-carbon technology manufacturing as a major export industry. In 2015, the government launched "Made in China 2025", designating solar cells, wind turbines, batteries, and electrolyzers as strategic sectors. Through subsidies, tax incentives, and R&D support, the policy placed low-carbon technologies at the core of China's industrial strategy. Supported by these initiatives, China established itself as the "world's renewable energy factory," achieving dominant production capacity, expanding domestic renewable deployment, and accelerating exports and overseas investment.

In 2020, China informed the United Nations General Assembly of its goal to achieve carbon neutrality by 2060, signaling a shift toward a cross-sector, nationwide CN agenda. While trade frictions with the U.S. and European economies persist, China continues to expand its capabilities in emerging domains such as electrolyzers for hydrogen production, synthetic fuels, and nuclear power. These developments are expected to further consolidate China's position as a global manufacturing powerhouse in the era of industrial decarbonization.

Investment Trends by Clean Technology Type in China



In China, investment in clean technologies has increased steadily (about 10% year-on-year growth) since 2020, reaching a world-beating $818 billion in 2024. The share of renewables in the energy mix has also continued to rise, from 28% in 2020 to 34% in 2024. This shows that investment is expanding in step with national policies.

Technology, transport electrification (such as EV), renewables, and transmission and distribution together account for over 90% of total investment, with growth and expansion ongoing. As of 2024, EV-related investment represented just under half of total investment, while renewables accounted for 35% and transmission and distribution for 11%. Investment in energy storage is also increasing from a low base.

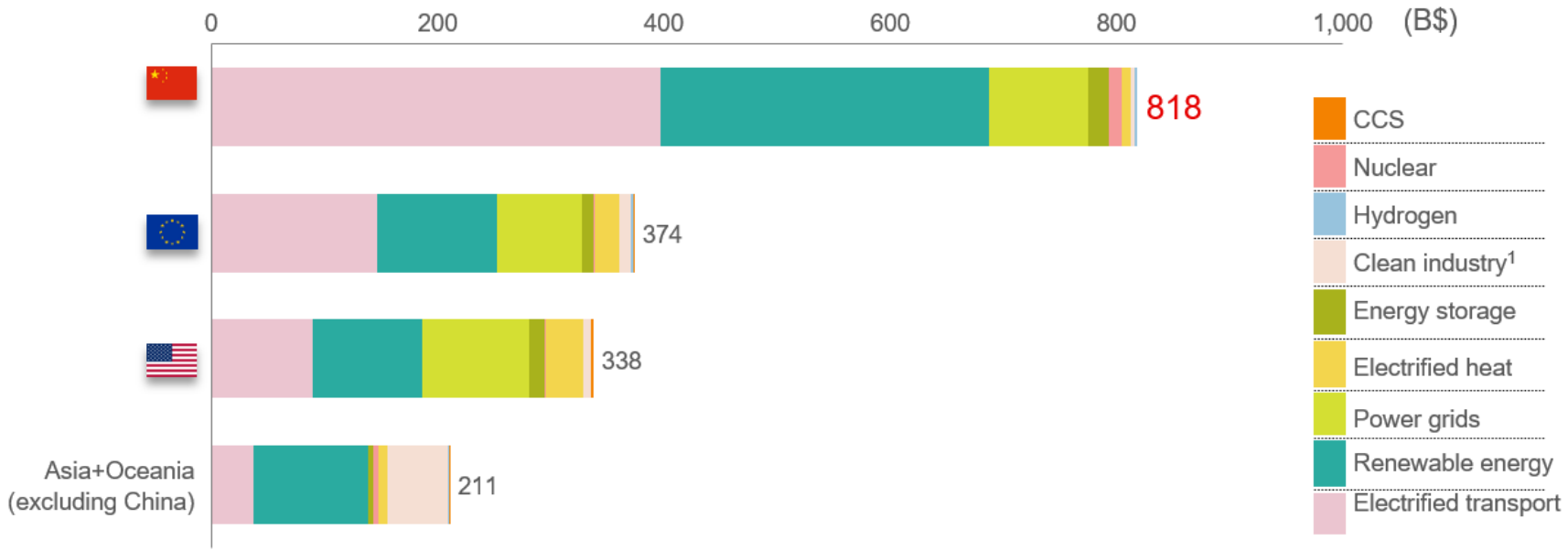
Although its share of the total remains relatively small, investment in energy storage is also increasing, reflecting active capital spending to enable the effective utilization of variable renewable power such as solar and wind.

---

1. Projects related to clean steel, clean ammonia, circular economy, and bioplastics aimed at achieving net zero in the industrial sector through CN technologies

Source: BloombergNEF. Note: Start years differ by sector, but all sectors are present from 2020 onwards. Most notably, power grids start in 2020. CCS refers to carbon capture and storage. Ember Website; IEA Website

International Comparison of Clean Technology Investment Scale in Major Regions (2024)



China is **first** among major regions for **total investment**, and is a leader in CN technologies

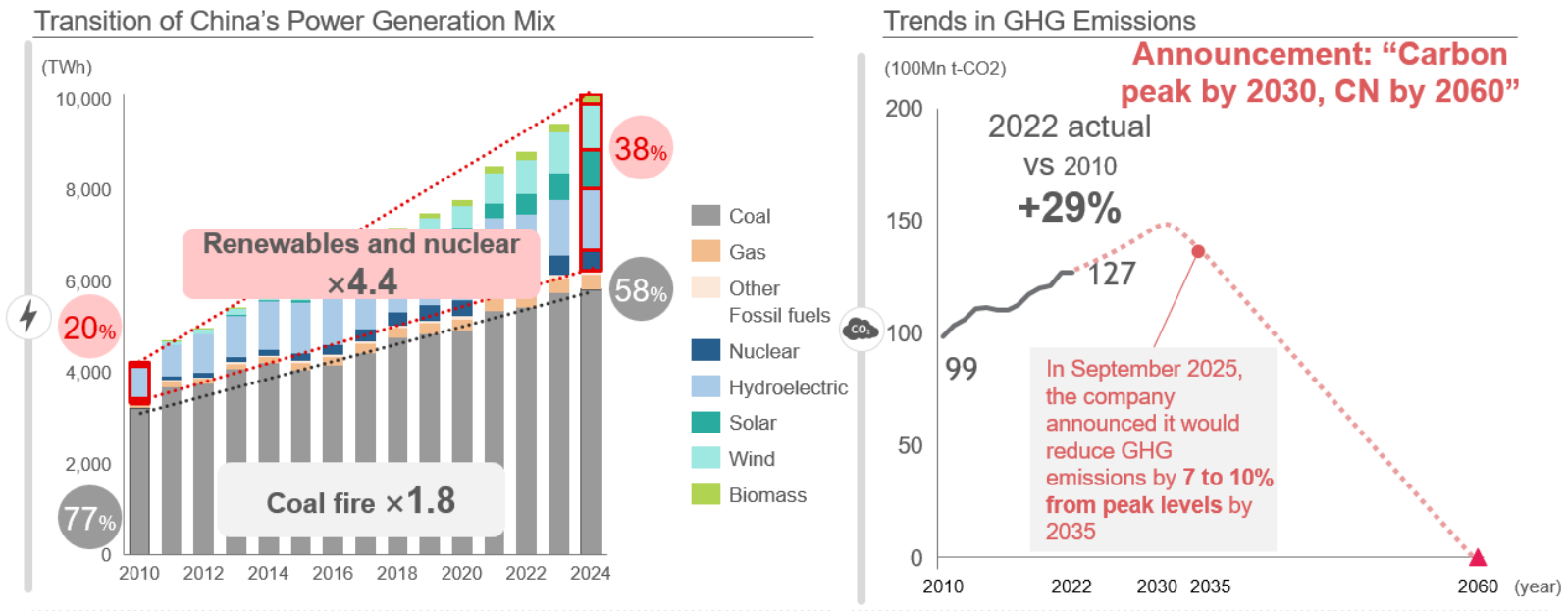
China's investment scale in clean-related technologies is sweeping the world. By 2024, its investment scale (818 billion USD) was equivalent to 2.2 times that of Europe and 2.4 times that of the U.S., accounting for approximately one-third of the world's total clean investment on its own. This overwhelming investment scale demonstrates that China possesses unmatched competitiveness in the mass production and supply of clean technologies.

In other words, China has established its position as a major CN technology powerhouse based on its comprehensive capabilities: manufacturing clean-related equipment and products domestically, stably sourcing the necessary materials and resources within the country, and creating massive domestic demand to drive industrial growth in a virtuous cycle.

---

1. Projects related to clean steel, clean ammonia, circular economy, and bioplastics aimed at achieving net zero in the industrial sector through CN technologies
Source: Bloomberg NEF

Trends in China's Power Generation Mix and GHG Emissions



Expansion of renewables and nuclear power continues, but coal-fired power generation is also increasing

China has announced the 2060 CN target, emissions are still rising moderately

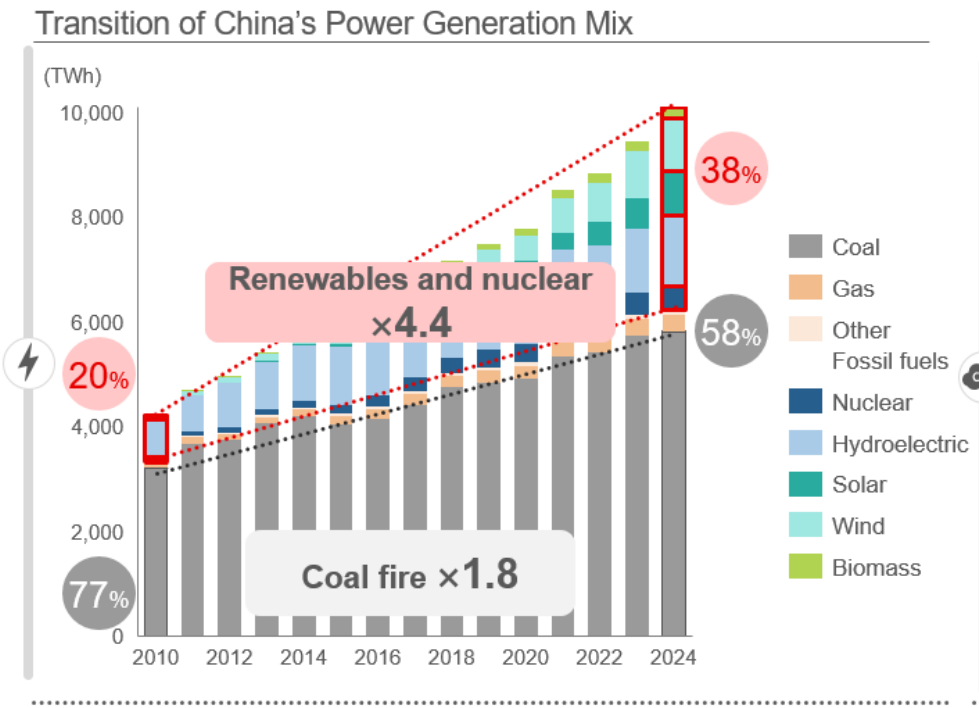
Over the past decade, the share of renewable energy and nuclear power generation in China has steadily increased while dependence on coal has declined. Specifically, renewable energy and nuclear power rose from 20% of the total in 2010 to 38% in 2024, while reliance on coal-fired generation fell from 77% to 58% over the same period. That said, total power generation rose 2.4 times between 2010 and 2024, meaning the absolute volume of coal-fired generation increased 1.8 times.

Underlying these trends are China's industrialization and electrification, which have meant that electricity demand has risen faster than improvements in energy efficiency. As a result, GHG emissions continue to grow, and were 29% above 2010 levels in 2022. In addition, the Chinese government announced in September 2025 that it would reduce GHG emissions by 7-10% from the peak level by 2035. While the Chinese government has set a target of reaching a carbon peak by 2030 and carbon neutrality by 2060, the pace of power demand growth and coal's ongoing role suggest that further action will be required. This will include expansion of renewables and nuclear power, alongside strengthened implementation of mechanisms such as the national emissions trading system (ETS) and tax incentive frameworks. Together, these will be critical for achieving meaningful GHG reductions beyond 2030.

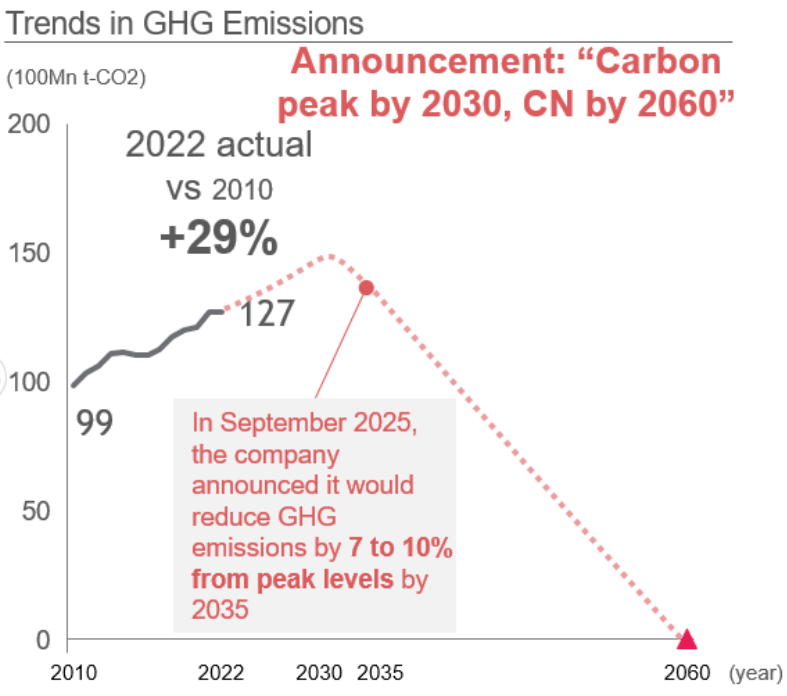
---

1. Sum of solar, wind, and biomass generation. Increase in generation (TWh) calculated
Source: Ember Website; Climate Watch Website; IEA Website; Nikkei

CN-related Progress in China Over the Past Year



Expansion of renewables and nuclear power continues, but coal-fired power generation is also increasing



China has announced the 2060 CN target, emissions are still rising moderately

---

1. CN-related vehicle targets include BEVs, PHEVs, FCVs; 2. Decision on Basic Policies at the Fourth Plenary Session of the 20th Central Committee of the Communist Party of China in October 2025; Source: Public Information

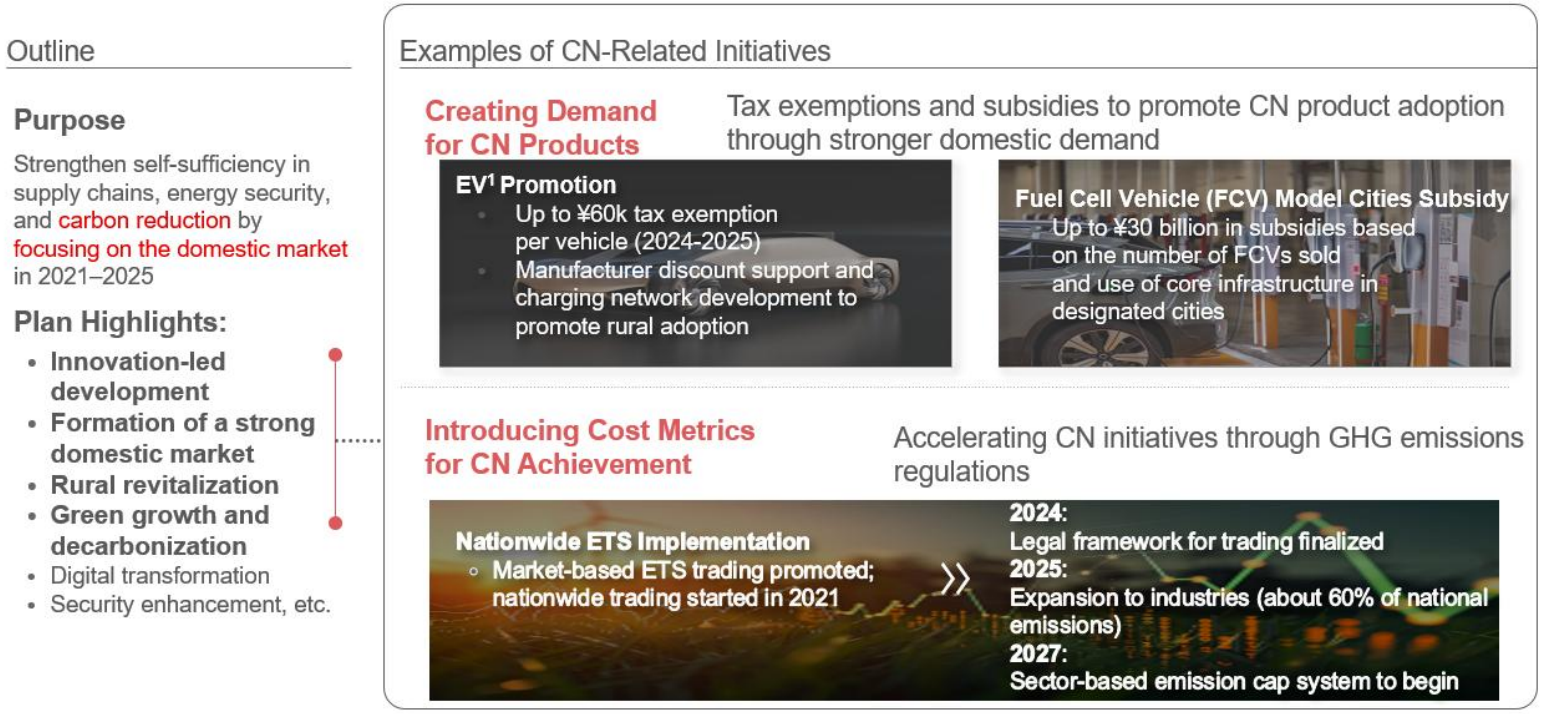
CN-related Progress in China Over the Past Year

Over the past year, China's progress has been shaped by both domestic policy initiatives and international developments. Domestically, the government has promoted the growth of CN-related industries under the framework of the 14th Five-Year Plan (2021–2025). Key measures include stimulating demand for CN products through subsidies and tax exemptions and expanding the ETS to cover high-emissions sectors such as steel, cement, and aluminum.

In January 2025, China enacted its first comprehensive Energy Law, consolidating its existing energy legislation into a single legal framework. A key feature of the law is that it puts CN on par with national security as a central policy objective. It also creates a legal mandate for the indicators and targets required to accelerate CN. The law requires that renewable energy be prioritized, that the state guarantee grid access for renewable electricity, and that diverse non-fossil energy sources such as wind, solar, biomass, and geothermal be comprehensively promoted. It also defines hydrogen as an energy source to be actively developed, recognizes fossil fuels as complementary to decarbonization (emphasizing cleaner and more efficient use), and calls for the expansion of market mechanisms essential to achieving CN. Together, these signal China's intention to advance CN as a national strategic priority.

In October 2025, the government finalized the policy direction of the 15th Five-Year Plan (2026–2030), which emphasizes the development of green advanced industries and the implementation of supply chain resilience strategies. Meanwhile, internationally, Chinese exports has been significantly impacted by the additional tariffs imposed under the U.S. Trump administration, which have undermined product price competitiveness. At the same time, Europe has imposed tariffs on Chinese goods and tightening local procurement requirements, making their protectionism a major concern for China's trade and industrial outlook.

Outline of China's 14th Five-Year Plan



The 14th Five-Year Plan (2021–2025) emphasizes domestic market-driven growth, including enhancing supply chain self-sufficiency, reinforcing energy security, and advancing decarbonization. Within this broad framework, CN is positioned as a growth driver, with policies designed to strategically support key industries such as renewable energy, electrification, and hydrogen. In parallel, China has supported domestic demand through consumer, manufacturer, and local government tax exemptions and subsidies, aiming to accelerate adoption of products such as EV and fuel cell electric vehicles (FCEV).

On the institutional side, China in 2021 piloted its national ETS, starting with the power generation sector. Since 2025, its coverage has expanded to include high-emission industries such as steel, cement, and aluminium. As a result, the system now encompasses approximately 60% of national emissions, helping guide corporate investment toward low-carbon technologies.

Note: 1CNY=20JPY
1. CN-related vehicle targets include BEVs, PHEVs, FCVs
Source: China Executive Briefing Website; UNDP.pdf; public information

Outline of China's 15th Five-Year Plan:7 Fundamental Policy Directions

1 **Achieve remarkable results in high-quality development**	• Strengthen the foundation of the real economy through building a modern industrial system (Prioritizing economic development, to accelerate their development of China into a manufacturing powerhouse by adhering to intelligent and green initiatives) • Expand high-level opening-up and create new frameworks for international cooperation and win-win relations
2 **Significantly enhance self-reliance and self-strengthening in science and technology**	• Accelerate self-reliance in high-level science and technology and drive the development of "new productive forces"
3 **Open new breakthroughs in deepening comprehensive reform**	• Accelerate the creation of a robust domestic market and a new development pattern • Speed up the establishment of a high-level socialist market economy system to reinforce growth momentum
4 **Enhance social civilization to a higher level**	• Stimulate innovation through national cultural creativity and promote the prosperity and development of socialist culture
5 **Continuously improve the quality of people's lives**	• Accelerate the modernization of agriculture and rural areas, and steadily advance rural revitalization • Optimizing the regional economic structure and promoting development through interregional coordination • Strengthening the safeguarding and improvement of people's livelihoods and steadily advancing the "common prosperity" of all people
6 **Achieve new progress in building a Beautiful China**	• Accelerate the comprehensive greening of economic and social development, and build a "Beautiful China"
7 **Further strengthen national security protection**	• Promote modernization of the national security system and capabilities, and build a high-standard "Safe China" • High-Quality Advancement of National Defense and Military Modernization

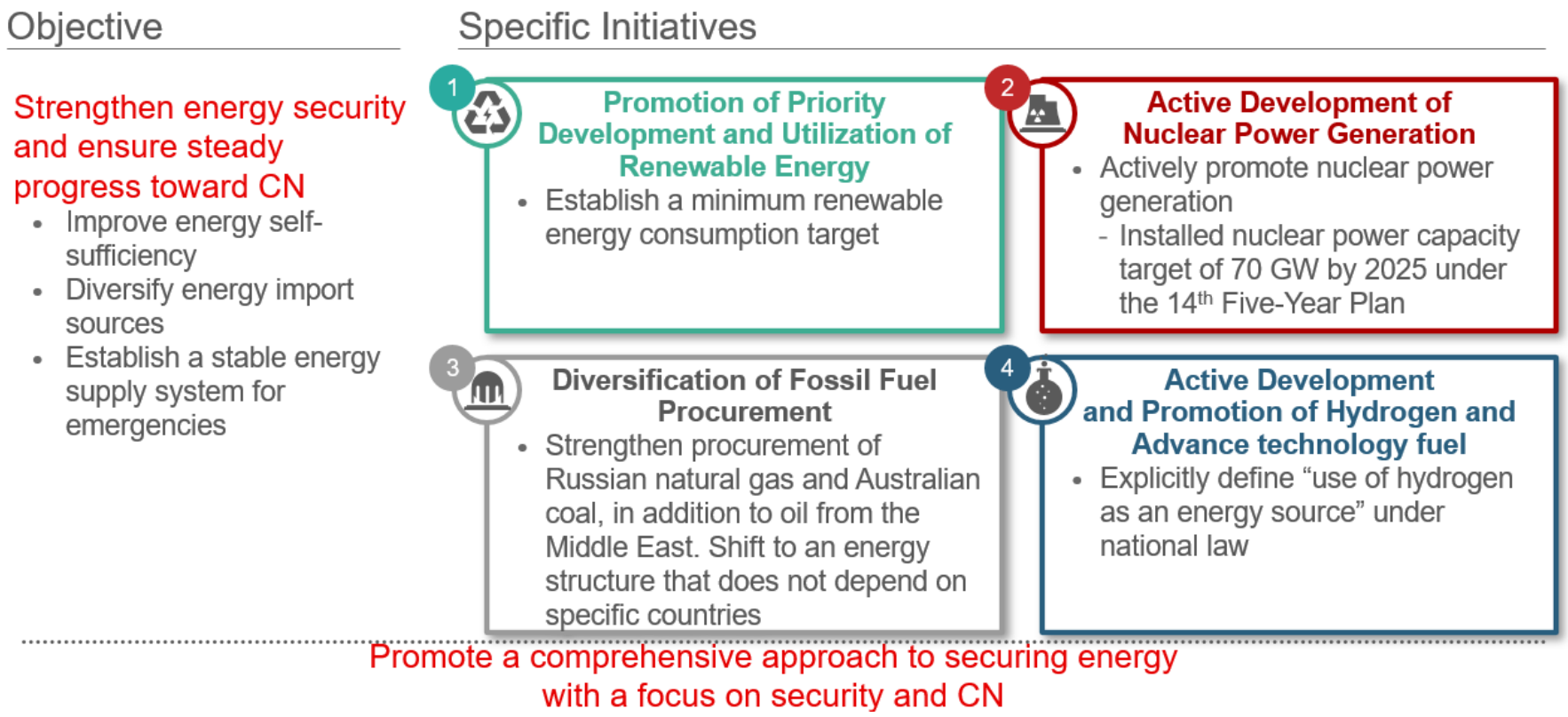
Aims to maintain its status as the "world's factory" through domestic development of CN technologies and diversification of export destinations

The 15th Five-Year Plan (2026–2030) is set to emphasize development themes such as "high-quality growth" and "technological self-reliance." While the detailed plan is scheduled to be published and approved at the National People's Congress in March 2026, the theme for decarbonization will likely be a transition from "quantitative expansion"—focused on scaling up renewables and EVs—to "qualitative enhancement," through a deepening of institutional and market mechanisms relating to carbon reduction.

Building on the trajectory of the 14th Five-Year Plan, the new plan is expected to include extensive support for CN, including strategies for strengthening renewable energy, advancing hydrogen development, and achieving the 2030 emissions peak target.

Note: The recommendations in each field presented in the communiqué released at the Fourth Plenary Session of the 20th Central Committee of the Communist Party of China in October 2025 are organized and linked to the seven fundamental policy areas considered to be most relevant to the development goals
Source: JETRO HP

China's Energy Law (January 2025): Objectives and Initiatives

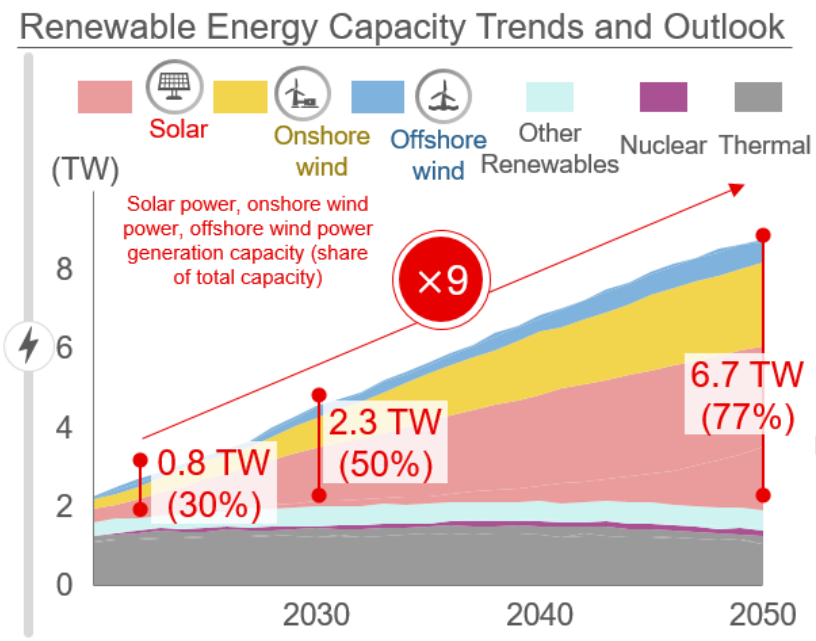


January 2025's Energy Law positions CN as a policy objective of equal importance to national security. It also provides a legal foundation for the goals and measures designed to accelerate progress toward CN.

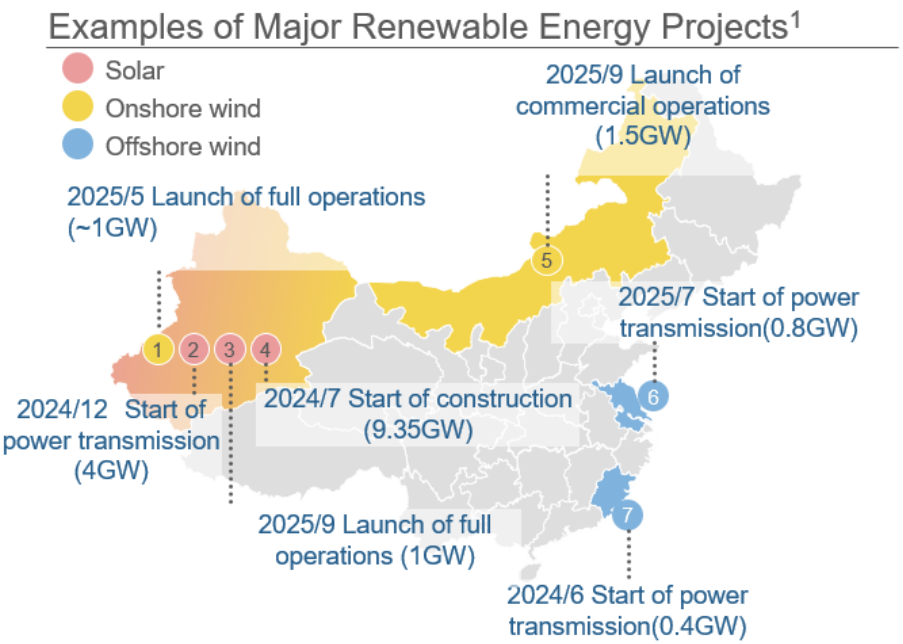
The law provides for prioritized development and utilization of renewable energy, mandatory guarantee of grid access for renewable electricity, comprehensive expansion of diverse non-fossil energy sources, active development and promotion of hydrogen, diversification, cleaning, and efficiency improvement in fossil fuel use, and the enhancement of market mechanisms essential for achieving CN. Under these principles, proactive policy support is expected to be implemented to drive China's transition toward a low-carbon energy system.

Source: EnviX; GCFEN

Progress: Trends in Renewable Energy



Renewable energy is expected to grow, driven by solar and onshore wind



Construction and operation of large-scale projects have continued over the past year

China has positioned the expansion of renewable energy deployment as a core national strategy for achieving the 2060 CN goal. The country's renewable power generation capacity is projected to rise nearly nine times—from approximately 0.8TW in 2020 to around 6.7TW by 2050.

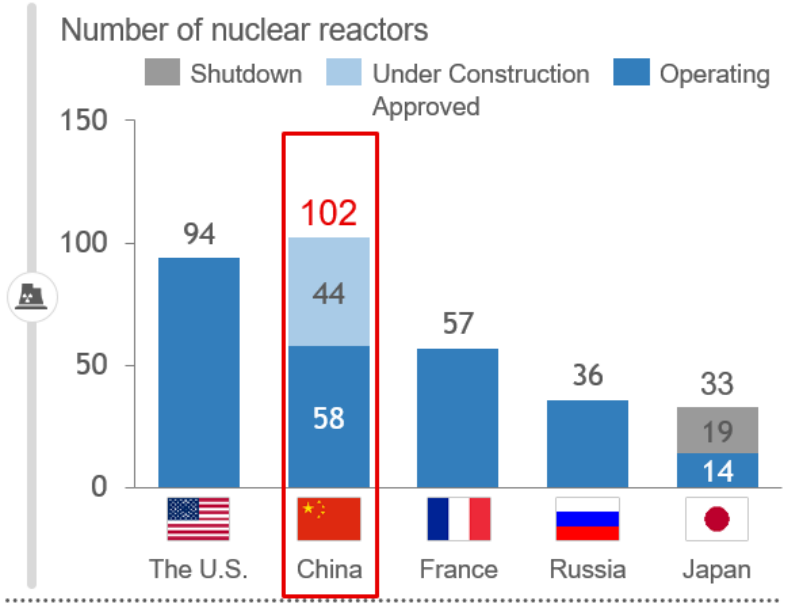
The National Energy Administration publishes renewable energy project announcements on a monthly basis, highlighting steady progress on large-scale developments. In particular, massive solar and onshore wind projects are being built in inland regions. For example, in the Xinjiang Uyghur Autonomous Region, construction of a 9.35GW solar power project began in 2025, while in the Inner Mongolia Autonomous Region, an onshore wind project with a 1.5 GW capacity has commenced commercial operations.

---

1. Aggregated representative cases from among the National Energy Administration of China has been publishing new renewable energy projects monthly since 2024 and plotted them for each province. Projects without corporate logos involve multiple operators or the operator is undisclosed. The examples shown are major projects exceeding 1,000 MW for solar, 400 MW for offshore wind, and 1,000 MW for onshore wind; Source: DNV; Public Information

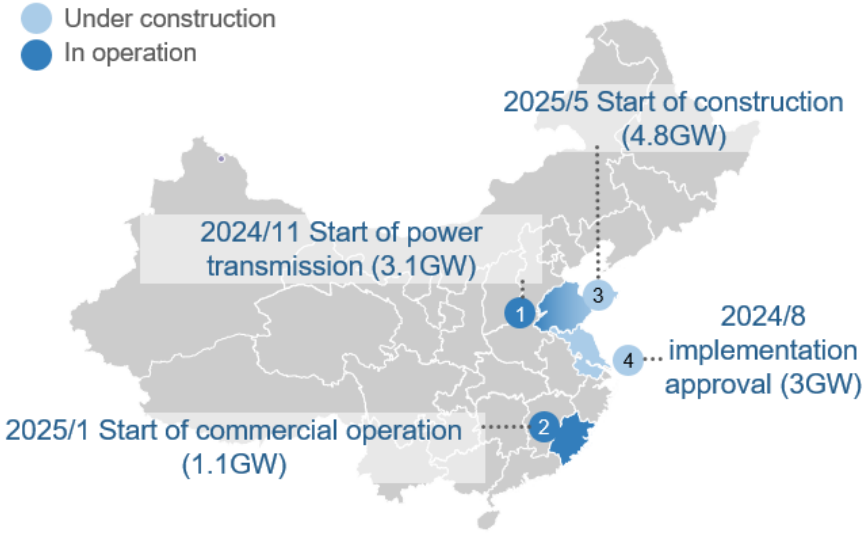
Progress: Trends in Nuclear

Nuclear Power Generation Capacity in Major Countries (as of Jan 2025)



China is No.2 globally for nuclear power but is accelerating construction and approvals to become No.1

Examples of Major Nuclear Power Projects in China[1]



In the past year, construction and operations have continued, mainly in coastal areas

In China, nuclear power is seen as a key technology that supports both energy security and low-carbon electricity generation. Under the 14th Five-Year Plan, China set a target to reach a total installed nuclear capacity of 70GW by 2025. The Energy Law explicitly states the government's commitment to the active development of nuclear power.

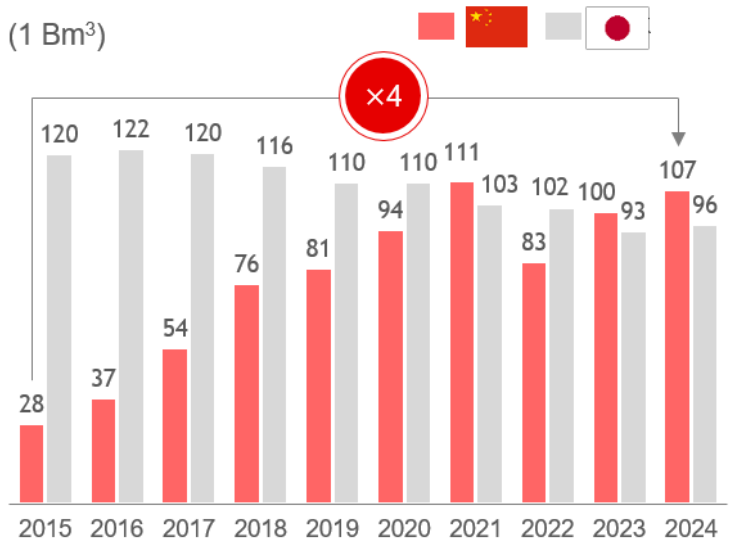
As of January 2025, China operated 58 nuclear reactors, making it the second-largest market for nuclear plants in the world after the U.S. An additional 44 reactors have been approved or are under construction, positioning China to become the largest nuclear power producer globally. Over the past year, several large-scale nuclear projects—mainly concentrated in coastal provinces—have seen construction start or grid connection commence, indicating that nuclear power development is set to accelerate further.

---

1. Representative projects listed in the China National Nuclear Safety Administration's regulated-project database (those that have made progress since 2024) were aggregated based on public information and plotted for each province. Examples of large-scale projects with planned generation capacity of 1,000,000 kW or more
Source: The Yomiuri Shimbun Website; National Nuclear Safety Administration Website; Public Data

Progress: Trends in LNG

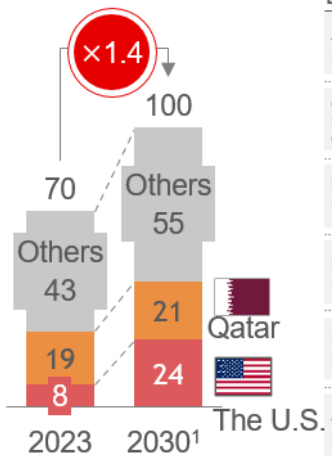
Comparison of LNG Net Import Volumes (Actual Results)



Over the past ten years, China's LNG net imports have increased about fourfold, surpassing those of Japan to make China the world's largest LNG importer

China's LNG Long-Term Contract Volumes and Projects

LNG Long-Term Contract Volumes



Contracts Announced as of 2025

Buyer	Seller	Duration	Volume (Mt/year)
ZheJiang Energy	BP	10 year	100
China Resources Gas	Woodside Energy	15 year (2027~)	60
ENN Natural Gas	ADNOC	15 year (2028~)	100
Pearl River Investment	Conoco Phillips	15 year (2028~)	30
Guangzhou Gas	Mercuria	5 year (2026~)	40
ZhenHua Oil	ADNOC	5 year (2026~)	NA

Strengthening long-term contracts in anticipation of rising LNG demand

Natural gas demand has risen steadily since the 2000s, driven by growing concerns over air pollution and the need for energy transition. Under the 13th Five-Year Plan (2016–2020), the government introduced the policy of "fuel switching from coal to natural gas and renewables," accelerating the shift toward cleaner energy sources. As a result, domestic supply could not keep pace with demand, leading to a sharp increase in LNG imports—which expanded 4 times between 2015 and 2024. In 2021, China's net LNG imports grew 18% year-on-year, surpassing Japan's to make China the world's largest LNG importer.

Anticipating continued growth in demand, China has turned to long-term supply contracts. Between 2023 and 2030, the total volume under long-term agreements is expected to increase 1.4 times, with particularly strong growth in procurement from the U.S. Activity in 2025 has remained robust, including the signing of a 15-year contract for 100 million tons per year.

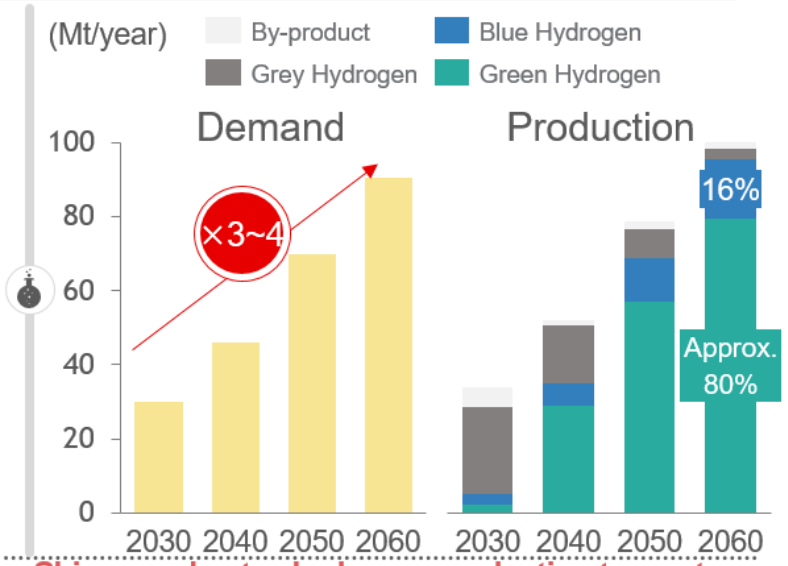
---

1. Estimate based on the cumulative total of contracts concluded as of June 2023

Source: Enerdata Website; JOGMEC Website; S&P Global HP; Woodside Press Release; Reuters (1/2); Reuters (2/2); Mercuria HP

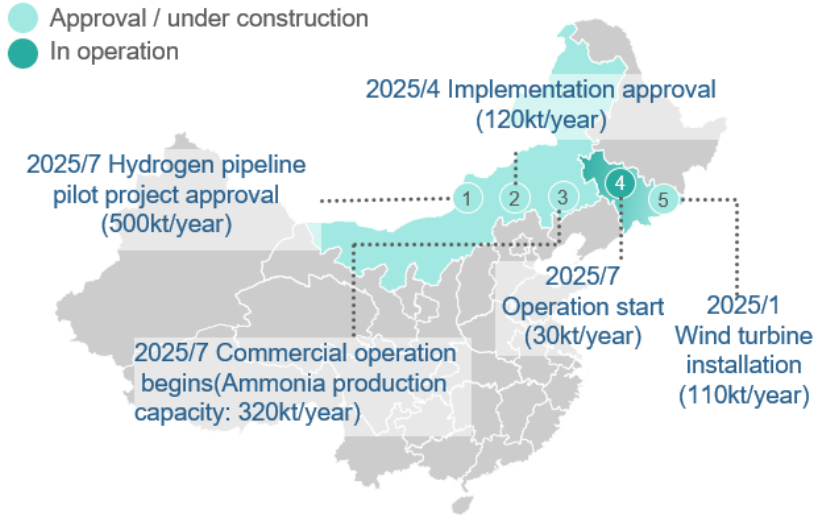
Progress: Trends in Hydrogen Production

Outlook for Hydrogen Production Volumes (IEA forecast)



China accelerates hydrogen production to meet growing demand; green hydrogen expected to account for about 80% of production by 2060

Examples of Large-Scale Green Hydrogen Projects in China[1]



Certification and construction for green hydrogen production are progressing

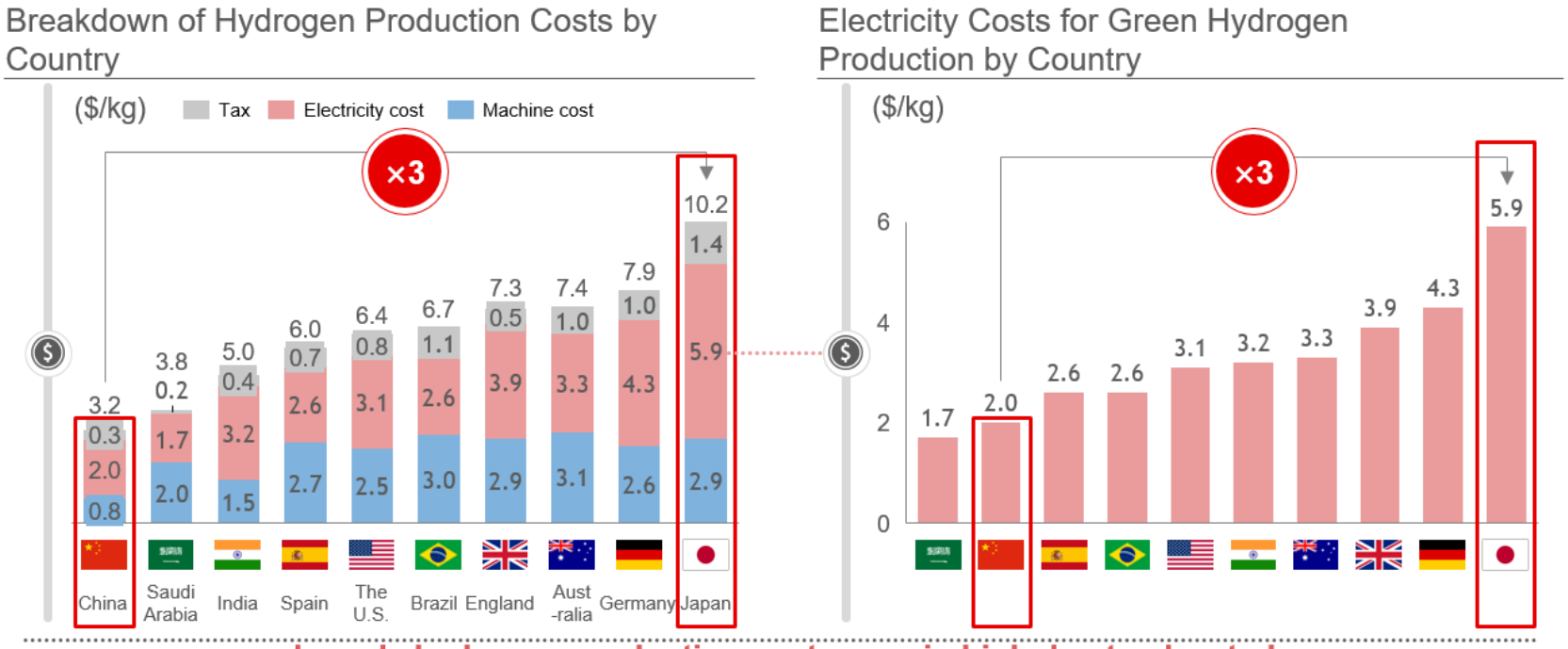
Since the early 2000s, China has conducted R&D in hydrogen technologies for fuel and FCEV. In 2019, the National Energy Administration published a Hydrogen Roadmap, positioning hydrogen as a key part of the national energy structure and promising to expand renewables-based production over the medium to long term. Hydrogen was formally incorporated into China's energy policy under the 14th Five-Year Plan (2021–2025), while the 2025 Energy Law defined hydrogen as an energy source to be actively developed and utilized.

These incremental efforts toward hydrogen development are expected to continue. According to outlook set by the IEA, hydrogen demand in China is expected to triple between 2030 and 2060, with hydrogen production expanding to nearly 100 million tons per year by 2060. The focus will be on green hydrogen, which is expected to account for about 80% of production in 2060. Already, tangible progress is being made. A 30,000-ton-per-year project began operations in Jilin Province in July 2025, while in the Inner Mongolia Autonomous Region, several large-scale projects exceeding 120,000 tons per year have obtained approval for construction and testing.

---

1. Aggregation of representative projects from GlobalData or First Batch of Demonstration Projects for Green and Low-Carbon Advanced Technologies (with progress since 2024 as of October 2025), together with state-certified projects; plotted by province. Large projects defined as planned H_2 production capacity ≥30,000 kW Note. as of October 2025
Source: IEA; Public information

International Comparison of Green Hydrogen Costs (2025)



Japan's hydrogen production costs remain high due to elevated renewable energy costs. China's costs are about one-third of Japan's and among the lowest in the world

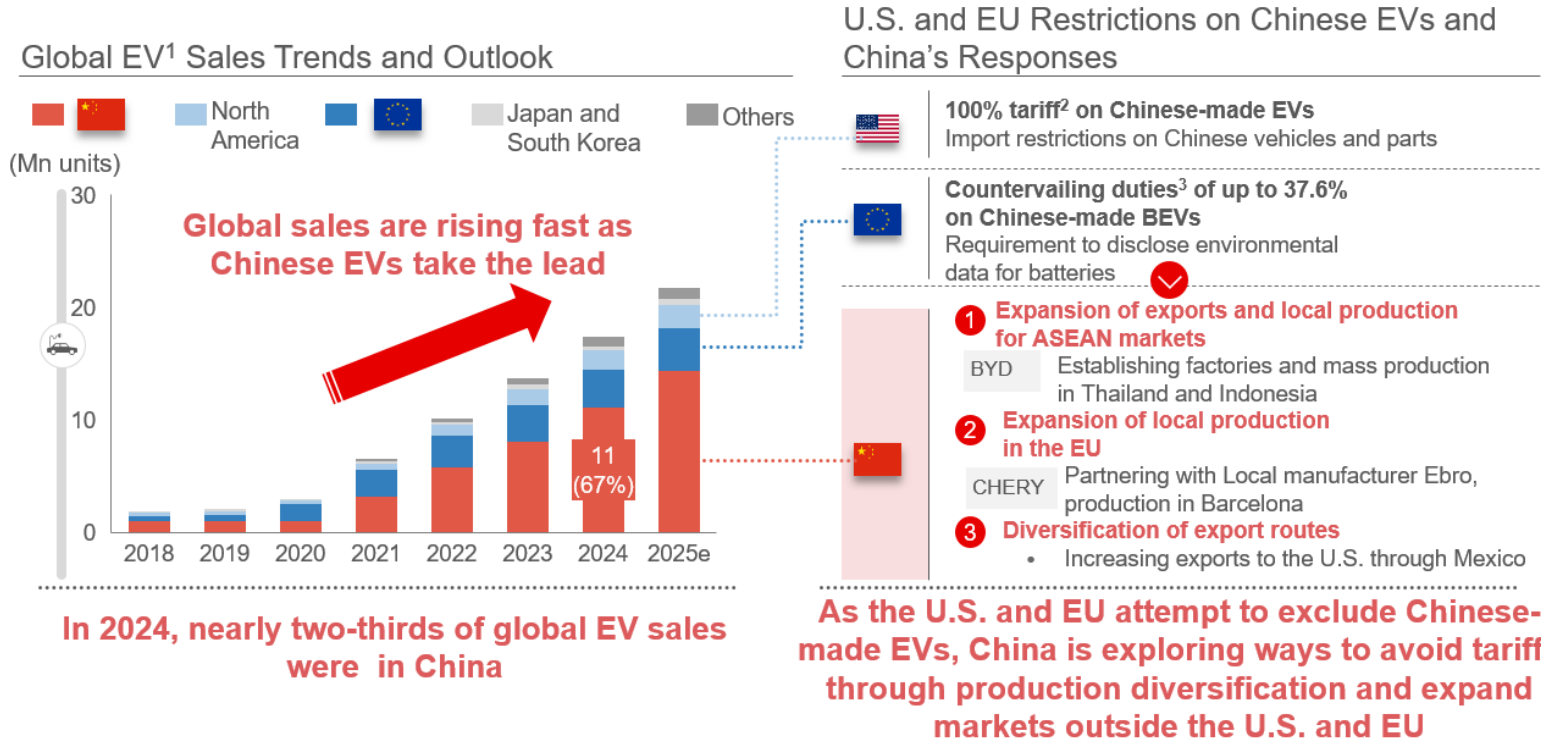
Green hydrogen produced in China is highly cost-competitive. As of 2025, a comparison of hydrogen production costs across major countries shows that China is among the cheapest at about $3.2/kg, around one-third of Japan's production cost of $10.2/kg.

The primary factors behind low costs are abundant renewable energy resources and low electricity prices. Electricity accounts for approximately 66% of the total cost of green hydrogen production. China's cost of renewable electricity used for green hydrogen generation stands at $2.0 per kilogram, second only to Saudi Arabia, and about one-third of Japan's cost ($5.9 per kilogram).

In addition, several structural factors are at play. The country has established a mass-production system for electrolyzers and related equipment, has adopted clear, government-led policies to expand hydrogen adoption, and has developed diverse sources of domestic demand across sectors including transportation, chemicals, and steelmaking. Collectively, these elements underpin China's emergence as a global leader in green hydrogen manufacturing and deployment.

Source: BloombergNEF, "Hydrogen Levelized Cost Outlook 2025"

Progress: Trends in EV



Turning to EV trends. China has established an overwhelmingly dominant position in global markets. Nearly two-thirds of all EV sold worldwide in 2024 were sold in China, and the share is expected to rise further in 2025. This dominance is underpinned by national and local government policies, including purchase subsidies, expansion of charging infrastructure, and preferential license plate programs—as well as the establishment of an integrated, vertically oriented supply chain covering everything from batteries to complete vehicles. This structure enables major Chinese EV models to achieve a manufacturing cost advantage of about 20–30% compared with European and American automakers.

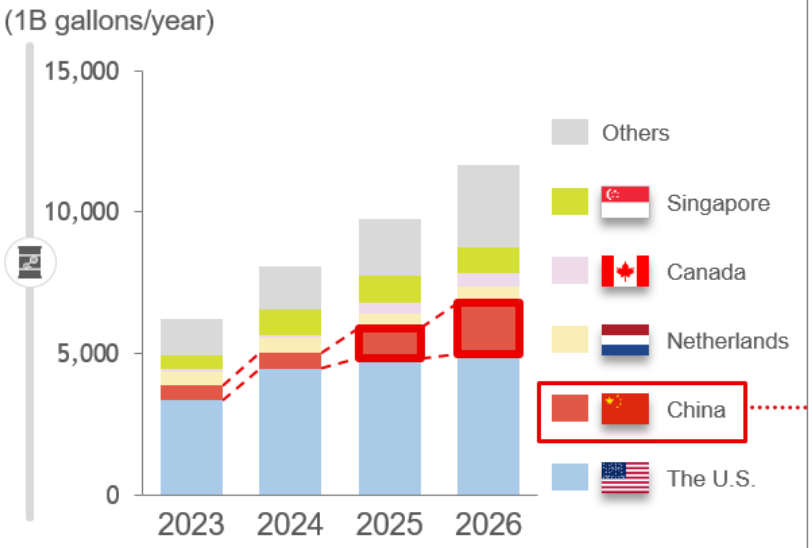
In the EU and the U.S., China's rapid ascent in the EV sector has led to increasingly protectionist measures. In 2024, the U.S. imposed a 100% tariff on Chinese-made EV, alongside import restrictions on vehicles and components. Europe took similar steps in July 2024, with the introduction of tariffs of up to 37.6% and new requirements mandating the disclosure of environmental data. Tariffs have eroded the price competitiveness of Chinese EV manufacturers in the markets. However, China has expanded exports to ASEAN countries, including boosting local production capacity. It has also expanded investment in manufacturing within the EU, aiming to diversify export destinations and production bases while mitigating the impact of trade barriers.

---

1. Includes battery EVs (BEV) and plug-in hybrid EVs (PHEV); 2. Effective for import declarations starting September 2024; 3. As of July 2024
Source: IEA(1/2); IEA(2/2) ;Public company data

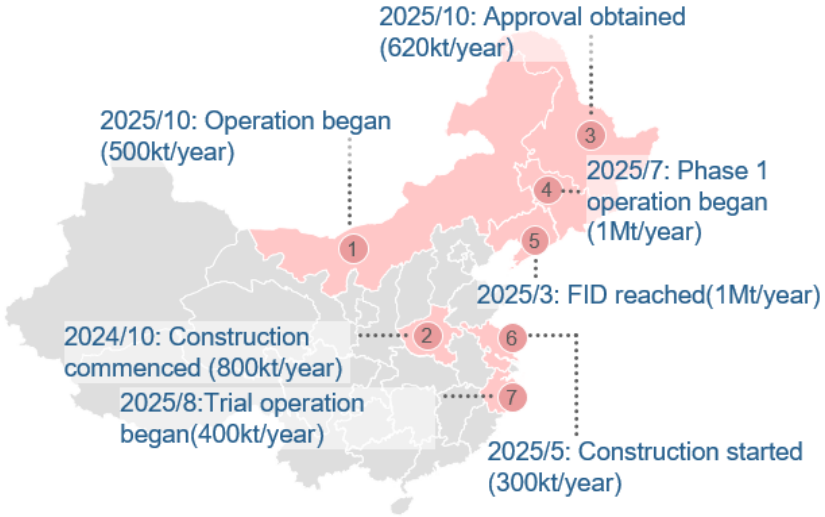
Progress: Trends in Synthetic Fuels

Outlook for Synthetic Fuel Production Capacity[1]



China plans to rapidly expand synthetic fuel production capacity (2025-2026)

Examples of Large-Scale Synthetic Fuel Development Projects in China[2]



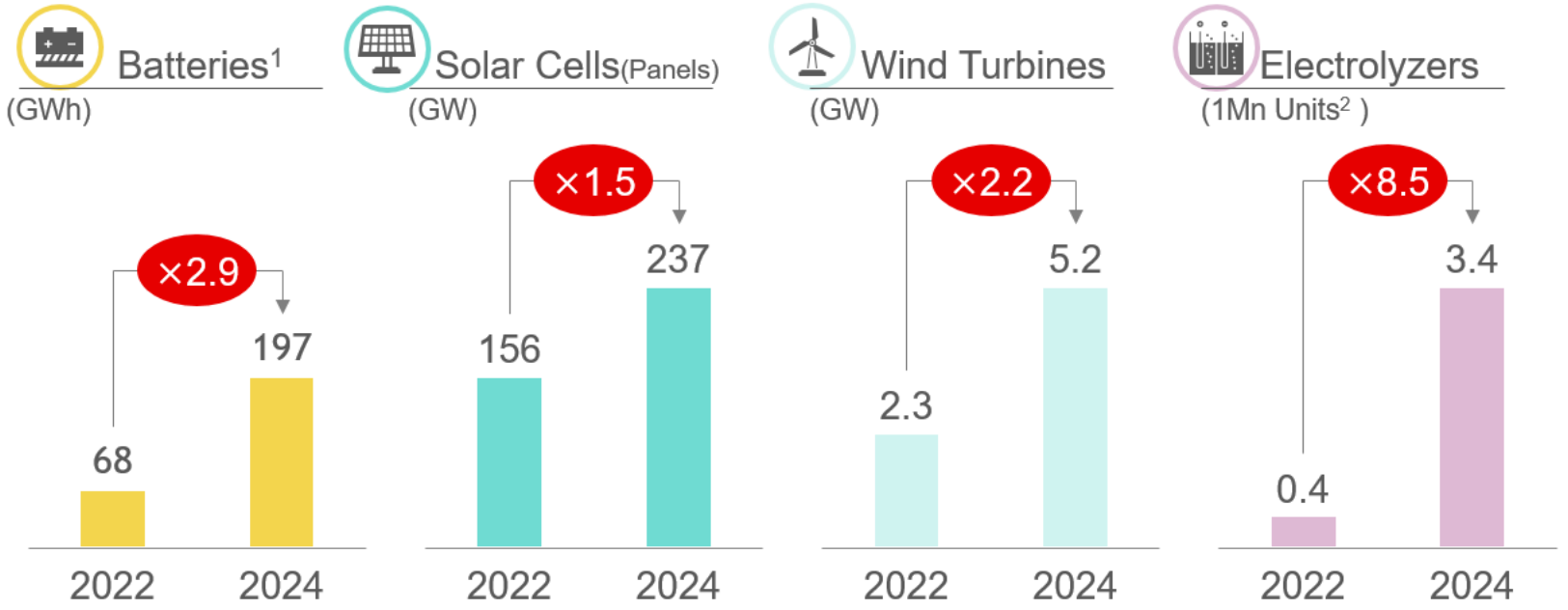
Projects for hundreds of thousands of tons of synthetic fuel production are progressing, primarily in coastal areas

Use of synthetic fuels—including sustainable aviation fuel (SAF) and e-methanol—is expanding rapidly. According to BNEF, China's synthetic fuel production capacity will more than triple between 2023 and 2026. The growth is supported by two primary factors: the recovery of the aviation market and rising international pressure for decarbonization. In addition, there is growing low-carbon demand in the chemicals industry, which is driving deployment of e-methanol.

Currently, new synthetic fuel production facilities are being developed across multiple regions of China. Indeed, construction is under way for several SAF and e-methanol plants with capacity of around 500,000 tons per year. Operations are scheduled to begin after 2025.

1.Estimated by Bloomberg NEF based on publicly available production plans in each country; main fuels include renewable methanol, SAF;
2. Representative examples of green methanol or SAF development projects selected for the National Energy Administration's Green Liquid Fuel Technology Research and Industrialization Pilot Project Phases 1 and 2, with a production capacity of 400,000 tons/year or more and progress made after 2024
Source: Bloomberg NEF, based on public company announcements. Note: Estimated product volumes are estimates based on disclosed information and assumptions on product yields. We estimate a volume if a company has disclosed that they will produce a certain product. The intention is to produce a high-level estimate for total potential product that could be available. In reality, product yields are flexible and will vary. The values can be overwritten with the user's own estimates; Public information

Progress: Trends in CN Technology Exports



China's major CN technology products are expanding exports fast

Exports of Chinese CN-related technologies have expanded significantly, covering a wide range of products including batteries (lithium-ion and others), solar panels, wind turbines, and electrolyzers. Among these, electrolyzers saw the largest increase in export volume in 2024 compared with 2022, rising by a factor of 8.5. Drivers of this surge include exceptionally low manufacturing costs that enhance price competitiveness, high levels of in-house production for raw materials and components, and policy support for exports.

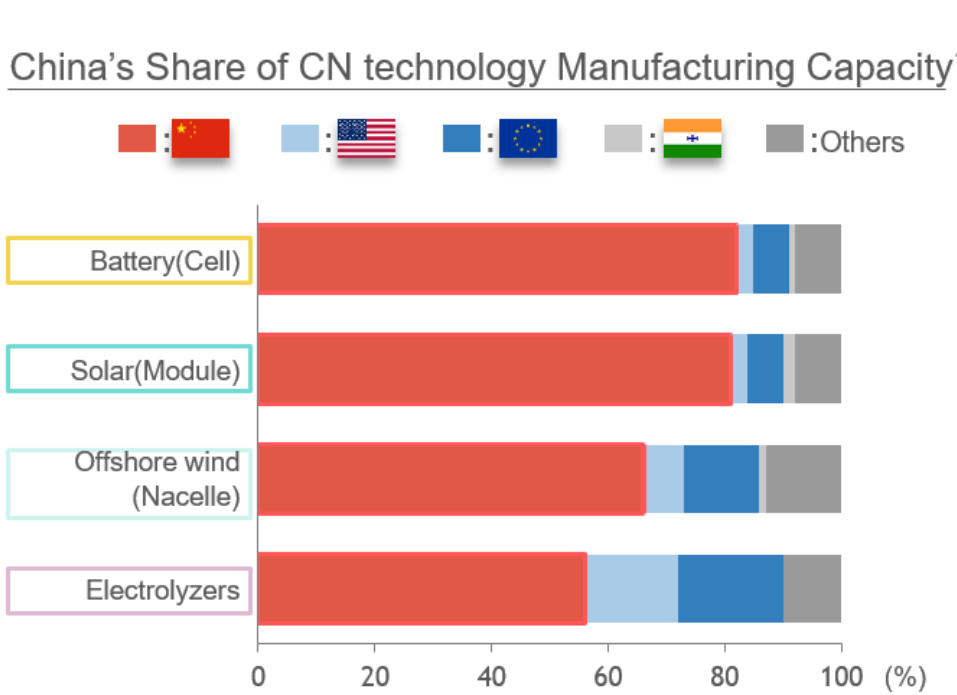
China has capitalized on its vast domestic market and government-driven industrial policies to accelerate the adoption and scale-up of CN-related technologies, firmly establishing itself as a leading manufacturing powerhouse. In recent years, sectors such as solar and batteries, policy-backed large-scale investments have pushed production capacity well beyond domestic demand. To offset the risk of overcapacity, China has increasingly turned to export markets in recent years. As a result, Chinese products and components are now widely available worldwide, further reinforcing China's influence within the global supply chain for CN technologies.

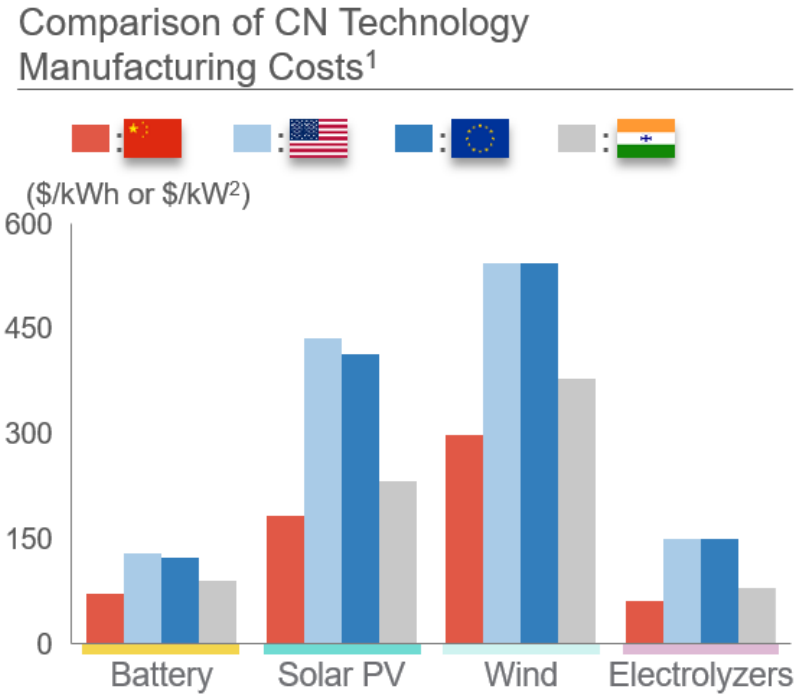
---

1. Includes lithium-ion batteries, lithium iron phosphate batteries, power batteries, and other types of batteries. Data for 2020 and 2021 are not disclosed;
2. Number of exported units

Source: Central China Securities ; Ember Website; CWEA Website; China Customs Website

International Comparison of CN Technology Manufacturig Capacity and Production Costs





China dominates major CN technologies

China has a dominant share of manufacturing capacity across major product categories. For batteries, solar and wind power components, and electrolyzers (key export growth drivers) China has an overwhelming share of global production capacity. Again, cost competitiveness is a major driver.

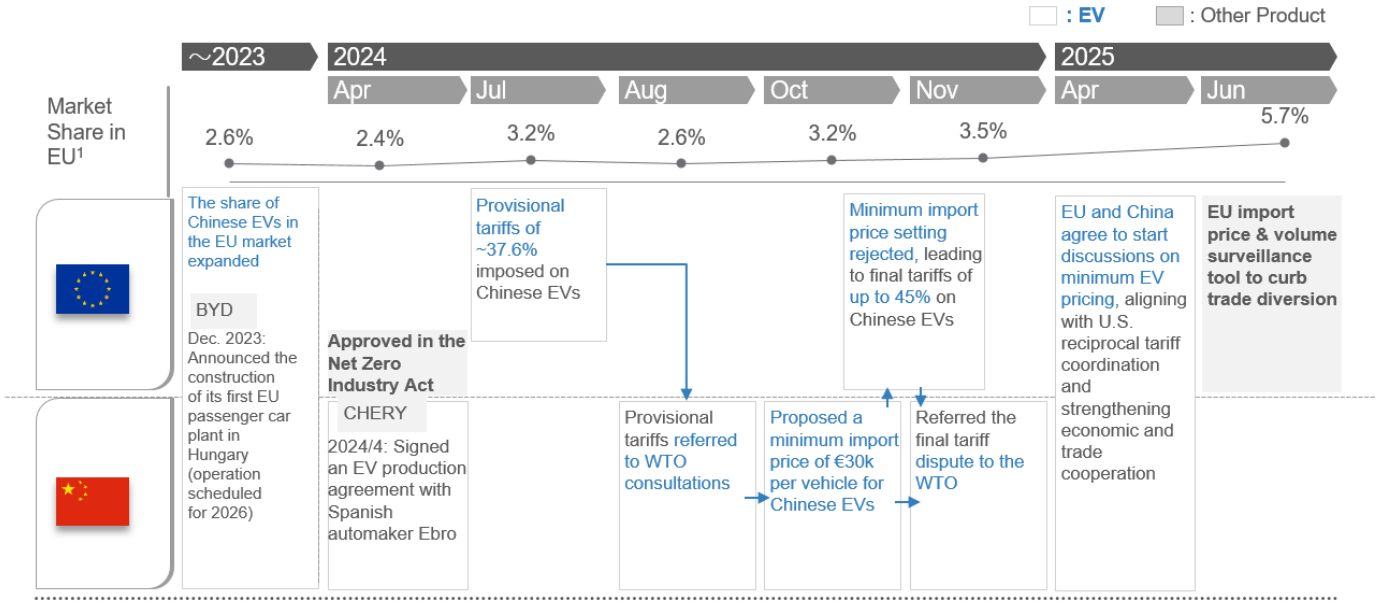
China benefits from lower-cost production

As of 2023, China produced all major CN products at the lowest cost globally.

---

1. 2023 actual; 2. Batteries shown in $/kWh; other products shown in $/kW
Source: Advancing Clean Technology Manufacturing Abstract: An Energy Technology Perspectives Special Report;

Emerging Challenge: Impact of European Tariff Policies on the Market Share of Chinese-Made Cars



Europe imposed tariffs in response to the growing share of Chinese EVs. The market share of Chinese EV manufacturers is expected to level off from 2024

China has an overwhelming cost competitiveness in the global market as a major manufacturer of CN technologies such as EVs and batteries, but the current challenge is the protectionist trade sanctions imposed by the U.S. and Europe.

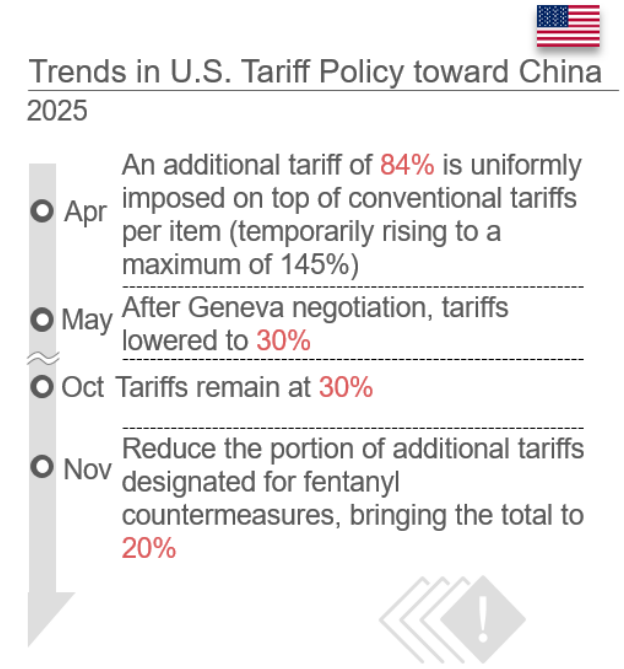
In Europe, following the introduction of procurement regulations to avoid excessive dependence on Chinese-made electrolyzers in public offerings, there are moves to strengthen countermeasures against EVs. This is attributable to the rapid increase in passenger car share among Chinese manufacturers in the European market. As of 2023, 2.6% of newly registered passenger cars in Europe were sold by Chinese manufacturers, making it a major player in the European passenger car market.

In response to this situation, the European Parliament and the Council adopted the Net Zero Industry Bill in April 2024 and announced measures to impose a temporary anti-subsidiary duty of up to 37.6% on imports of Chinese-made BEVs as of July 2024. As an alternative to tariffs, China proposed to Europe the introduction of a minimum import price system. Reacting to the European side's refusal to this proposal, China filed a complaint with the WTO regarding tariff measures, and the two sides agreed to start discussing the possibility of a minimum import price system in 2025. The Europe has continued to be cautious about imports from China, and in June it introduced a new system to monitor import price volumes.

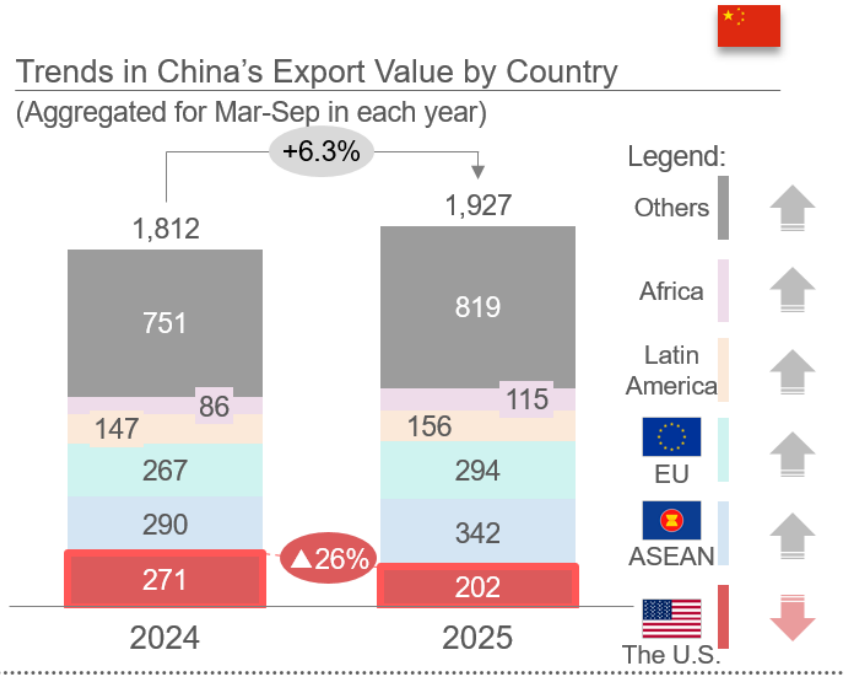
However, despite this offensive, the share of passenger cars manufactured in China in the European market continues to rise in 2025. This may be due to Chinese manufacturers strengthening sales of plug-in hybrid electric vehicles (PHEVs) and circumventing tariffs on BEVs.

1. Refer to the monthly data of new EV registrations and indicate it as the range up to the estimated median for each year
Note: BEV refers to battery electric vehicles, and PHEV refers to plug-in hybrid electric vehicles. Source: Public information; MUFG Research Consulting Website; MUFG Research Consulting PDF

Emerging Challenge: Decline in Exports to the U.S. due to U.S. Tariff Policies



In 2025, China faces high tariffs, with specifics fluctuating depending on negotiations



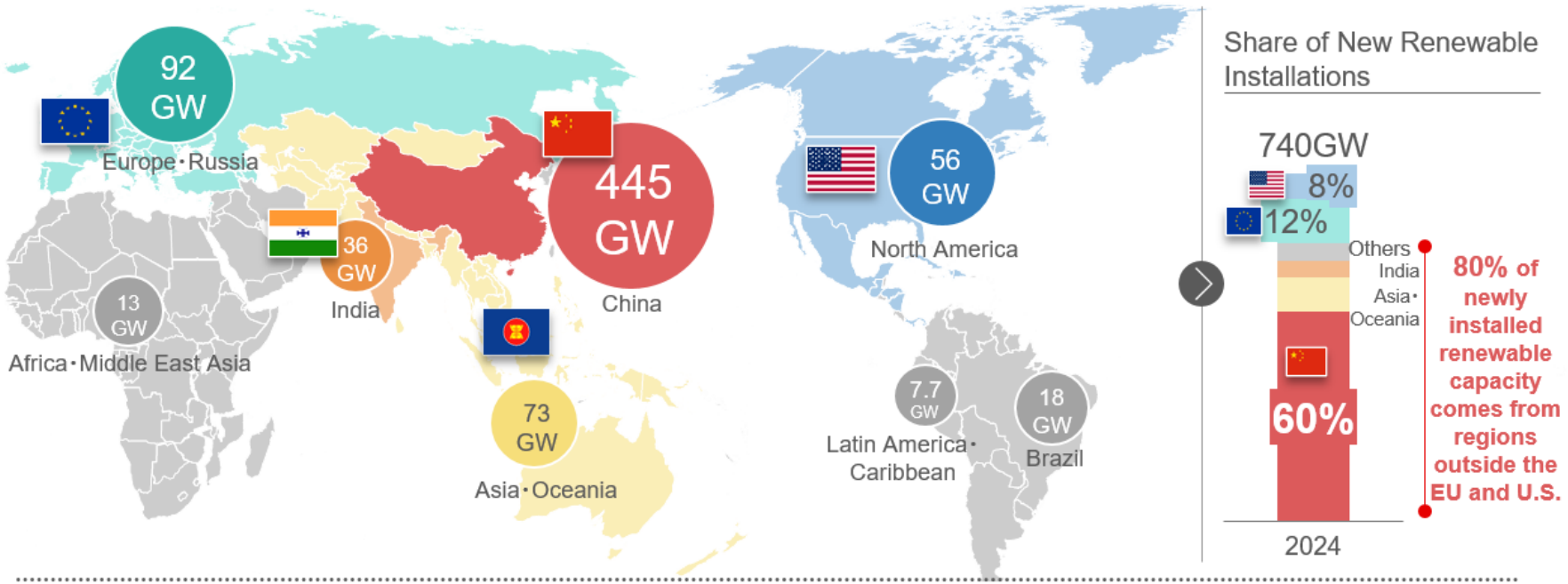
In 2025, China's exports to the U.S. fell by about 25%, with the trade flowing into other regions including the EU

Under the second Trump administration, the U.S. reinforced its trade policy and tariff measures against China, building on the Section 301 tariffs of the U.S. Trade Act first implemented in 2018. As a result, high tariffs were reimposed and extended on a wide range of Chinese products. Negotiations between Washington D.C. and Beijing remained deadlocked for an extended period, but the U.S.–China summit in October 2025 led to an easing of tensions. Nevertheless, many observers argue that fundamental structural issues remain unresolved, leaving the potential for renewed friction.

From the perspective of the impact of U.S. tariff measures, China's export data by destination between March and September of 2024 and 2025 show that while total exports increased by 6.3% year-on-year, exports to the U.S. fell by about 26%. Given that the U.S. accounted for just under 15% of China's export value during April–September 2024. These figures indicate that the tariffs have had a significant impact on China's trade performance. In response, China has increased exports to other markets, particularly within ASEAN and other emerging regions, suggesting that Chinese products displaced by U.S. import restrictions are being redirected to alternative destinations.

Source: General Administration of Customs of the People's republic of China Website; Nikkei(1/2); Nikkei(2/2);JETRO

International Comparison of New Renewable Energy Power Generation Capacity (2024)



Despite trade frictions with EU and the U.S., China's massive domestic demand and expansion into global markets—particularly in Asia—will help it maintain its position as a major producer and exporter of CN technologies

Despite current global trade tension, China is highly likely to maintain its position as a global manufacturing and export powerhouse for CN technologies in the years ahead. Key drivers will include strong domestic demand and expanding markets away from the U.S. and European economies.

In 2024, China accounted for about 60% of all newly installed renewable power capacity worldwide. Moreover, regions outside Europe and the U.S. accounted for around 80% of total global renewable installations. This reflects two major dynamics: China's acceleration of renewable energy adoption and the expansion of renewable deployment in emerging regions across Asia, Africa, and Latin America, driven largely by Chinese-made equipment and components. These trends suggest that about 80% of the global renewable energy market—primarily in non-U.S. or EU regions—remains highly accessible and strategically significant for China. There is little doubt that China's global expansion in CN-related products and technologies will continue and grow going forward.

Note: Since the newly installed power generation capacity for each region is rounded, the total value may differ from the sum of individual regions
Source: REN21 Website

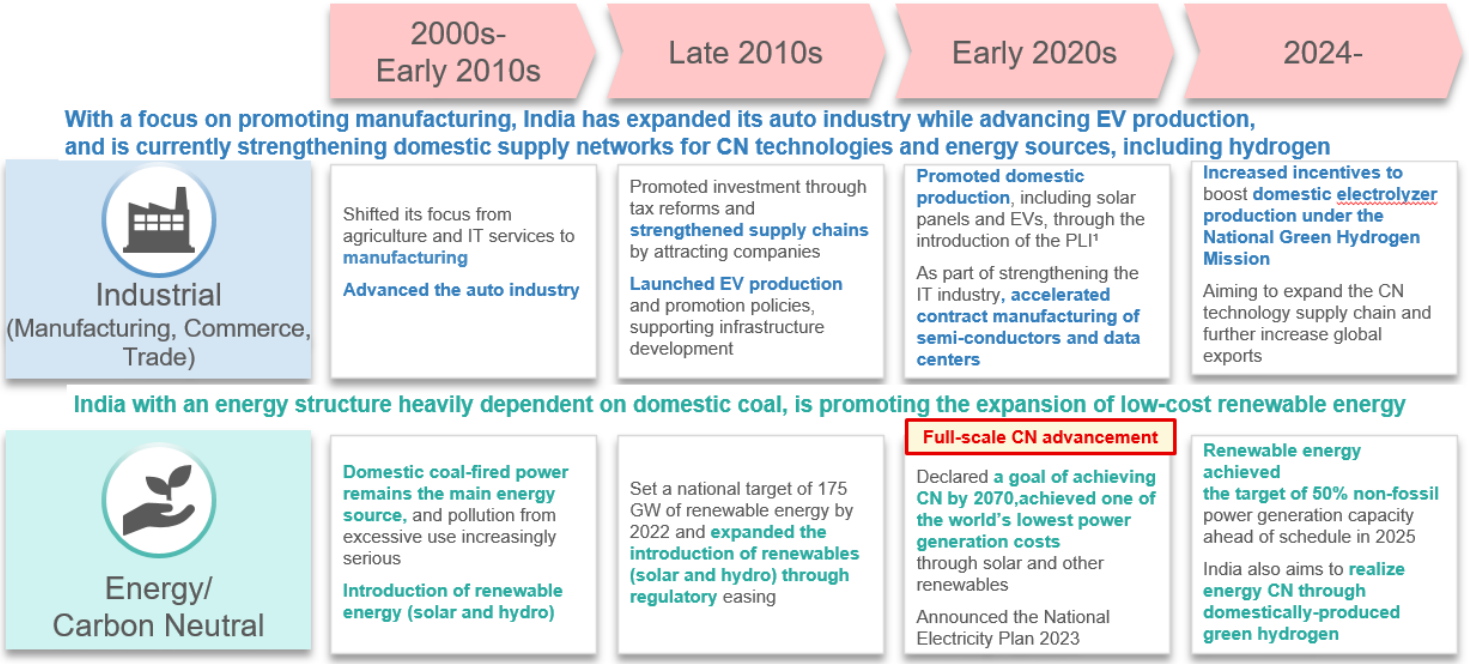
Summary

1. China has established **a position leading the world in renewable energy and EV adoption**, leveraging **the cost competitiveness gained through industrial development** to dominate the global market in the CN sector as well.

2. Concerns are growing over **declining exports due to factors such as tariff policies in EU and the U.S.** At the same time, efforts are underway to stimulate domestic demand, **develop new markets outside EU and the U.S., and advance new areas beyond EVs and renewable energy such as nuclear power and synthetic fuels.**

3. While skillfully aligning its industrial policy with the trend toward CN,**CN investment is expected to expand** to solidify its position as a manufacturing powerhouse.

Trends in Industrial and CN Policies in India



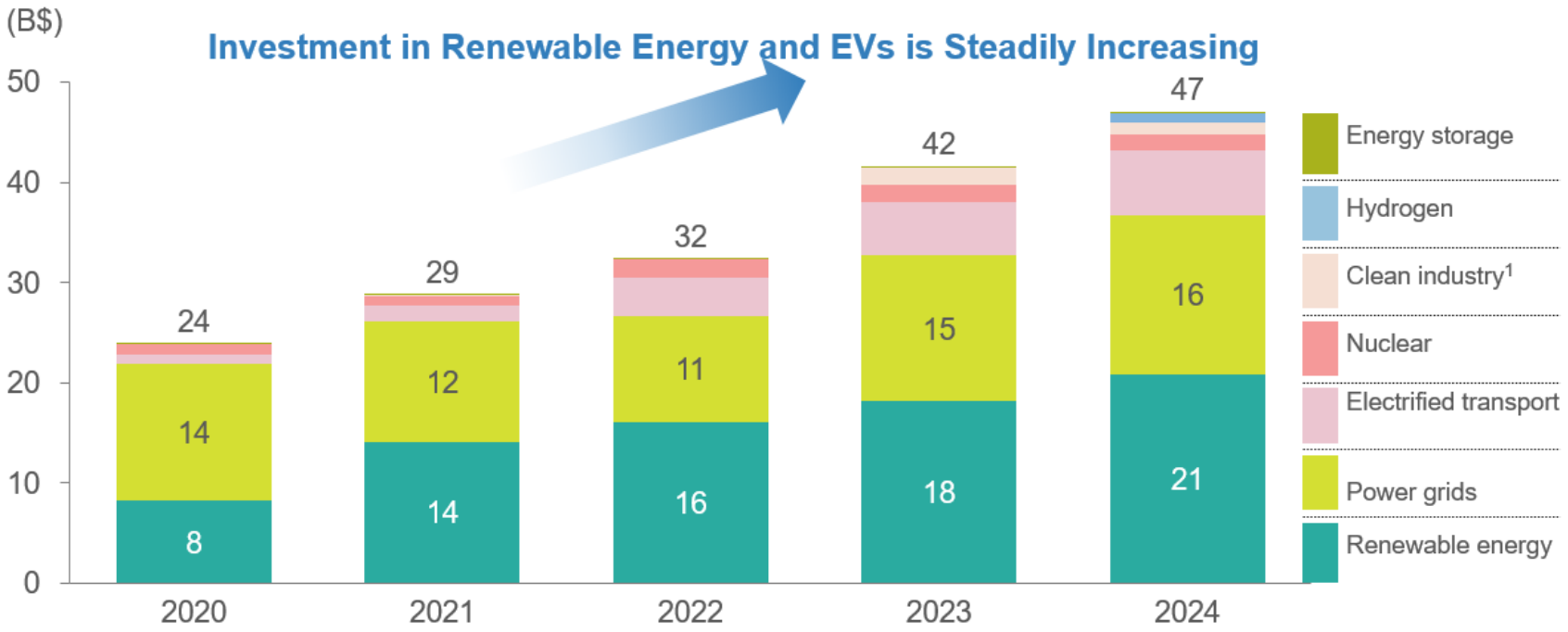
In India, industrial, energy, and CN policies are focused on promoting manufacturing and pursuing decarbonization—all while transitioning away from a coal-dependent energy structure. To evolve from an economy historically reliant on agriculture and services into a global manufacturing hub, the Indian government's policies aim to strengthen the manufacturing base, attract foreign investment, create employment, and promote self-reliance in supply chains, alongside the development of green industries.

Driven by economic growth and population expansion, India's energy demand is projected to rise sharply over the next five years. To ensure adequate supply, the government is implementing plans for a rapid expansion of non-fossil fuel generation.

It has already made good progress, achieving its target of 50% non-fossil energy by 2025. Renewable energy sources—primarily solar and onshore wind—are also the cheapest power options, including coal. This competitiveness provides the foundation for both industrial decarbonization and sustained renewable expansion.

By the early 2020s, India had reached renewable generation costs that were second only to China globally, and the government has positioned green hydrogen production and export as a national mission, with a view to creating a global hydrogen supply hub. India has also set ambitious target for nuclear power. Although the current scale is inferior to that of China and the U.S., the diversification of the energy mix and the promotion of domestic technology development suggest that it has the potential to become a growth sector in the future.

Investment Trends by Clean Technology Type in India



Over the past five years, investment in clean-related technologies has continued to grow steadily, reaching approximately $47 billion in 2024—about double the level in 2020. By technology category, renewable energy, transmission and distribution, and transport electrification (including EV) have been the primary growth drivers. As of 2024, renewables accounted for around 45% of investment, transmission and distribution for about 30%, and transport electrification for just over 10%.

Among other CN technologies, investment in nuclear power has remained stable at around $1–2 billion annually since 2020, while hydrogen-related investment surged to approximately $1 billion in 2024. This sharp increase reflects the initial rollout of projects under the “National Green Hydrogen Mission,” approved by the Indian cabinet in 2023.

---

1. Projects related to clean steel, clean ammonia, circular economy, bioplastics aimed at achieving net zero in the industrial sector through CN technologies
Source: BloombergNEF. Note: Start years differ by sector, but all sectors are present from 2020 onwards. Most notably, power grids start in 2020. CCS refers to carbon capture and storage. No electrified heat data collected for India

CN-related Progress in India Over the Past Year

With government support, India is advancing CN technologies and nuclear expansion, but U.S. protectionism and China oversupply are emerging concerns

Recent CN developments in India can be viewed through two lenses: domestic policy dynamics and the impact of international trends. Domestically, the third Modi administration lost its parliamentary majority in 2024. As a result, consensus building among state governments and coalition partners has become essential for energy and CN-related policies. This has increased the risk of delays in addressing challenges such as restructuring the power distribution sector and amending the Electricity Act.

Despite these complexities, India has maintained its direction of journey towards CN. In January 2024, the government revised the implementation framework for the National Green Hydrogen Mission—originally approved in 2023—and introduced a production-linked incentive scheme that rewards the output of green hydrogen and ammonia. In February 2025, India launched its first Nuclear Energy Mission, setting ambitious targets to expand nuclear capacity from the current 9GW to 100GW by 2047, with an interim milestone in 2035.

Externally, India's export environment has been significantly affected by U.S. trade policies. With U.S. tariffs raised to as high as 50%, India has sought to reduce its dependence on the U.S. market by strengthening partnerships with ASEAN countries, the Middle East, and Europe.

---

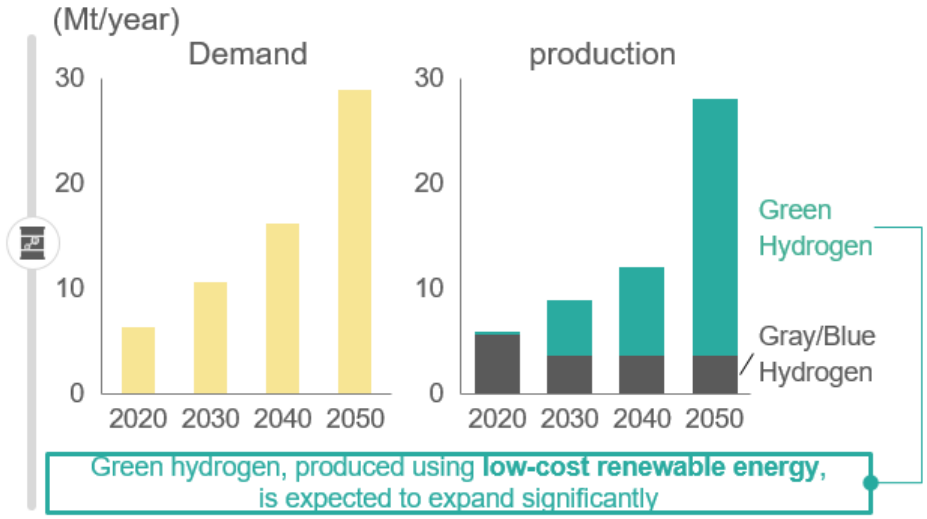
1. Small Modular Reactors

Source: Public information

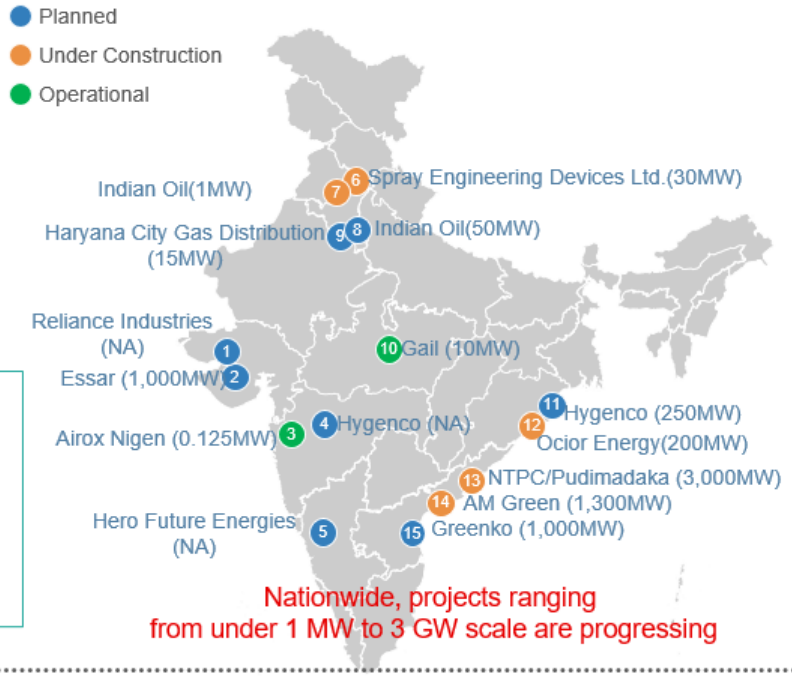
Progress: Trends in Green Hydrogen

Forecast of Green Hydrogen Demand and Production

National Hydrogen Mission (approved by the Cabinet in Jan 2023)
Aims to expand green hydrogen production in India and establish the country as a global hub for the manufacture and export of electrolyzers and products required for its production



Examples of Major Green Hydrogen Projects
(as of Oct 2025)



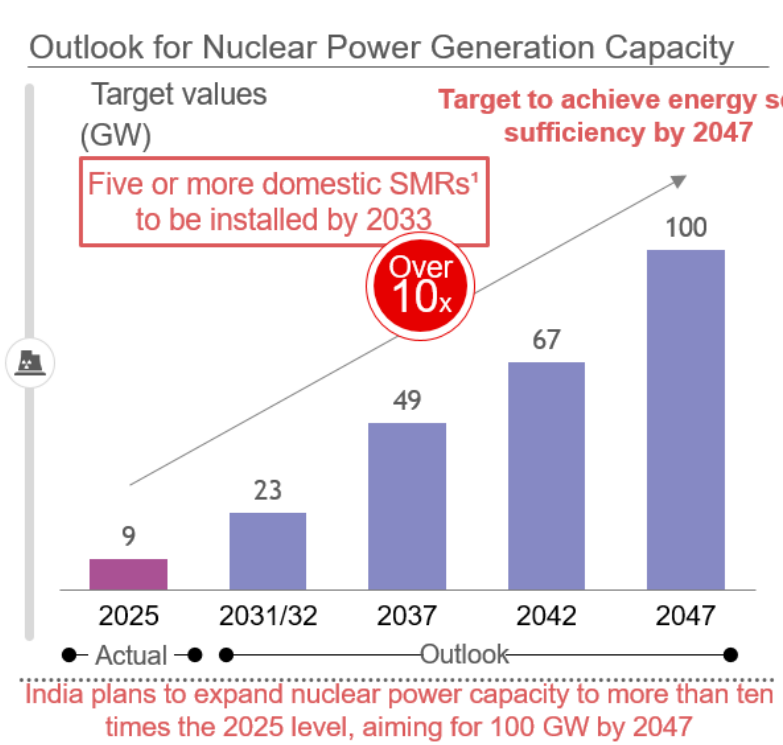
India is leveraging low-cost renewable energy to promote domestic investment and target green hydrogen exports

Hydrogen is one of the two major CN technologies that the Indian government is aiming to expand its supply chain. In January 2023, the Modi administration approved the National Hydrogen Mission by the Cabinet and has set out a policy of expanding green hydrogen production in India and aiming to become a global hub for the manufacture and export of electrolytic tanks and related products necessary for the production of green hydrogen.

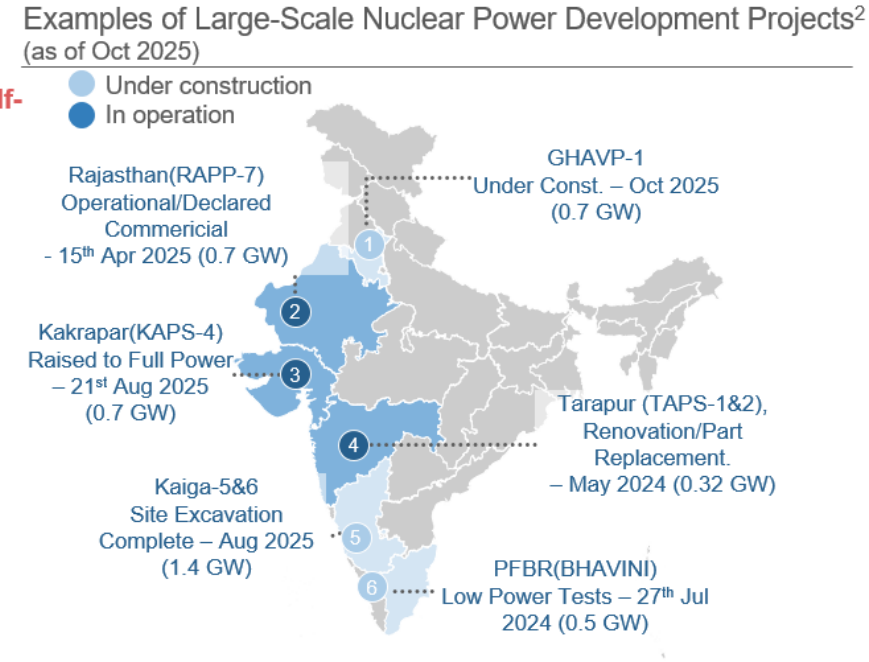
India's ability to leverage low-cost renewable energy in India is a major advantage, and the production volume of green hydrogen, which aims to produce 5 million tons by 2030, is expected to increase to about five times by 2050. It is predicted that less than 90% of the total hydrogen production by 2050 will be green hydrogen. Under a nationwide push, numerous green hydrogen projects across India are now planned, under construction, or already in operation.

Source: NITI Aayog; MITSUI&CO. GLOBAL STRATEGIC STUDIES INSTITUTE Report; Digital Research Report

Progress: Trends in Nuclear



India plans to expand nuclear power capacity to more than ten times the 2025 level, aiming for 100 GW by 2047



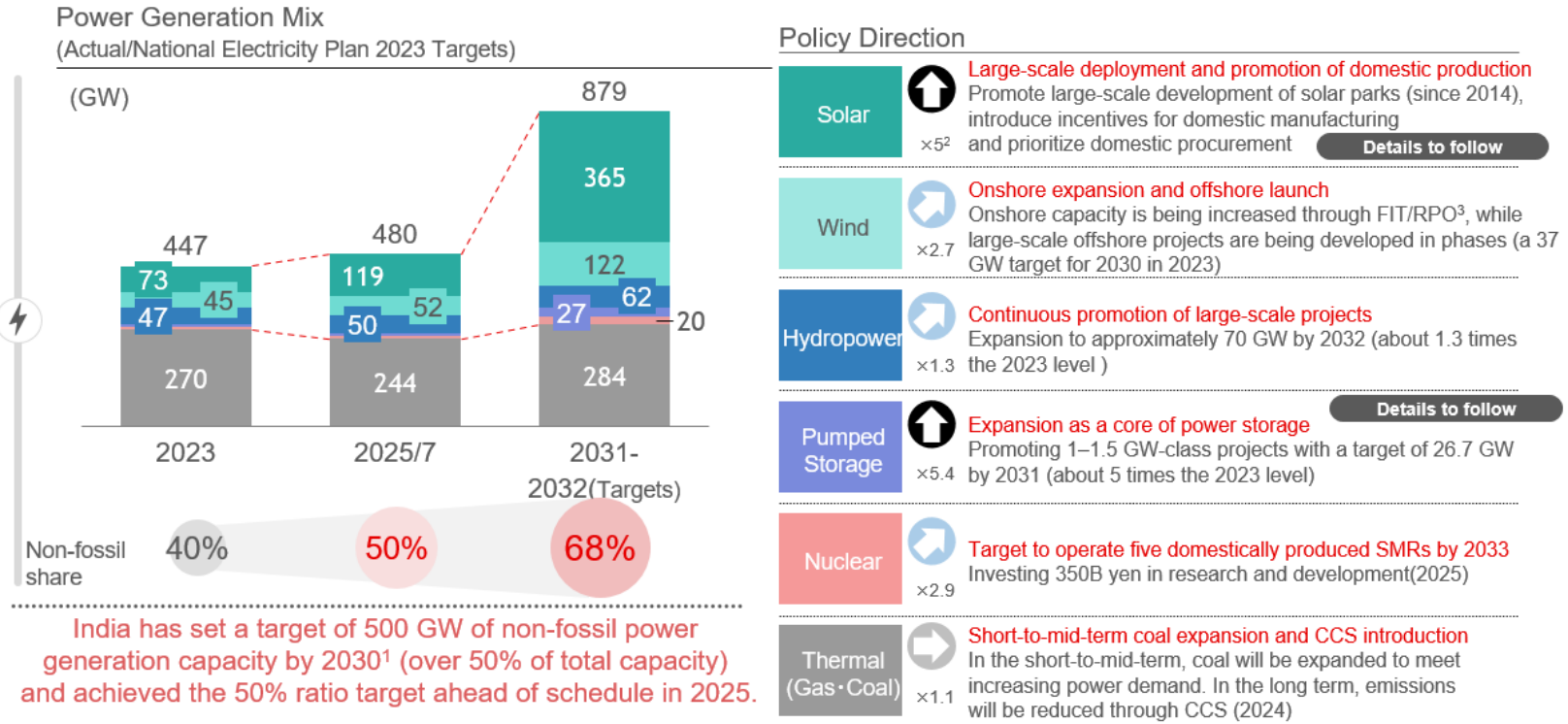
Nationwide progress is being made on the renovation of existing facilities and the operation of new installations

The Indian government has redefined nuclear power as an energy source that simultaneously supports energy security and decarbonization, pursuing a strategic policy shift centered on both supply chain expansion and domestic technology development. In February 2025, it announced the Nuclear Energy Mission, setting a long-term goal to expand nuclear generation capacity from 9 GW in 2025 to 100 GW by 2047, more than a tenfold increase. A defining feature of this mission is its explicit policy focus on promoting the development of domestically produced small modular reactors (SMRs). The plan calls for the installation of at least five SMRs by 2033, with demonstration projects already underway. This mission was introduced as a concrete measure following Prime Minister Narendra Modi's Independence Day address on August 15, 2021, in which he declared the goal of achieving an "Energy Independent India" by 2047, marking the country's centennial of independence. The initiative reflects India's intent to actively expand nuclear power as a key pillar of its future energy mix. At present, nuclear power projects are under construction across the country, led by entities such as the Nuclear Power Corporation of India Limited (NPCIL) with strong government support.

---

1. Small Modular Reactors; 2. Compiled based on publicly available information, this report tracks representative projects in each state that have seen progress following official announcements made in 2024 or later. Projects are plotted by country, focusing on large-scale projects with a planned generation capacity of 0.3 GW or more
Source: Department of Atomic Energy Press release; Nuclear Engineering International ;Public information

Energy Plan and Policy Direction



The Indian government, in its National Electricity Plan 2023, announced a target to expand non-fossil fuel power generation capacity to 500 GW—equivalent to more than 50% of total installed capacity—by 2031–2032. At the time of the plan's publication, the non-fossil share stood at 40% (approximately 390GW). However, with the rapid expansion of renewable energy deployment, the goal was achieved ahead of schedule in July 2025. The Indian government has indicated a long-term policy to further increase the non-fossil fuel ratio to over 68% by 2031-2032.

By technology, solar power and pumped-storage hydropower are seen as the key drivers of expansion, with plans to increase their combined capacity more than fivefold from 2023 levels by 2031–2032. To support this transition, projects for large-scale pumped-storage projects are already underway, with a strong emphasis on domestic procurement. Wind, hydropower, and nuclear power are also slated for significant growth, with the government targeting 1.34 to 2.9 times expansion in capacity, supported by enhanced central and state government policies. For fossil-fuel-based thermal power, efforts are being made to promote cleaner operations through the adoption of CCS.

---

1. In accordance with the standard notation used in government documents, the projected power generation capacity for FY2031–2032 is recorded as the target for 2030; 2. For each power source, the change in generation capacity from 2023 to 2030 is based on the figures in the National Electricity Plan 2023; 3. Renewable Purchase Obligation.
Source: National Electricity Plan2023; Reuters; Ministry of Power; Central Electricity Authority

Progress: Trends in Renewable Energy

Recent Developments in Solar and Pumped Storage
(Over the Past Year)

Solar

Largest Amount of Bidding and Installation

- Although some construction schedules were extended, due to domestic supply and grid connections, about 13 GW of new capacity was added (Jan-May 2025)
- The cumulative installed capacity surpassed 100 GW in January 2025
- As a distributed energy source, national and state governments provide subsidies for residential rooftop solar systems, reaching 1mn households in 2025

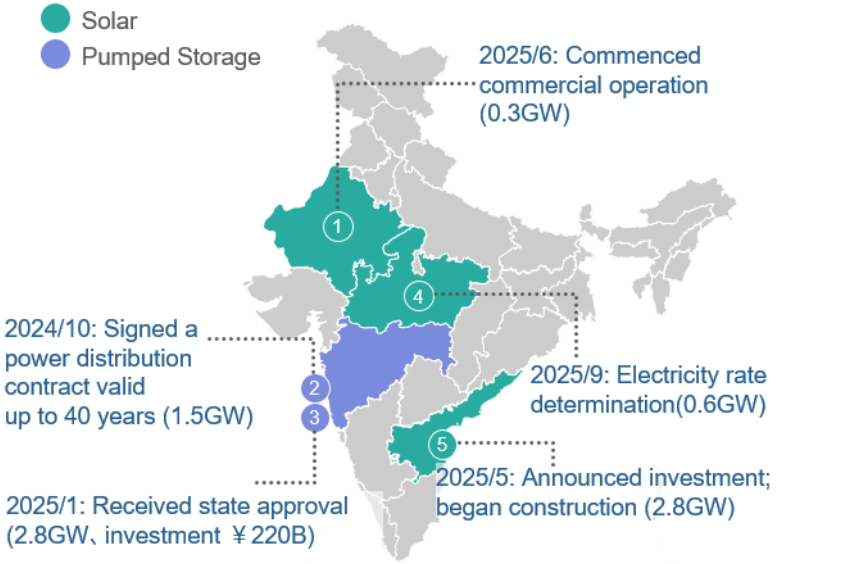
Pumped storage

Transmission Cost Exemption and Approval of Numerous Large Projects

- In June 2025, the 100% exemption of inter-state transmission costs was extended, with the national government bearing the cost until June 2028
- 6 large-scale projects were approved (totaling 7.5 GW, 2024)
- In Maharashtra State, policies promoted the installation of combined pumped-storage and solar power, as well as their use in public facilities

The introduction of solar and pumped storage power is accelerating with government support

Examples of Major Solar and Pumped Storage Projects[1]
(as of Oct 2025)



Contract signing, construction, operation of large-scale projects are progressing across various states to expand grid supply

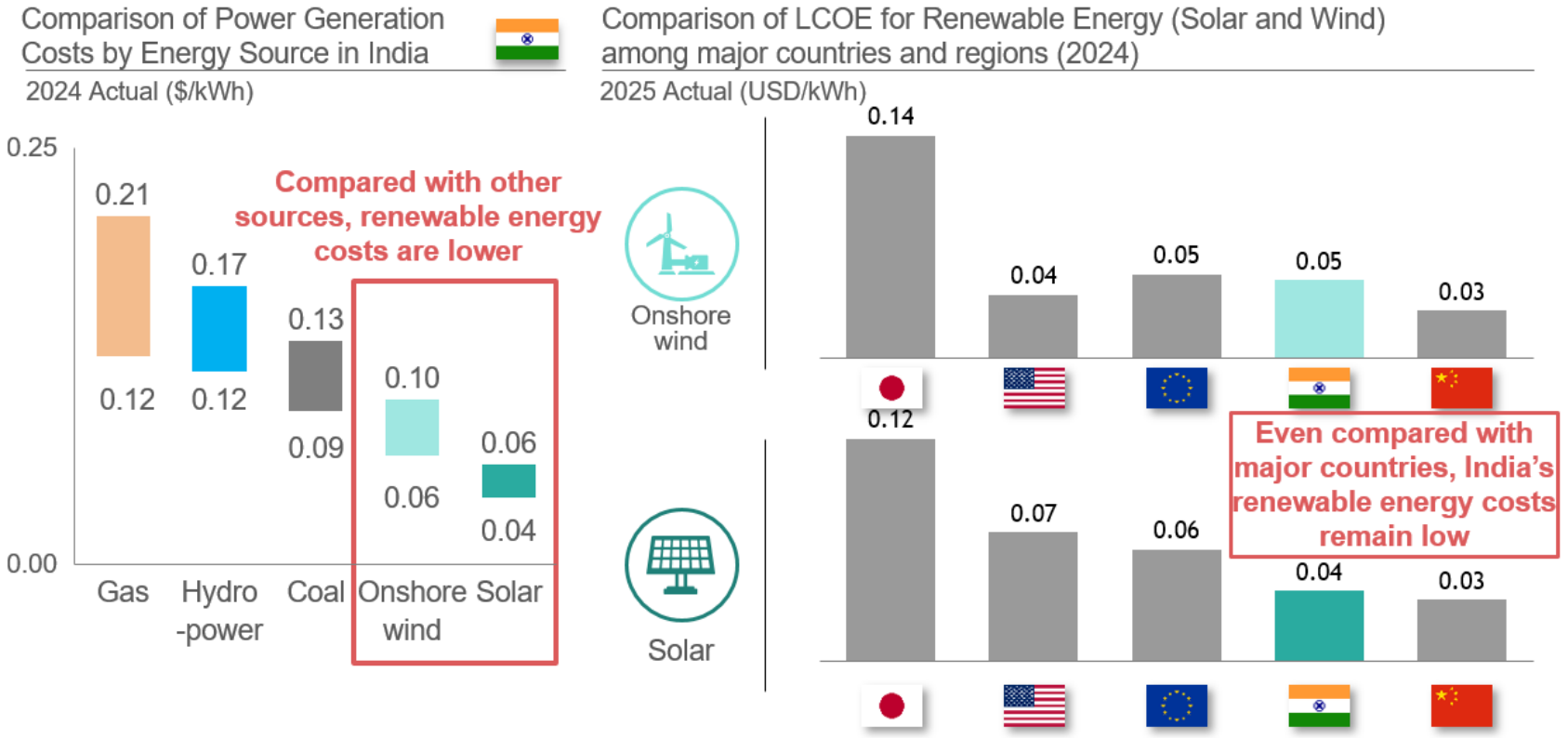
Since the announcement of the National Electricity Plan 2023, which set targets of a 50% non-fossil energy share and 500GW of generation capacity, the deployment of renewable energy has expanded rapidly, led by solar power and pumped-storage hydropower. On solar power, 2024 saw record-breaking tenders and capacity additions, and by the end of January 2025, cumulative installed capacity surpassed 100GW. In addition to utility-scale solar projects, the government has set up subsidy programs to promote distributed generation through rooftop solar installations. In 2025, there were rooftop systems on one million homes.

Pumped-storage hydropower has been positioned as an energy storage and balancing resource to complement the variability of renewables, and several large-scale projects were approved during 2024. In June 2025, the government extended the full exemption of interstate transmission charges, further accelerating the expansion of new installations. In Maharashtra, a long-term power distribution agreement of up to 40 years has been concluded, making a significant contribution to the diversification of India's power generation mix.

---

1. Representative projects (those that have made progress since 2024) were aggregated based on public information and plotted for each province. Examples of large-scale projects with planned generation capacity of 1,000,000 kW or more
Source: Public information

Renewable Energy Generation Costs

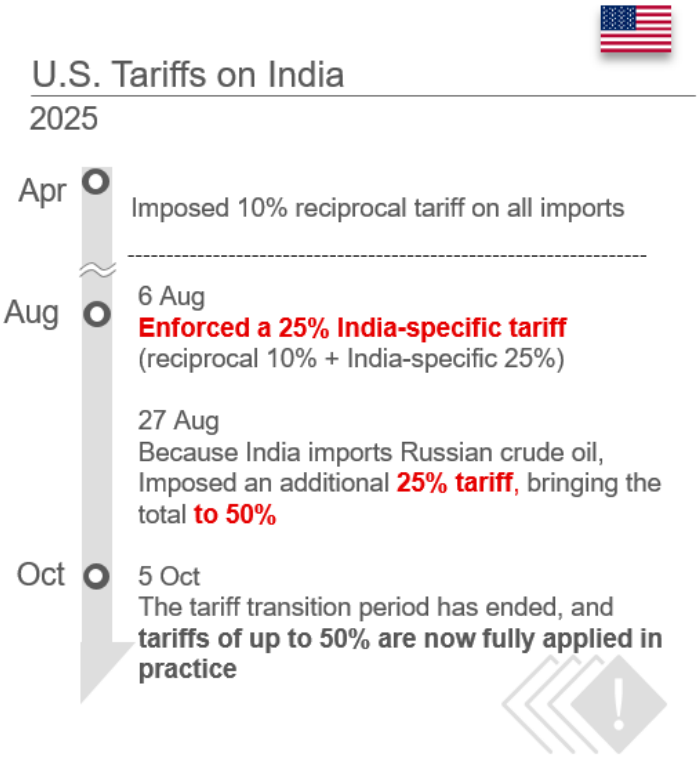


India's rapid acceleration of renewable energy deployment and its achievement of the 50% non-fossil energy share target by 2025 can be attributed not only to strong policy support but also to the remarkable economic competitiveness of renewables. In particular, the levelized cost of electricity (LCOE) for solar and onshore wind has fallen below that of coal, the cheapest fossil fuel source, making renewables the most cost-effective option in India's energy mix.

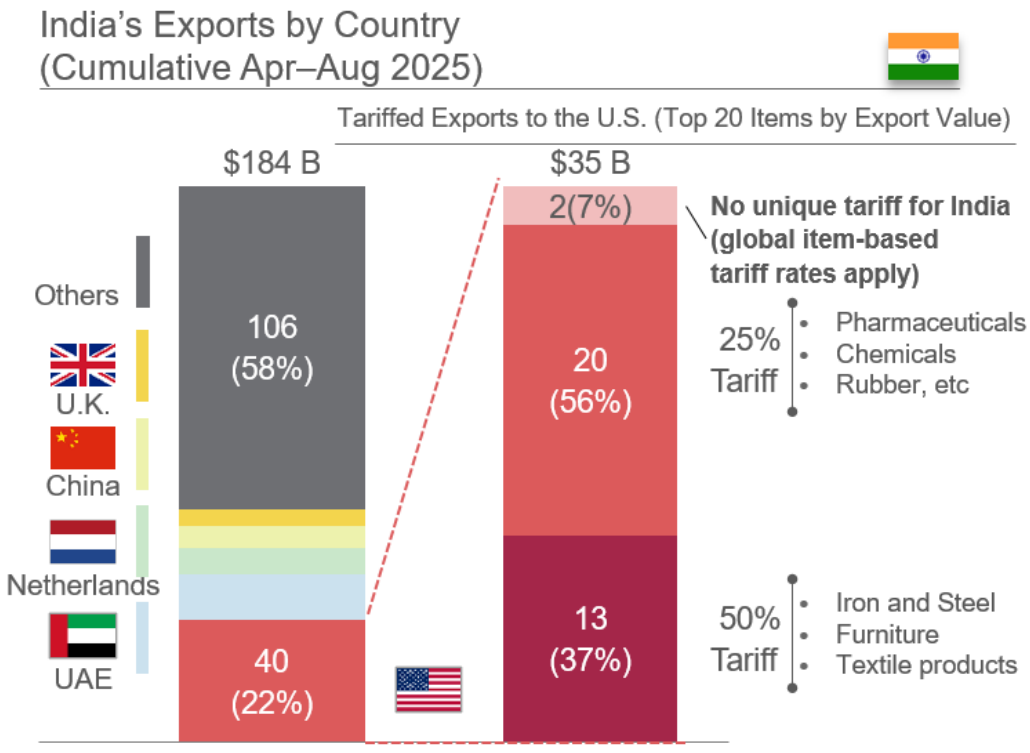
From an international perspective, India's renewables cost competitiveness ranks among the highest in the world. According to BNEF, the LCOE as of 2024 for solar and onshore wind in India is second only to China. The Modi administration aims to leverage this cost advantage to build a green hydrogen supply chain, positioning India as a global hub for clean energy manufacturing and exports.

Source: BloombergNEF 2025 LCOE: Data Viewer (v 1.0.4) Note: The LCOE range represents a range of costs and capacity factors. All LCOE calculations are unsubsidized. Categorization is based on the primary use case.; IRENA

Emerging Challenge: Outlook on Impact of U.S. Tariff Policies



Tariffs imposed by the U.S. on India are rising significantly



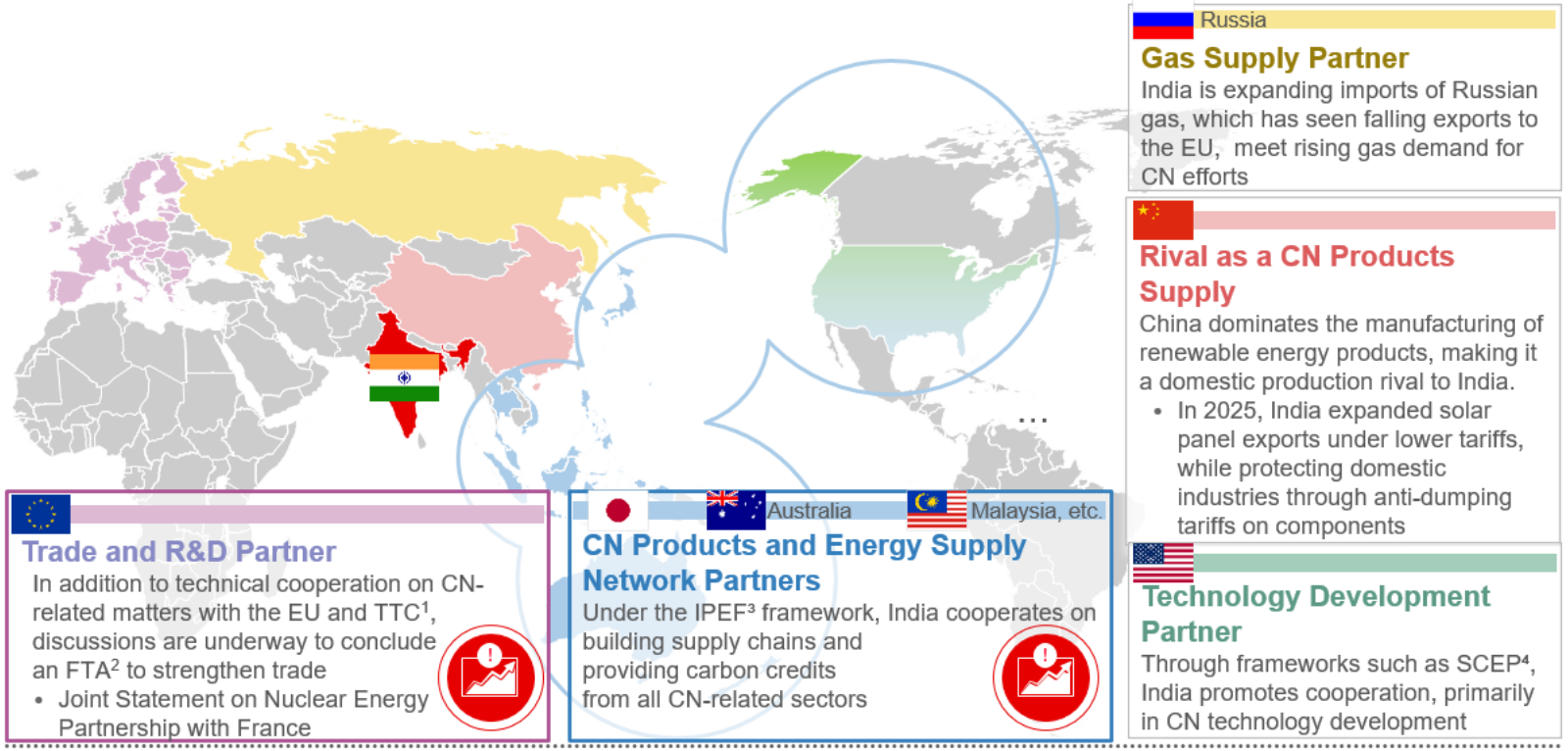
The U.S. is India's largest export destination, and many major products are affected by additional tariffs

The most pressing current challenge facing Indian exports is the high-tariff measures imposed by the second U.S. Trump administration. Although negotiations between the U.S. and India over tariff adjustments are ongoing, cumulative tariffs reached up to 50% as of August 2025. In the April–August 2025 period, exports to the U.S. accounted for 22% of India's total exports, meaning tariffs will strike a significant blow to the Indian economy.

An analysis of the top 20 export items to the U.S. shows that 37%—including steel, furniture, and textile products—are subject to the maximum 50% tariff, while 56%—comprising pharmaceuticals, chemicals, and rubber products—face 25% tariffs. As a result, the core export categories of India's manufacturing sector have been heavily affected by these additional U.S. trade measures.

Source: Nikkei; The White House; Federal Register; Ministry of Commerce and Industry Website

International Partnerships Relating to Energy



In response to trade frictions with the U.S., India is pursuing a structural shift in both the economic and energy domains, seeking to strengthen partnerships with other nations and regions. In particular, Europe, Japan, and ASEAN have emerged as key partners for trade and CN supply chain cooperation, with India actively advancing collaborations aimed at deepening long-term relationships and establishing these regions as major future export destinations.

---

1. Trade and Technology Council; 2. Free Trade Agreement; 3. Indo-Pacific Economic Framework for Prosperity; 4. Strategic Clean Energy Partnership
Source: MEA (1/2); MEA (2/2); Press Information Bureau; IPEF; Nikkei; GOVERNMENT OF INDIA (1/2); GOERMENT OF INDIA (2/2); DOE

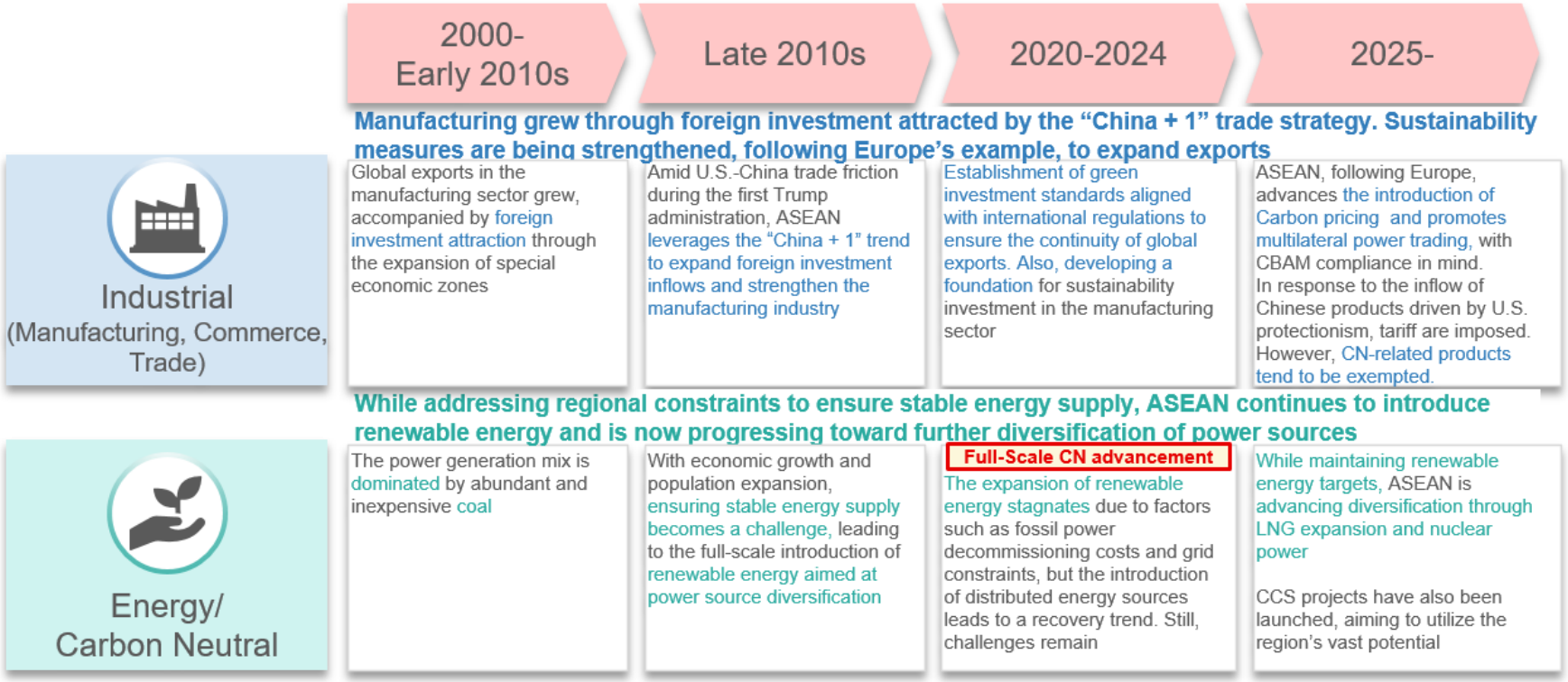
Summary

1. In response to growing energy demand, India continues to **expand renewable energy**—led by solar and pumped storage—and **introduce nuclear power on a large scale**, aiming to **achieve energy self-sufficiency by 2047.**

2. India is boosting domestic manufacturing and local supply chains in the auto and IT sectors, while expanding **green hydrogen production using low-cost renewables** to drive exports.

3. Amid cooling relations with the U.S. due to tariffs, India **is strengthening its ties with the EU, ASEAN, and Japan, aiming to grow as a carbon-neutral products/energy supplier** with government support.

Trends in Industrial and CN Policies in ASEAN

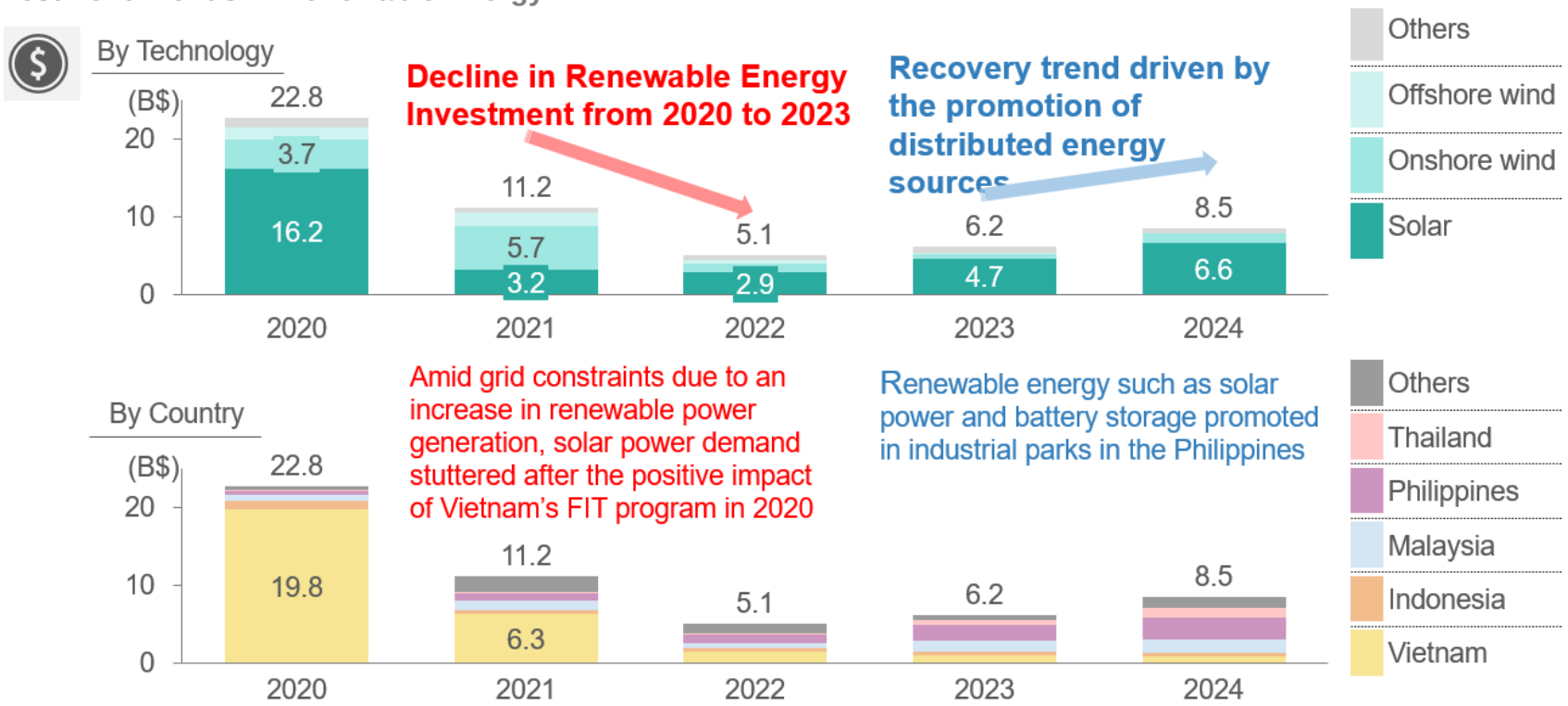


In the ASEAN region, industrial, energy, and CN policies are geared toward both promoting manufacturing and advancing decarbonization. Across diverse national circumstances, governments are prioritizing the strengthening of manufacturing bases and attracting foreign investment to position the region as a key hub in a "China+1" supply-chain strategy. Achieving this requires partnerships with advanced economies such as Europe and Japan—particularly through foreign investment and supply-chain integration—so environmental and climate regulatory frameworks that often echo European standards have been introduced.

Similar to Japan, ASEAN faces structural headwinds: renewables still lack a clear cost advantage over fossil fuels, making large-scale deployment economically challenging. Even so, major economies—including Indonesia (CN by 2060), Vietnam (CN by 2050), and Thailand (CN by 2050)—have set ambitious renewable energy targets to align with international norms, and policy support is expected to continue.

In parallel with renewables, ASEAN countries are also pursuing energy diversification—stepping up investment in natural gas and nuclear power—and launching CCS projects that leverage the region's substantial geological storage potential.

Investment Trends in Renewable Energy[1]



In the nine major ASEAN countries—the Philippines, Malaysia, Thailand, Singapore, Vietnam, Laos, Indonesia, Myanmar, and Cambodia—investment in renewable energy has fluctuations over the past five years. In 2020, total renewable investment reached approximately $ 23 billion, but by 2022 it had fallen sharply to around $ 5 billion. This decline was primarily driven by two factors: the emergence of transmission and grid constraints amid a surge in renewable power generation, and a sharp drop in solar investment following the end of Vietnam's feed-in tariff (FIT) scheme. Solar had accounted for about 70% of total investment in 2020.

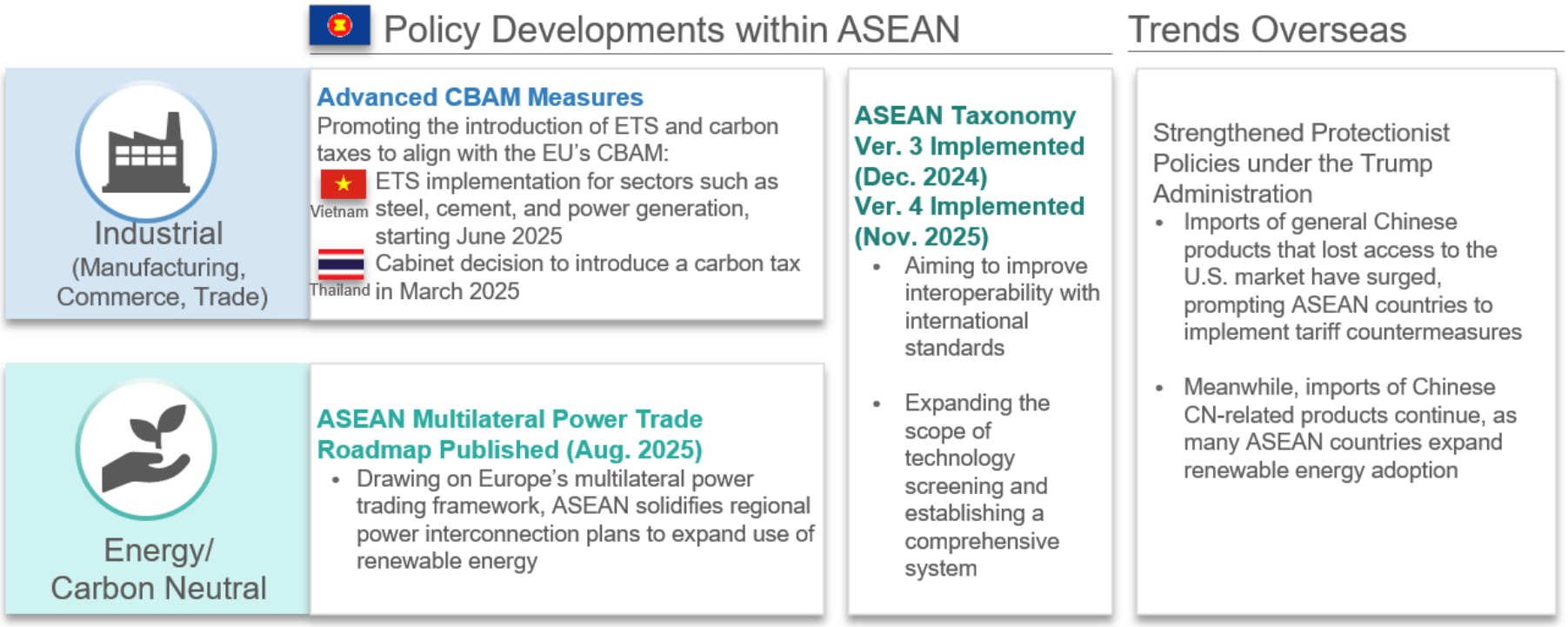
More recently, between 2022 and 2024, investment has shown a gradual recovery, with total renewable investment reaching $ 9 billion in 2024, of which nearly 80% came from solar power projects. This rebound has been supported largely by the deployment of distributed solar and battery storage systems within industrial parks in Philippines, which have become a key driver of localized renewable generation. Conversely, offshore wind power, which represented around 7% of total investment in 2020, has continued to decline. As of 2024, there are no notable new offshore wind investments, reflecting stagnation in this segment across the region.

---

1. The Philippines, Malaysia, Thailand, Singapore, Vietnam, Laos, Indonesia, Myanmar, Cambodia

Source: BloombergNEF. Note: Solar includes small-scale and utility-scale investment. New investments only. A list of renewables included in the 'Others' category can be found on slide 25 of this report. Energy Transition Partnership; The Philippine Economic Zone Authority

CN-related Progress in ASEAN Over the Past Year



Following Europe's lead, ASEAN is advancing industrial CN and regional renewable energy cooperation with aiming to boost exports, while using the inflow of Chinese CN products due to U.S. protectionism to accelerate renewable energy expansion

Source: Public information

CN-related Progress in ASEAN Over the Past Year

Developments in ASEAN over the past year can be divided into two categories: policy progress and the impact of international trends. Within ASEAN, governments have more actively promoted ETS and carbon taxes, as they prepare to align with the EU's CBAM.

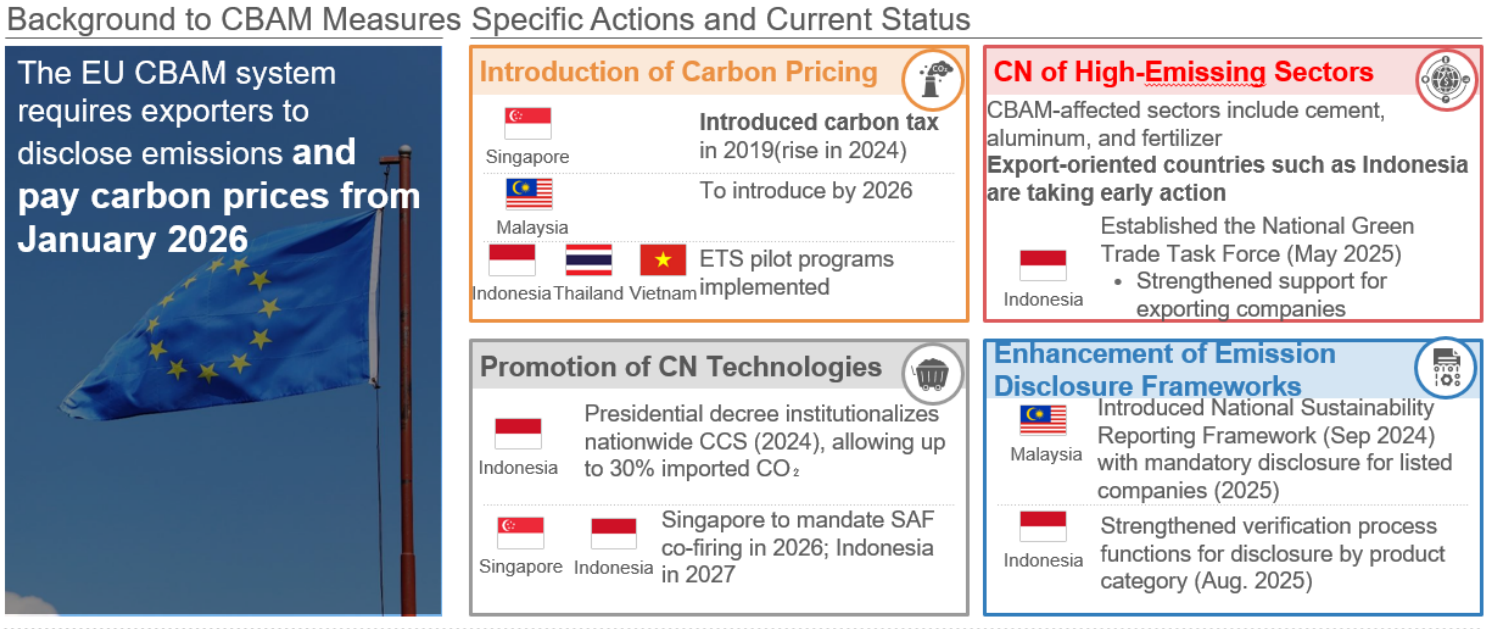
In the energy sector, significant progress has been made on regional power integration. In August 2025, ASEAN published its Roadmap for Multilateral Power Trade, taking a significant step toward institutionalizing cross-border electricity trading. The initiative, inspired in part by the European model, aims to expand renewable energy use through coordinated regional power exchange frameworks.

The ASEAN Taxonomy Version 3 came into effect in December 2024, adding two new sectors—construction and real estate, and transport and storage—to the Plus Standard priority categories. Given the wide diversity in economic development stages and technological capabilities across ASEAN member states, relying only on qualitative criteria makes it difficult to build a common understanding of what truly counts as "green." The Plus Standard, which sets out technical screening criteria, helps address this by providing more transparent and comparable benchmarks, thereby enhancing the credibility of investments aligned with decarbonization.

In these phase-out and benchmarking criteria—such as those newly added for the transport sector—the ASEAN Taxonomy is also designed to be interoperable with international standards, including the International Maritime Organization's (IMO) 2023 GHG Strategy. Furthermore, ASEAN Taxonomy Version 4 came into effect in November 2025. By progressively strengthening this framework for classifying and making visible sustainable activities within the region, ASEAN is reinforcing the foundation for mobilizing capital inflows and investment in sustainable projects.

International developments—particularly Trump administration tariffs—have had a significant impact on ASEAN's trade structure. With the U.S. market seeing lower levels of Chinese imports, large volumes of Chinese products, including CN-related goods such as solar panels, batteries, and electrolyzers, have flowed into ASEAN markets. ASEAN governments have adopted protective tariffs for general imports but have allowed imports of CN products to support renewable energy deployment. As a result, member states now face the complex challenge of balancing industrial development with renewable energy expansion.

Progress: CBAM Responses in ASEAN Countries



ASEAN countries are accelerating independent CBAM measures to strengthen exports to the EU

From January 2026, the EU's CBAM will require exporters outside the region to disclose emissions and, where applicable, pay carbon prices. In anticipation, ASEAN member states have accelerated the establishment of institutional frameworks to maintain and strengthen their export competitiveness to Europe. The key pillars of ASEAN's response include: the introduction of carbon pricing mechanisms, decarbonization of high-emitting sectors, promotion of CN technologies such as CCS and SAF, and enhancement of GHG emissions disclosure systems.

Across the region, countries are making progress on carbon pricing systems, with many countries at evaluation or pilot stages. Singapore, a regional frontrunner, raised its carbon tax rate in 2024, building on a framework introduced in 2019. In promoting CN technologies, Singapore has decided to mandate the blending of SAF for the aviation sector starting in April 2026 as part of its efforts to achieve decarbonization.

Vietnam launched its ETS in June 2025, initially covering the steel, cement, and power generation sectors.

Indonesia has taken a particularly active approach. As a major exporter of cement and aluminum to Europe, it established a Green Trade National Task Force in May 2025 to coordinate CBAM-related policy responses. Domestically, Indonesia has also mandated the blending of SAF and biodiesel, underscoring its commitment to aligning industrial and energy policies with global decarbonization trends.

Source: EU "a carbon border adjustment mechanism"; Public information

Progress: ASEAN Multilateral Power Trading

Vision for ASEAN's Regional Power Grid

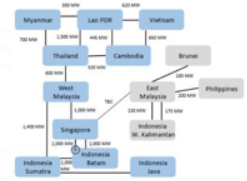
Aiming for **power grid interconnection across the ASEAN region,**10 members countries[1] signed a memorandum in 2007

In recent years, progress has accelerated to establish a framework for power trading between countries with abundant renewable energy and those with high energy demand

Specific Initiatives and Current Status

Publication of the Multilateral Power Trading Roadmap

Each country is promoting legal and institutional frameworks for multilateral renewable energy power trading (August 2025)



Envisions a regional power grid by 2040

Laos :Hydro Singapore

Vietnam Philippines :Solar trans-mission Malaysia

Vietnam :Wind Thailand

Progress in Electricity Trade Between Specific Countries

Under LTMS-PIP[2], transmission capacity doubled to 200MW (Sep. 2024)

First multilateral power trade in ASEAN

Renewable energy from Laos transmitted through Thailand and Malaysia to Singapore(2022)

In pursuit of a unified ASEAN power grid, several member countries are formulating a roadmap and undertaking initial implementation

A key initiative in ASEAN is the development of multilateral power trading. Although the concept of an interconnected ASEAN power grid has existed since 2007, it is only in recent years that governments have accelerated efforts to promote it as a framework for expanding renewable energy adoption and ensuring a stable power supply across the region. At the ASEAN Ministers on Energy Meeting in August 2025, the region published the "Study on the Roadmap for Multilateral Power Trade in ASEAN", which includes a 2040 vision for regional grid integration and supports member states in advancing legal and regulatory frameworks.

The roadmap outlines mechanisms such as transmitting solar power from Vietnam and the Philippines to Malaysia, and exporting Vietnam's wind power to Thailand, aiming to achieve a balanced renewable energy supply-demand system in the region.

Leading the multilateral power trading initiative is the Laos–Thailand–Malaysia–Singapore Power Integration Project (LTMS-PIP). It was announced in September 2024 that this project will double the transmission capacity from a maximum of 100MW to 200MW, showing progress in the utilization of renewable energy within the region.

---

1. Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Vietnam; 2. Laos–Thailand–Malaysia–Singapore Power Integration Project.
Source: ASEAN Centre for Energy; Energy Market Authority Press Release

Challenges: Issues in Expanding Renewable Energy Deployment

Renewable Energy Generation Potential (2023)

Solar

- High potential regions[1]
- Low potential regions[1]

(%):
Share of high-potential regions in country

Wind

- High potential regions[2]
- Low potential regions[2]

Major ASEAN countries meet the conditions for both solar and wind power generation, amid varying levels of renewable energy potential

Challenges for Renewable Power Generation

Fossil Power Decommissioning Costs

The average operating age of coal-fired power plants is around 13 years, which is **newer than the global average**[3]
Early retirement is expected to create concerns over fiscal and financial burdens

Subsidies provided for coal and petroleum products, with electricity prices for fossil fuels set at low levels

High Capital Costs

Financing costs for renewable energy projects are **two times higher than in OECD countries**
largely due to the underdevelopment of green finance markets

WACC[4] of solar
Advanced Economies : 5.0~6.5%
: 9.4%
: 9.0%

Grid Instability

There are regions with **unstable** power grids and **insufficient** transmission capacity

Frequent blackouts occur because of weak grid Infrastructure

Power generation is curtailed due to insufficient capacity

Policy Uncertainty

Frequent revisions to renewable energy procurement and electricity pricing schemes have reduced investment reliability

For solar and wind power, retroactive FIT reductions; refund requests have been imposed

The transition to renewable energy will not happen overnight, and the use of coal-fired power and gas is expected to continue

---

1. Regions with an average output of ≥ 3.7 kWh/kWp are classified as high-potential, and those with < 3.7 kWh/kWp as low-potential; 2. While an average wind speed of ≥ 4.5 m/s is often considered the minimum required for power generation, we classify regions with ≥ 5.0 m/s as high-potential and those with < 5.0 m/s as low-potential; 3. the global average: 22 years; 4.Weighted Average Cost of capital; Note. As of September 2025
Source: Global Solar Atlas Website; Global Wind Atlas Website; IEA (1/2); State of Global Coal Power 2023; IEA (2/2); Public Information

Challenges: Issues in Expanding Renewable Energy Deployment

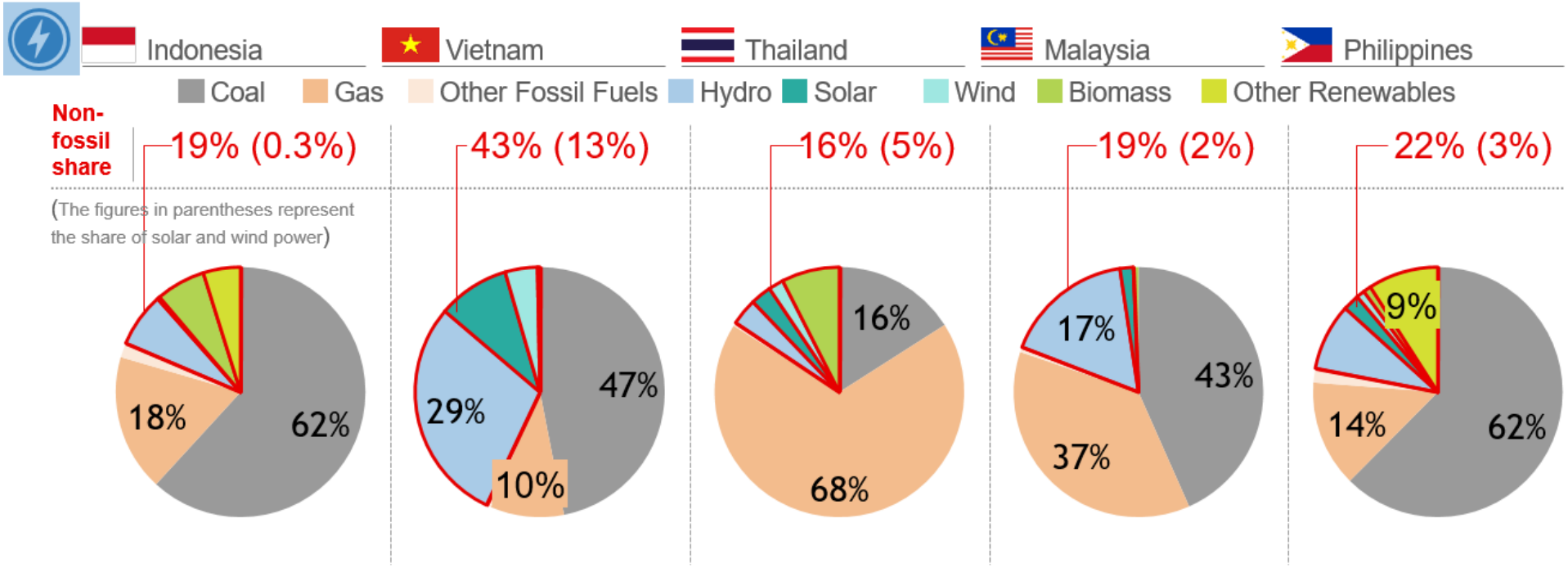
Progress is being made toward establishing frameworks for renewable energy exchange and optimization, including regional power integration initiatives. Many of the region's major economies possess the necessary solar and wind generation conditions, offering significant renewable potential. However, the expansion of renewable deployment faces several structural barriers. These include the cost of decommissioning fossil fuel power plants, high financing costs, grid instability, and policy inconsistency.

One of the most significant challenges is the cost of phasing out fossil fuel power, which stems from the relative immaturity of ASEAN's coal-fired plants, which have average ages of about 13 years, compared to the global average of 22 years. This makes early retirement financially burdensome. Additionally, in countries such as Indonesia and Malaysia, government subsidies for coal and petroleum products continue to keep fossil fuel electricity prices artificially low, encouraging continued fossil fuel consumption.

Grid instability also poses a major obstacle. In some countries, the power grid is fragile, with frequent blackouts and capacity shortages. As renewable power output is heavily influenced by weather and environmental conditions, it is prone to fluctuations, meaning grid infrastructure and balancing systems are essential for stable supply. In recent years, some countries have begun to address this issue through the deployment of distributed energy resources.

Overcoming these challenges will require consistent, long-term CN policy support. However, in several ASEAN nations, policy continuity is being undermined by factors such as changes in government, subsidy dependence, and the financial constraints of state-owned utilities. Thus, establishing a stable foundation for sustained renewable energy expansion is likely to be a key policy focus in the coming years.

Status of Renewable Energy in ASEAN (Breakdown of Power Generation Mix in 2023)

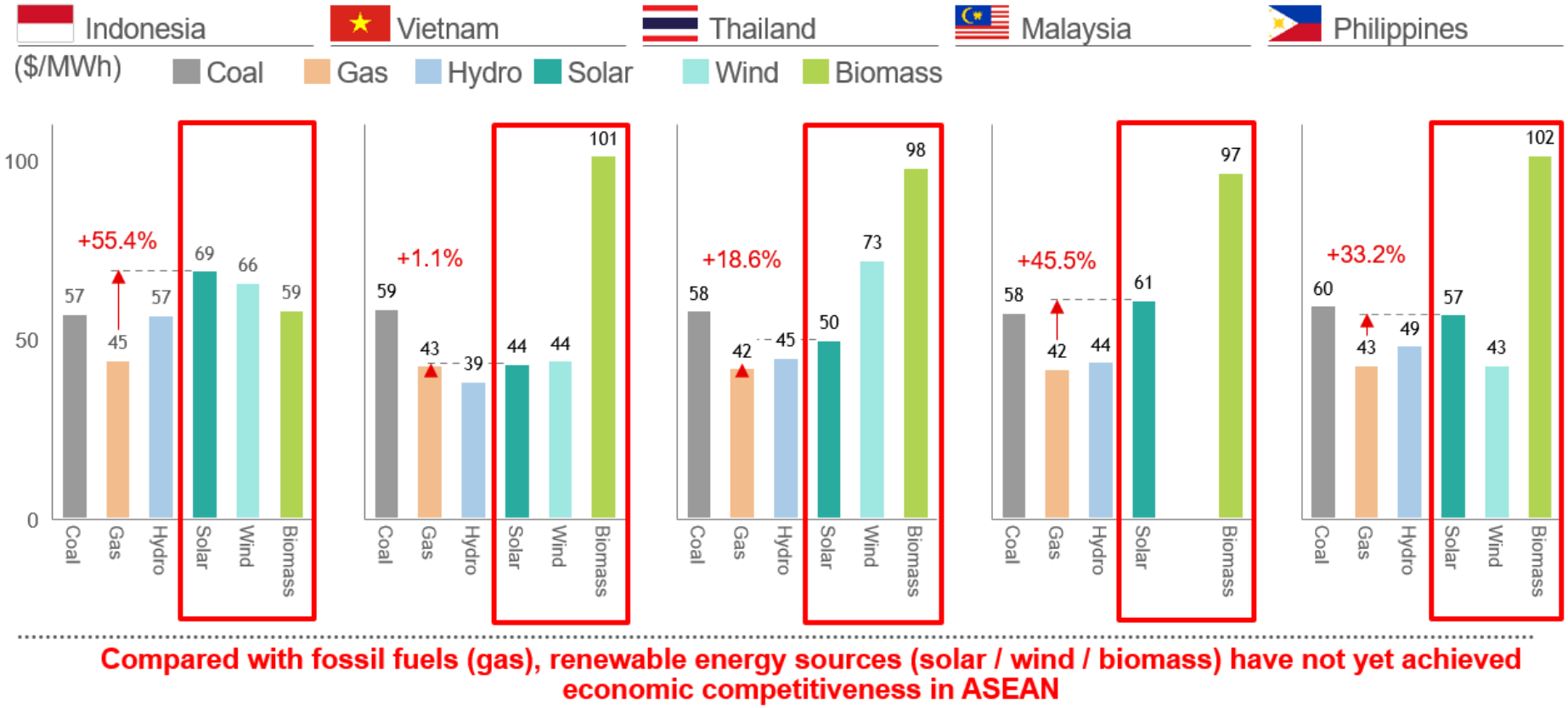


Fossil fuels remain the primary energy source in all countries, and the share of solar and wind power is still small

In the major ASEAN economies, the share of non-fossil energy sources in total power generation remains limited, and the overall level of renewable energy adoption is low. As of 2023, in the region's five largest economies, coal and natural gas together accounted for over 60% of total generation. While hydropower plays a notable role—representing 29% of generation in Vietnam and 17% in Malaysia—the shares of solar and wind remain below 15% in every major country.

Source: Electricity Data Explorer | Ember Website

Power Generation Costs (LCOE) by Technology[1]



---

1. Actual 2023
Source: ASEAN Renewables: Investment Opportunities and Challenges; Integrating Solar and Wind in Southeast Asia – Analysis - IEA

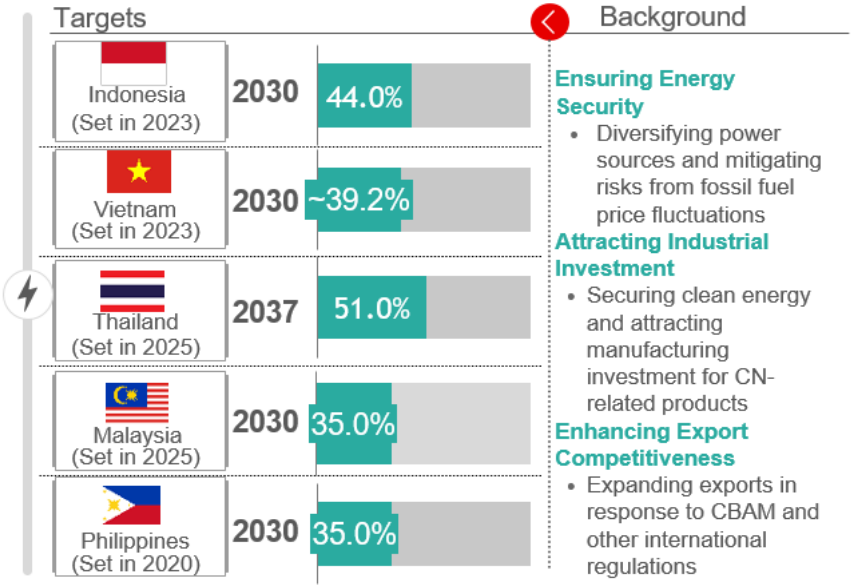
Power Generation Costs (LCOE) by Technology

One major reason renewable deployment has not leapt forward in the five major ASEAN economies—unlike in the U.S., Europe, China, or India—is that renewables are not yet economically competitive. Comparing levelized costs of electricity (LCOE) by generation source as of 2023 using Ember's calculations based on The National Renewable Energy Laboratory's (NREL) Annual Technology Baseline (ATB) 2023 methodology shows that solar, wind, and biomass all remain less cost-competitive than natural gas, the cheapest fossil-fuel option. Among the five countries, Indonesia has the widest gap between renewables and gas, with solar costs exceeding gas by more than 1.5 times. Even in Vietnam, where the gap is smallest, solar is still about 1.1% more expensive than gas, and the spread widens to around 13% when compared with hydropower, the cheapest source overall.

Against this backdrop, the relatively weak price competitiveness of renewables reflects multiple factors: higher capital costs, regulatory design, and grid constraints. Although global renewable costs have fallen sharply in recent years, the IEA notes that in countries such as Indonesia, CAPEX for utility-scale solar and wind remains significantly higher than in China or India. Limited deployment scale, immature supply chains, and stringent local-content requirements also push up project costs. In many ASEAN markets, development, operational, and macroeconomic risks translate into higher financing costs. Moreover, current power-market structures tend to undervalue the attributes of renewables, making it difficult for investors to form long-term views—another key obstacle to accelerating investment.

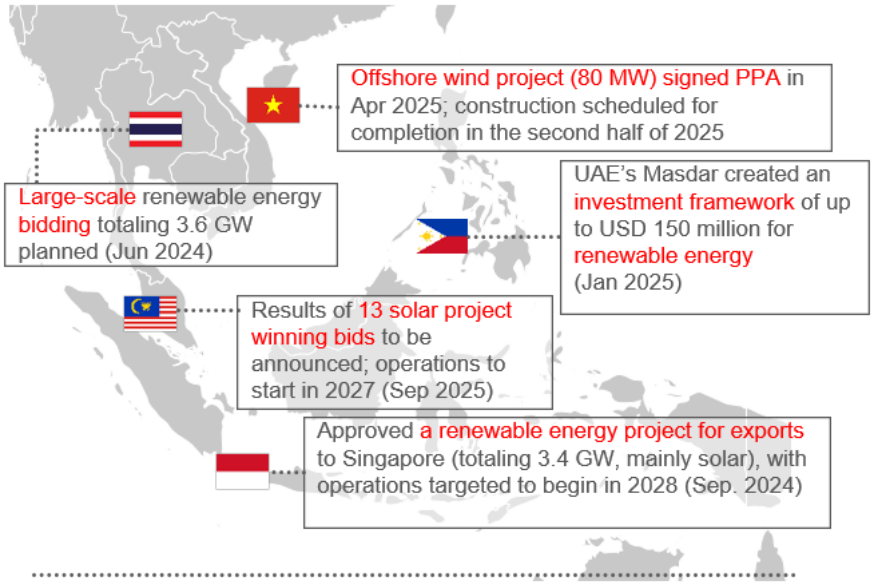
Progress: Trends toward Renewable Energy Expansion

Renewable Energy Ratio Targets[1] and Background by Country



Although there are challenges, with costs remaining high, most ASEAN countries have set renewable energy ratio targets of around 30–50% by 2030-2037

Examples of Renewable Energy Project Progress in ASEAN (From 2024 Onward)



ASEAN countries are taking steady steps toward expanding renewable energy adoption

While ASEAN countries face multiple barriers to renewable energy deployment, they continue to focus on expansion. Between 2022 and 2025, the five major ASEAN economies announced 2030-2037 renewable energy share targets ranging from 35% to 51%. These were driven by several factors: ensuring energy security through diversification of power sources, attracting investment in CN industries via clean power supply, and enhancing export competitiveness through alignment with mechanisms such as the EU's CBAM.

Individual countries are making tangible progress. For example, in the Philippines, the government has established a large-scale renewable investment framework of up to $15 billion in partnership with Masdar (UAE). In Indonesia, large-scale projects totaling 3.4GW—primarily solar—have been approved for exports to Singapore, with operations targeted for 2028. These developments underscore ASEAN's continued efforts to expand renewable deployment and strengthen its clean energy ecosystem.

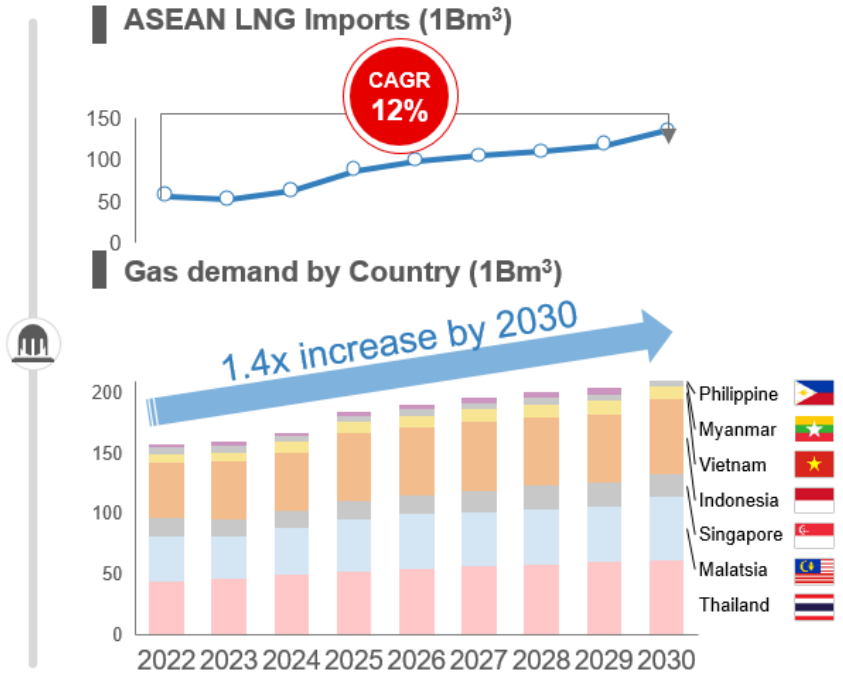
---

1. For countries other than Malaysia, the targets represent the renewable energy share in power generation, while for Malaysia, they represent the renewable energy share in installed capacity. The years in parentheses indicate the year the targets were set

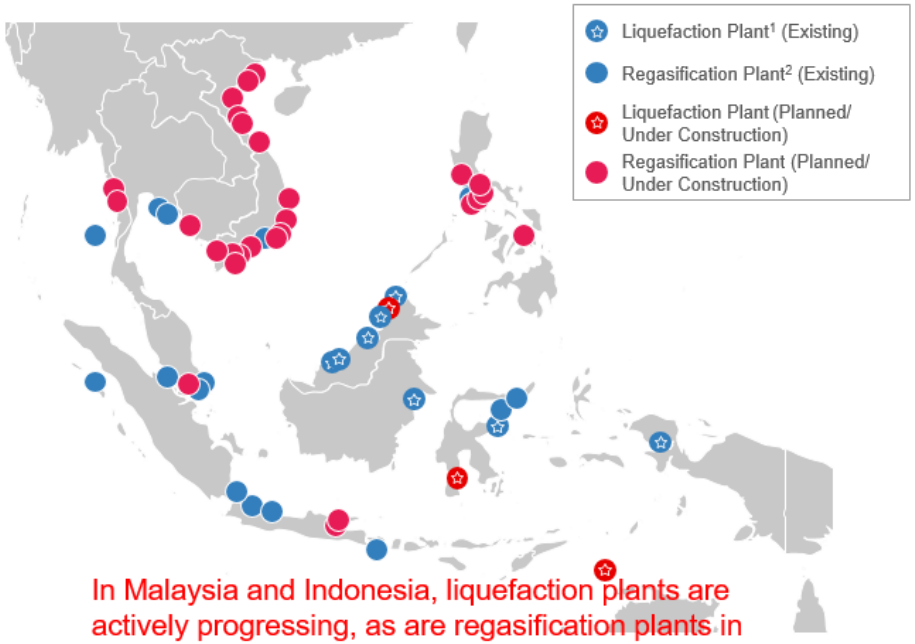
Source: JETP Indonesia; VIETNAM Government HP; EMBER; KENYATAAN MEDIA; Department of Energy Philippines; Public information

Progress: Status of LNG

Outlook for Gas Demand, LNG Imports by Country



Status of LNG Infrastructure Projects in ASEAN



In Malaysia and Indonesia, liquefaction plants are actively progressing, as are regasification plants in Thailand and Vietnam

Gas and LNG demand is expected to continue rising through 2030, and infrastructure development for gas utilization is advancing rapidly

As ASEAN countries pursue energy diversification, they are also actively promoting use of natural gas. LNG imports across the region are projected to grow at an average annual rate of 12% between 2022 and 2030, while gas demand in major economies is expected to rise by approximately 1.4 times over the same period. To meet this growing demand, ASEAN nations are rapidly developing gas-related infrastructure. In Malaysia and Indonesia, projects are underway to build liquefaction plants that cool and convert natural gas into LNG, while in Thailand and Vietnam, development of regasification terminals—which convert LNG back into gaseous form for consumption—is progressing.

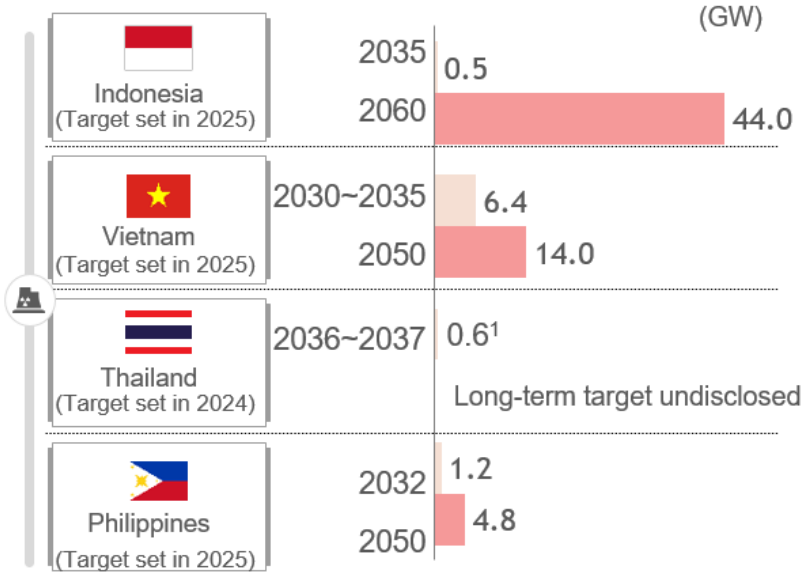
---

1. Facilities that cool natural gas and convert it into liquid (LNG) using equipment (refrigeration and liquefaction units); 2. Facilities that warm LNG to convert it back into gas and send it through pipelines, using equipment (gasifiers and gas compression systems)
Source: RBAC Website; JOGMEC HP

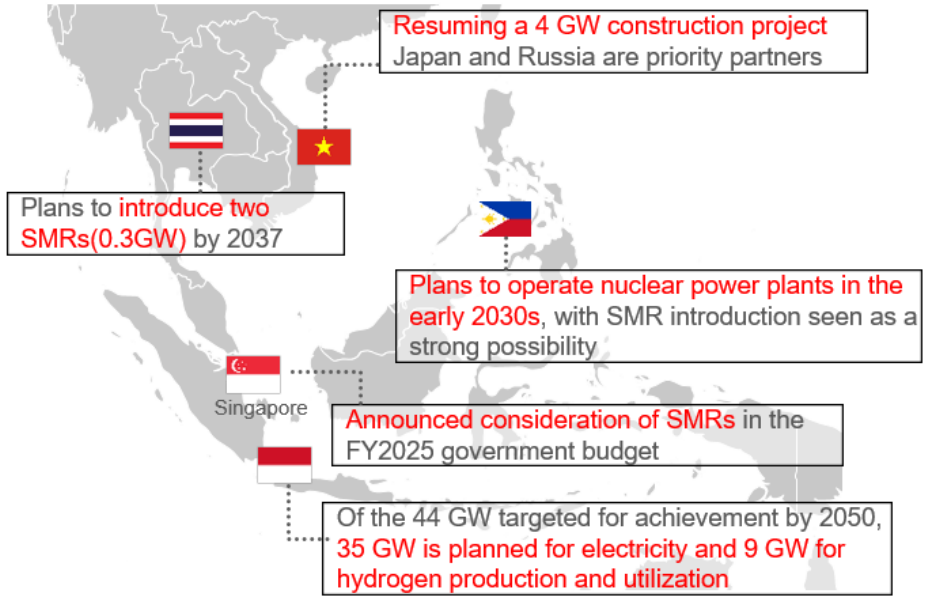
Progress: Status of Nuclear Power

Targets for Nuclear Power Capacity in ASEAN

Several countries have announced long-term nuclear power targets (Currently, no commercial nuclear power plants are in operation in ASEAN).



Trends in Nuclear Power Expansion in Major ASEAN Countries



Driven by commitments to decarbonization and rapidly growing electricity demand, ASEAN countries are advancing discussions on introducing nuclear power, mainly through SMRs

At present, there are no operational nuclear power plants in ASEAN, but several countries have identified nuclear energy as a key pillar of their diversification strategies. Among these, Indonesia, Vietnam, Thailand, and the Philippines have announced capacity targets. Notably, Indonesia unveiled an ambitious goal in 2025 to build 44GW of nuclear power capacity by 2060. This reflects both the region's commitment to CN and rapid growth in electricity demand driven by population increase and economic expansion.

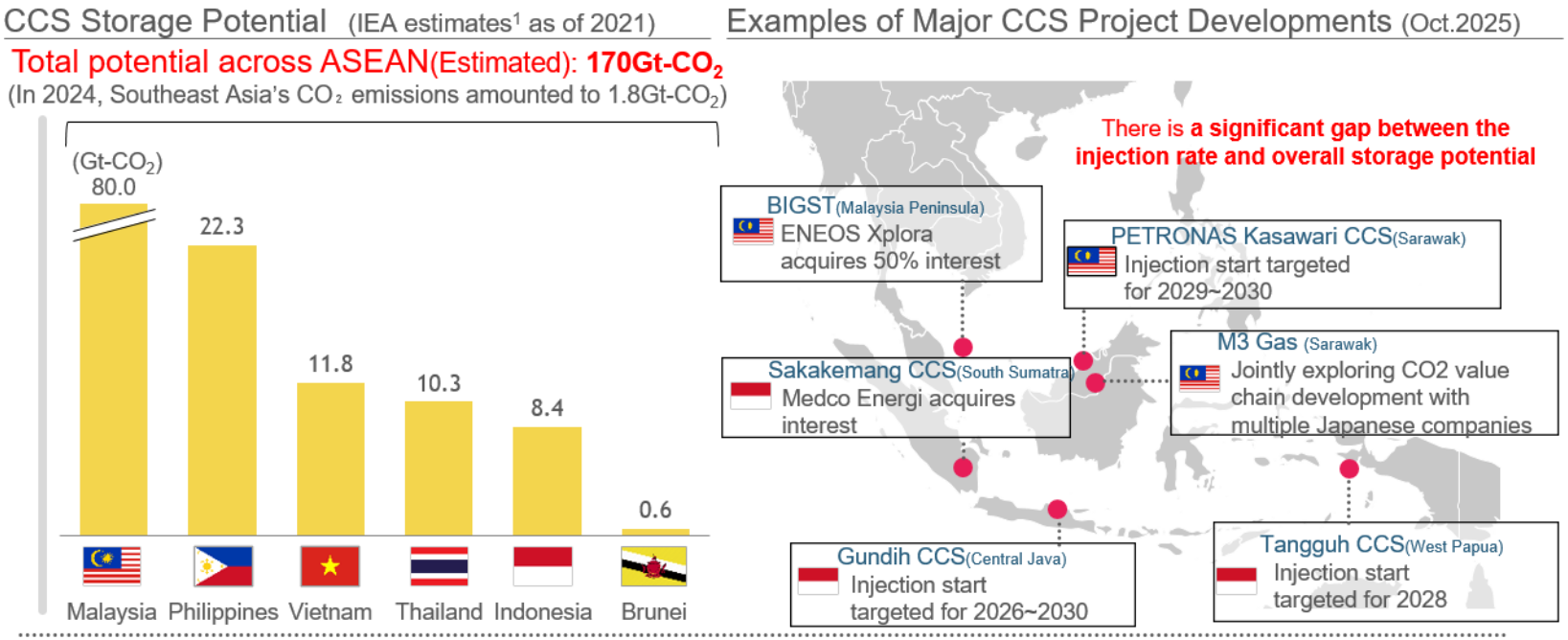
While all countries remain in the early stages of development—marked by feasibility studies, construction planning, and government budget considerations — more progressed plans are gradually taking shape. For instance, under Vietnam's 4GW nuclear development plan, Japan and Russia have been designated as priority partners, illustrating ASEAN's willingness to leverage international expertise to advance nuclear deployment initiatives.

---

1. Aiming for nuclear power to account for 1% of electricity generation by 2037, with a specific plan to achieve 0.6 GW through two SMRs

Source: ANTARA; Reuters; Nucnet; Enerdata; Public Information

Progress: CCS Technology



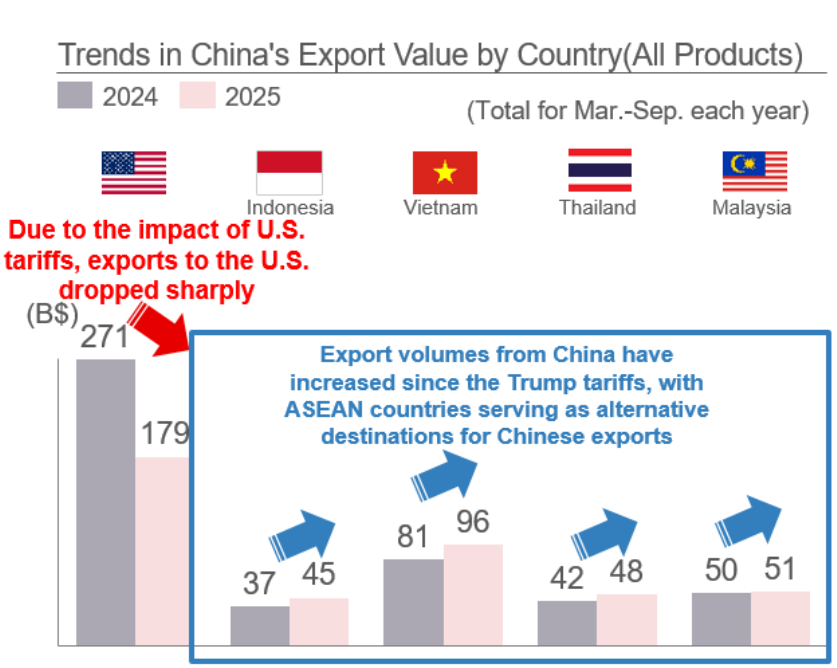
Southeast Asia has high CCS storage potential, with project development progressing mainly in Malaysia and Indonesia

One of the CN technologies generating high expectations within ASEAN is CCS. Several estimates of ASEAN's CCS storage potential have been produced by international organizations and think tanks. According to the IEA's 2021 report "Carbon Capture, Utilisation and Storage: The Opportunity in Southeast Asia (2021)", the estimated CCS storage potential for the ASEAN region is 170 Gt-CO_2 (170 billion tons-CO_2). Considering the total CO_2 emissions for all of Southeast Asia in 2024 were 1.8 Gt-CO_2, this scale is equivalent to nearly 100 years' worth. By country, Malaysia has most potential at 80 Gt-CO_2, accounting for half of the region's, followed by the Philippines (22.3 Gt-CO_2) and Vietnam (11.8 Gt-CO_2)

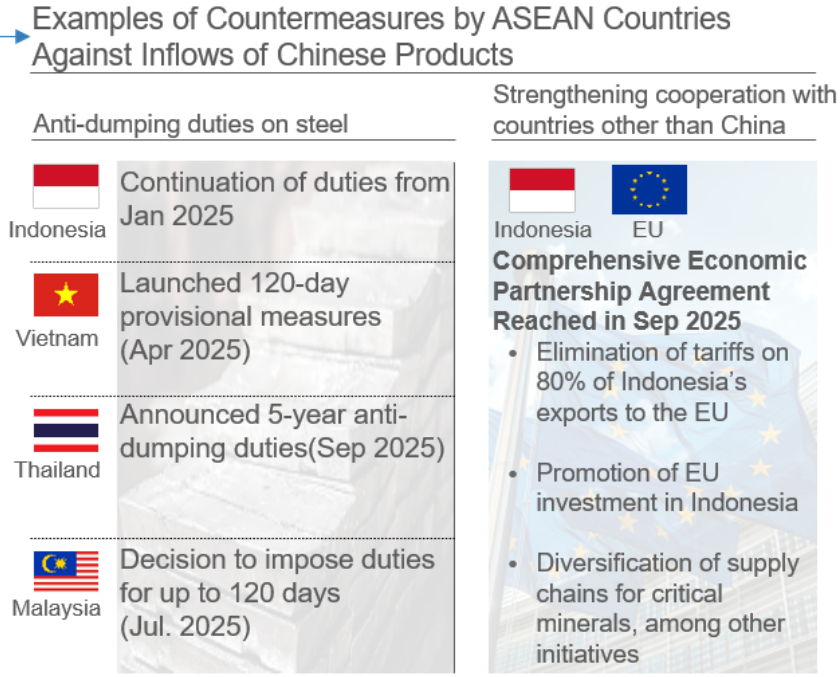
Estimates for CCS storage potential vary significantly, with some reports, like ERIA's Comprehensive CCUS Research Report: Storage, Value Chain, Policy & Regulation and Financing (2024), projecting an even larger combined potential of 214 Gt-CO_2 for Indonesia, Malaysia, Brunei, Thailand, Vietnam, and the Philippines. Large-scale CCS projects are currently underway, particularly in Indonesia and Malaysia. At the Kasawari CCS project off Sarawak, CO_2 injection is scheduled to begin in 2025. However, even with its relatively high injection rate of around 3.7 million tons of CO_2 per year (Mt-CO_2/yr), extensive further development will be required to fully unlock ASEAN's storage potential.

Note: Injection refers to the process of compressing and drying captured CO_2 and sealing it into geological formations such as depleted gas fields or saline aquifers
1. In addition to this estimate, organizations such as ERIA and OGCI have also published CCS storage potential figures, with variations existing between the published numbers depending on the issuing entity. According to ERIA's 2024 report, the combined potential for Indonesia, Malaysia, Brunei, Thailand, Vietnam, and the Philippines is 214 Gt-CO2.
Source: IEA (1/2); IEA(2/2); Public information

ASEAN's Trade with China



Following the decline in China's exports to the U.S., ASEAN countries have become alternative destinations for Chinese products



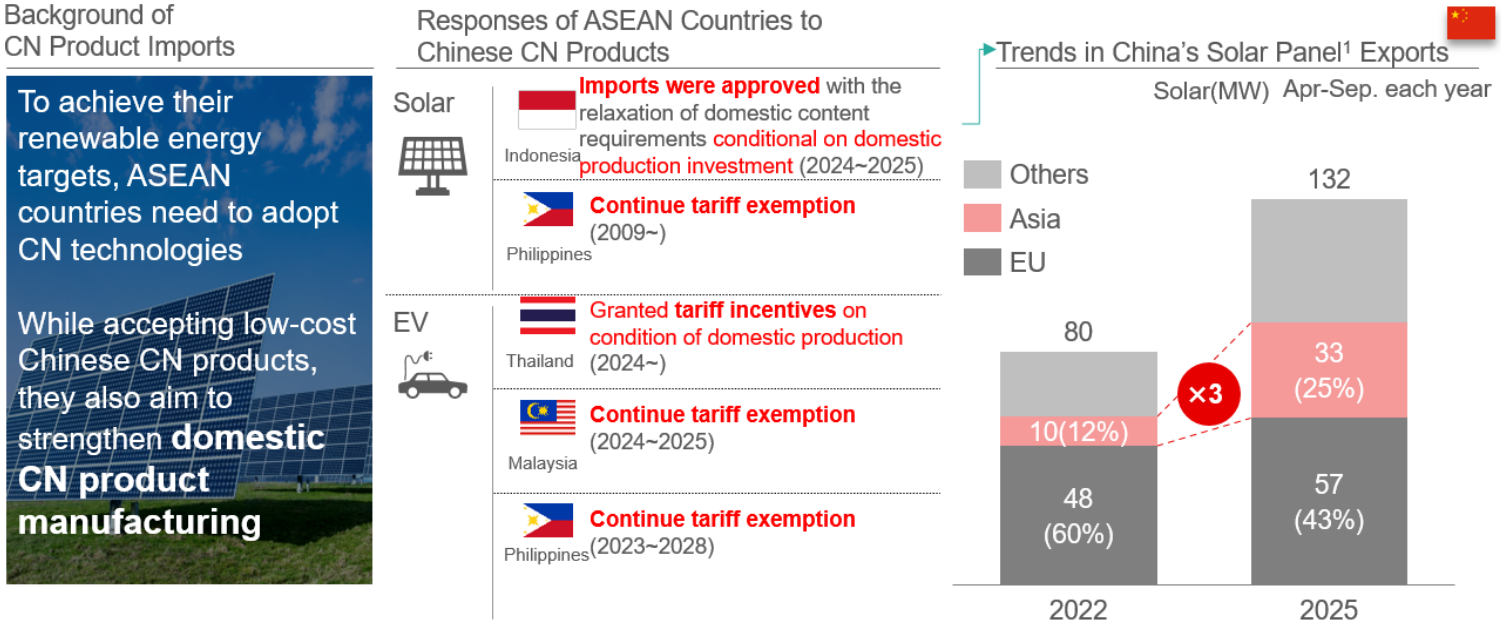
ASEAN countries are beginning to implement countermeasures in response to a sharp increase in imports of Chinese products

A major challenge is the influx of Chinese products to ASEAN which are no longer going to the U.S market due to the impact of tariffs. As Chinese exports to the U.S. have dropped, ASEAN has picked up the slack. In response, ASEAN nations have imposed countermeasures, the most immediate being the imposition of anti-dumping tariffs on steel. Indonesia has continued its duties on Chinese steel that predate the Trump tariffs, while Vietnam, Thailand, and Malaysia have enacted or decided on provisional tariff measures.

On a more medium-to-long-term basis, Indonesia has sought to strengthen economic cooperation with Europe. In September 2025, Indonesia reached an agreement on a Comprehensive Economic Partnership Agreement (CEPA) with the EU, aiming for partial tariff reductions on exports and increased European investment inflows.

Source: General Administration of Customs of the People's Republic of China HP; Public information

Status of ASEAN's Response to Imports of Chinese CN Products



To achieve both renewable energy expansion and domestic manufacturing enhancement, many countries are continuing to promote CN product imports while attracting foreign investment

In response to the rapid surge of Chinese imports, ASEAN countries have generally tightened countermeasures for general products, while adopting a more receptive stance toward CN-related products in order to prioritize renewable energy expansion.

Many ASEAN member states have set ambitious renewable energy targets driven by international CN commitments, and achieving these goals requires the large-scale adoption of CN technologies and products. Because low-cost Chinese CN products—such as solar panels—significantly lower the economic barriers to renewable deployment, many ASEAN countries have maintained tariff exemptions or low tax rates on CN imports even after the U.S. imposed additional tariffs on Chinese goods. At the same time, excessive dependence on Chinese products poses a risk to ASEAN's long-standing objective of strengthening domestic manufacturing industries. Consequently, countries such as Indonesia and Thailand are shifting away from purely import-driven approaches and imposing localization requirements for Chinese investment and technology. For example, Indonesia's amendment to the Renewable Energy Equipment Procurement Regulation in 2024 mandates a minimum local production ratio of 40%, effectively requiring Chinese companies to invest in domestic manufacturing in exchange for market access. Through such measures, ASEAN aims to balance the expansion of renewable energy deployment with the development of its own CN manufacturing base.

---

1. Export capacity of solar panels
Source: Ember-China's Solar PV Export Explorer; Public information

Summary

1. Amid demands for power source diversification to ensure stable energy supply, and the need to align with international standards for export expansion, **ASEAN countries have set renewable energy targets and are gradually promoting adoption, despite facing constraints such as fossil fuel power decommissioning costs.**

2. There are initiatives towards implementing ETS and carbon taxes, inspired by the EU's CBAM. Additionally, there is a drive to promote multilateral renewable energy trading within the region. **The region is tracking the EU's approach to pursuing economic growth, but full-scale efforts on industrial CN are yet to come.**

3. Alongside the introduction of renewable energy, ASEAN is **exploring the promotion of diverse energy and CN technologies, including strengthening LNG infrastructure, constructing new nuclear power plants, and launching CCS projects** that leverage regional potential.

Chapter2 Summary

Summary of Each Country's Trends

	Selection of Support Technologies to Strengthen Domestic Industry and DC Demand	Aiming to Strengthen Domestic Industry but Facing Challenges	Maintaining position as a manufacturing powerhouse	Industrial Expansion through Affordable Renewable Energy to Meet Growing Demand	Gradual CN in Cooperation with Developed Nations and for Energy Diversification
Industrial Characteristics	Aiming to reshore domestic manufacturing industries • Intention to bring back hollowed-out domestic manufacturing	Aiming to strengthen regional industries • Intention to protect regional industries and prevent outflows	Aiming to maintain domestic industries • Trade frictions are a concern, but China retains competitive industries	Aiming to build domestic industries • Shift focus from agriculture and services to manufacturing promotion	Aiming to build domestic industries • Region aims for "China+1" and promotes manufacturing
	Interest in utilizing domestic energy resources such as shale gas	Leveraging "CN" to foster industry growth through regulation-driven approaches	Leverages domestic demand for technology development and expands market share through cost competitiveness	Seeks growth while responding to rapidly expanding energy demand	Aims for economic growth through strategic partnerships with developed nations
Approach to CN	A second Trump administration would steer toward selective support for technologies • Continued support for LNG and nuclear power; reduced support for offshore wind and EVs	CN policies will continue with the aim of enhancing competitiveness while maintaining CN efforts • "Competitiveness Compass," "European Green Deal,"	Leads the world in renewable energy adoption and will continue expansion • In 2024, China accounts for 60% of global renewable energy adoption	As renewable energy costs are low, progress continues toward achieving non-fossil energy introduction targets	While CN following developed countries is necessary for attracting foreign companies and strengthening exports, renewable energy lacks cost competitiveness
	Increasing power demand from data centers drives the introduction of renewables such as solar energy	However, facing challenges such as rising energy costs and competition with Chinese products	Increasing production capacity for new technologies such as hydrogen (electrolyzers) and synthetic fuels, and nuclear power generation	Expansion of green hydrogen using inexpensive renewables and nuclear power introduction is also underway	Meanwhile, each country sets renewable energy introduction targets and proceeds gradually alongside energy diversification into LNG and nuclear power

Summary of Each Country's Trends

Looking back at our analysis thus far, it is clear that even amid significant global instability and growing concerns about the uncertain environment surrounding CN technologies, countries are advancing their CN responses by leveraging their own industrial structures and energy environments, focusing on areas where they can most readily enhance competitiveness.

The U.S. has leveraged CN technologies to strengthen its industries, aiming to revive its hollowed-out domestic manufacturing sector and reduce its trade deficit with China. This effort is underpinned by the natural gas supply capacityunlocked by the shale revolution and abundant capital. Under the second Trump administration, a shift from "broad-based support" to "selective support" has led to a slowdown in offshore wind and EVs. However, alongside natural gas and nuclear power receiving policy backing, solar and onshore wind—as economically viable clean power sources—are expected to advance, driven by robust electricity demand.

Europe has pursued renewable energy deployment and regulation-driven market formation to enhance energy security and accelarate CN technologies industrialization. Amid soaring energy prices and growing dependence on China, broader support measures focused on industrial competitiveness are being implemented. Progress is evident in renewables, EVs, and hydrogen, while expansion efforts are also visible in LNG and nuclear power.

Leveraging its massive domestic demand and long-established manufacturing capabilities, China has aligned its industrial policies with the global shift toward CN, achiving overwhelming cost competitiveness in solar, batteries, electrolyzers, EVs, and other fields. Already dominating the global market in CN technologies, China is expected to expand its CN-related investments to further solidify its position as a "manufacturing powerhouse."

India is promoting the advancement of its manufacturing industry and strengthening energy security against the backdrop of inexpensive renewable energy and rising energy demand driven by population growth. In addition to reinforcing domestic supply chains in the automotive and IT industries—areas where competitiveness can be readily enhanced—the country is expected to accelerate its efforts to expand green hydrogen production using renewable energy and increase exports.

ASEAN is promoting manufacturing as a "China +1" destination, while setting renewable energy targets and gradually expanding adoption to diversify power sources for stable energy supply and harmonize international standards to boost exports. Beyond introducing renewable energy, ASEAN is also seeking to diversify its energy sources and promote CN technologies through measures such as strengthening LNG infrastructure, building new nuclear power plants, and developing CCS projects that leverage the region's potential.

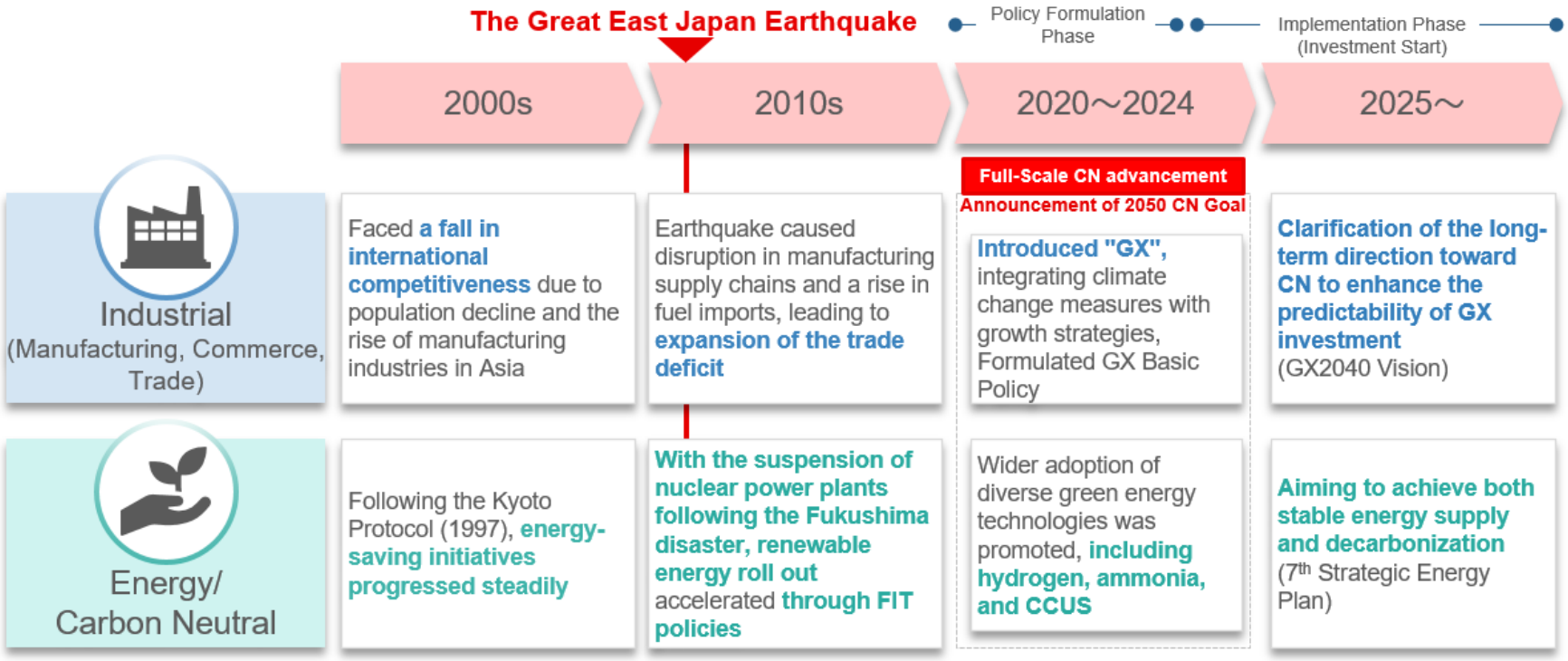
Considering these national trends, the next chapter turns to Japan. It reviews Japan's industrial and energy/CN policy trends and investment movements, in line with the analysis for other countries, then maps the structure and challenges of key sectors and considers the policies and initiatives needed to advance the transition in a way that fits Japan's industrial context.

Contents

Japan: Trends in CN Policies and Investments

Trends in Industrial and CN Policies in Japan

After the phase of policy formulation, which brings together industrial and CN policies, and a period of strategic development, Japan is entering implementation phase



Trends in Industrial and CN Policies in Japan

Looking back at changes in Japan's industrial and energy/CN policies, a distinctive feature is that the country has consistently pursued measures centered on energy conservation over the long term. The backdrop is Japan's structural constraint of scarce domestic energy resources, a very low energy self-sufficiency rate among OECD countries, and heavy dependence on imported fossil fuels.

After the oil crises of the 1970s, it became widely recognized that instability in energy supply posed a fundamental risk to the nation's economy and to people's lives. The idea that "reducing overall energy consumption contributes to national energy security" took root domestically. The government then institutionalized this concept through the 1979 Act on the Rationalization of Energy Use of and Shift to Non-fossil Energy, promoting efficiency improvements across industry, transport, and households. Because manufacturing sectors that consume large amounts of energy—such as steel, chemicals, and automobiles—supported Japan's economic growth and were a source of international competitiveness, energy conservation came to be positioned as an element of industrial policy for cost reduction and competitiveness. The statement that "energy conservation contributes to competitiveness and security" became the backbone of Japan's industrial and energy policies thereafter.

Energy conservation was not viewed merely as an environmental measure but as a means of preserving Japan's autonomy against "external risks," namely dependence on overseas resources. This thinking was carried forward in the 1997 Kyoto Protocol. Rather than immediately introducing European-style carbon taxes or emissions trading schemes that imposed strict reduction obligations of 6 % below 1990 levels for 2008 to 2012, Japan chose a uniquely Japanese approach centered on strengthening energy conservation and improving efficiency through industry-led voluntary action plans.

From the 2000s onward, policy reforms progressed in parallel with power-market liberalization and the expansion of renewable energy. However, the Great East Japan Earthquake in 2011 and the Fukushima Daiichi accident forced a major shift in the energy supply structure. With most nuclear power plants taken offline, the share of nuclear in the generation mix fell from about 30% in 2010 to under 1%, and Japan expanded fossil-fuel imports to fill the gap. As a result, in addition to a deterioration of the trade balance, industrial electricity tariffs rose by about 30%, which had a serious impact on corporate earnings and international competitiveness.

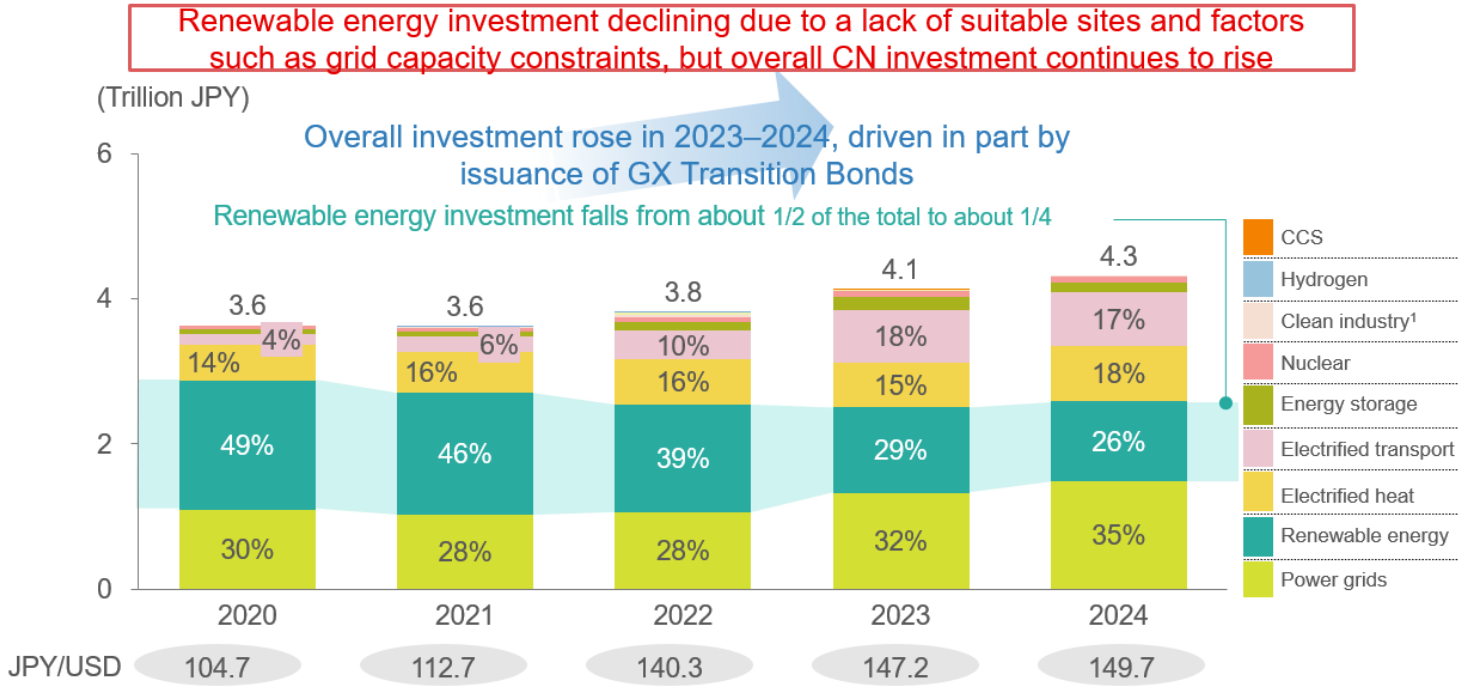
These developments exposed the limits of an energy-efficiency-first policy in ensuring energy security. In July 2012, under the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities, the government launched the FIT to spur the spread of renewables. The share of renewables in domestic installed capacity, which had been about 9% in 2010, rose to approximately 22% by 2021, led by solar PV. In 2013 the Energy Conservation Act was amended to further enhance demand-side efficiency. Policy support such as expanding the Top Runner program and providing BEMS (Building Energy Management System) subsidies in the building sector improved energy efficiency per unit of GDP by about 8 % over the ten years following the earthquake. Thus, after the Great East Japan Earthquake, Japan pursued an energy policy centered on a diversified and stable supply, combining conservation, renewables, and thermal power. Nonetheless, reliance on fossil fuels remained high and greenhouse-gas emissions temporarily increased. By the mid-2010s Japan fell into a situation where it was sometimes labeled a "laggard in environmental progress" among major advanced economies.

Meanwhile, as global trends moved toward progressively stronger carbon regulations, the European Green Deal announced in 2019 set out the concept of "climate-neutral competitiveness," which served as a stimulus. Japanese companies began to face rising risks of being left behind, particularly in export industries such as automobiles, materials, and electronics. The opening of the Task Force on Climate-related Financial Disclosures (TCFD) framework and the practical requirement for supply-chain emissions management became de facto export conditions, and the government was increasingly expected to present clear guidance at the policy level.

Trends in Industrial and CN Policies in Japan

In October 2020 the Suga administration announced the 2050 Carbon Neutral declaration, and in 2021 the Act on Promotion of Global Warming Countermeasures was amended to enshrine the CN target in law. In 2022 the GX Implementation Council was established, and under the Green Transformation (GX) policy that integrated climate measures with economic and industrial strategy, work proceeded on a roadmap for economic and social transformation toward decarbonization and on the design of related systems. Having passed through this initial policy-and-institution design phase, Japan is now, step by step, transitioning into an implementation phase in which private-sector GX-related investment proceeds under the GX 2040 Vision.

Investment Trends by Clean Technology Type in Japan



Total investment in Japan's clean technology sector has shown an upward trend over the past five years. Particularly in 2023 and 2024, the increased utilization of “GX Climate Transition Bonds” contributed to a noticeable expansion in investment. However, examining investment trends by technology reveals clear differences. Investment in renewable energy has continued to slow, with its share declining from about half to one-quarter of the total, due to structural factors such as the reduction of suitable sites and grid constraints. On the other hand, the electrification of transportation, including EVs, has expanded steadily, driving investment throughout the five-year period. By 2024, this sector accounted for approximately 17% of total clean-related investment.

Regarding the absolute amount of investment itself, compared to other countries examined in Chapter 2, it remains relatively small as of 2024, representing about 3.5% of China's level and about 8.4% of the US level. Furthermore, while investment in power transmission and distribution networks and electrification of heat utilization experienced temporary declines, it has shown a recovery trend in recent years. By 2024, these sectors accounted for 35% and 18% of total clean energy investment, respectively. The expansion in these areas is positioned as a core investment domain supporting the advancement of energy supply infrastructure and the electrification shift in industries.

---

1. Industrial projects pursuing net-zero emissions through carbon-neutral technologies, including clean steel, clean ammonia, circular economy, and bioplastics initiatives 2. Using the five-month moving average value for December of each year, MUFG Exchange Rate Chart Source: BloombergNEF. Note: Start years differ by sector, but all sectors are present from 2020 onwards. Most notably, power grids start in 2020. CCS refers to carbon capture and storage.

CN-related Progress in Japan Over the Past Year

Alongside the "GX2040 Vision" and the "7th Strategic Energy Plan," the government has offered support through GX Economy Transition Bonds

Progress of Policies

Industrial
(Manufacturing, Commerce, Trade)

Energy/ Carbon Neutral

The "GX2040 Vision"
Established to enhance the predictability of GX investment amid rising uncertainty in the investment environment

Newly formulated policy vision through 2040

The "7th Strategic Energy Plan"
In addition to the 2030 target (6th plan), the 7th plan sets a target for 2040

New energy plan to realize the policy vision

GX Economy Transition Bond Policy Support

- Support for industrial process conversion
  - Steel
  - Paper・Pulp
  - Chemical
- Support for CN technologies
  - Perovskite solar cells
  - Floating offshore wind power
  - Water electrolysis
  - Fuel cells
  - HVDC cable
- Hydrogen and ammonia price gap support(start of adoption)

Source: METI HP (1/3); METI HP(2/3); METI HP(3/3)

CN-related Progress in Japan Over the Past Year

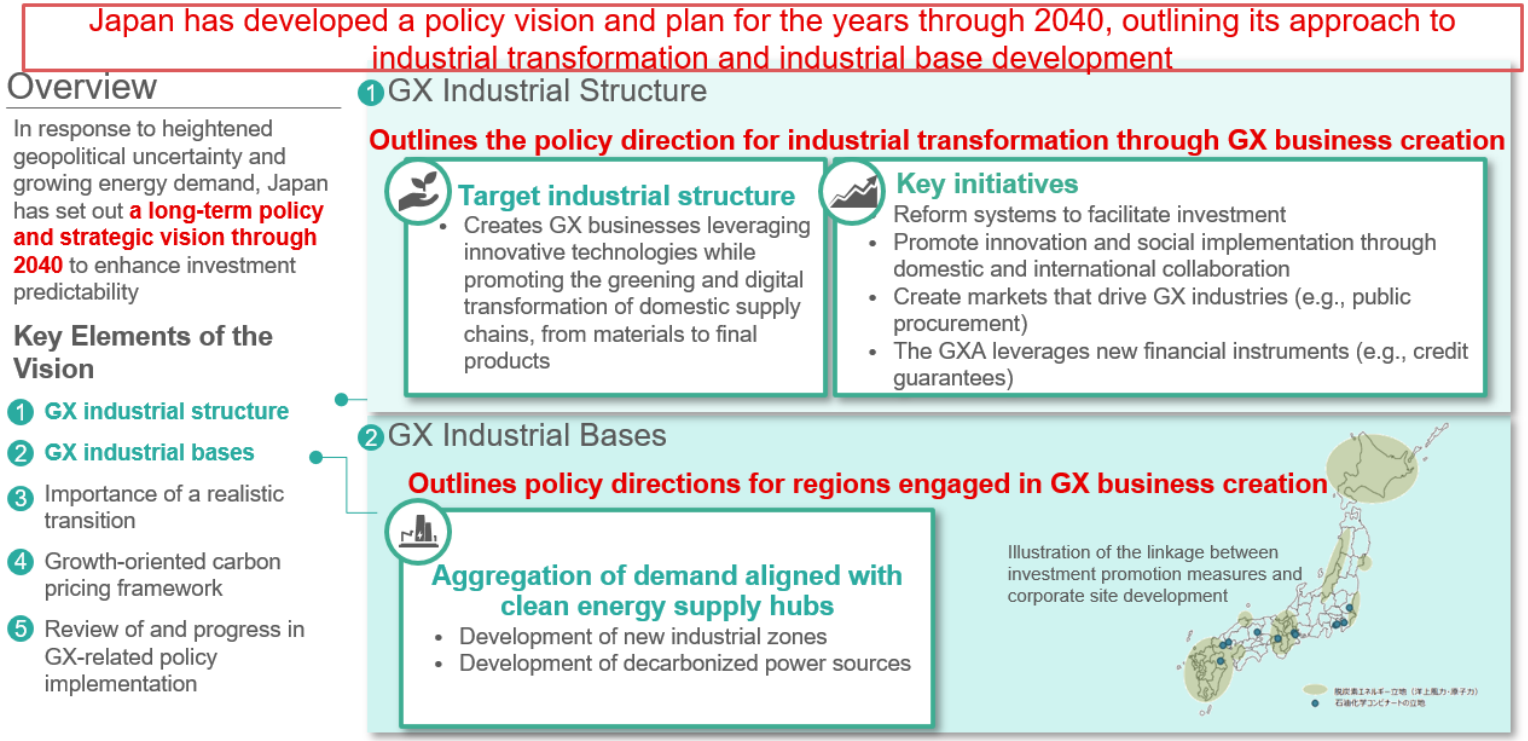
Looking back on 2025, major changes over the past year include the Cabinet's approval in February of the "GX 2040 Vision" and the "7th Strategic Energy Plan," which clarified Japan's medium- to long-term policy direction, as well as the launch of initiatives to support structural transformation in existing industries and the social implementation of CN technologies through the use of GX Climate Transition Bonds.

As discussed later, the GX 2040 Vision sets out a roadmap to 2040 for sharing visibility on GX-related investment between the public and private sectors, and provides guidance for driving energy transition and industrial restructuring on the basis of GX. Recognizing Japan's challenge of having innovative players and technologies but not scaling them up to commercialization quickly enough, the Vision underscores the need for wide-ranging measures such as improving corporate governance and capital-market frameworks to support growth investments and creating markets that will underpin emerging GX industries.

The 7th Strategic Energy Plan presents the outlook for the power supply mix through 2040 and lays out measures to achieve both stable energy supply and decarbonization. A key feature is the policy of introducing renewables to the maximum extent as main power sources; under this policy, Japan aims to shift away from its traditional dependence on fossil fuels and raise the share of renewables to around 40–50%.

In this way, Japan is working to build an integrated framework of policies, industrial measures, and investment conditions that uses GX as a lever to promote structural change in the economy while simultaneously delivering energy transition and supply stability.

CN-related Progress in Japan Over the Past Year: the GX 2040 Vision



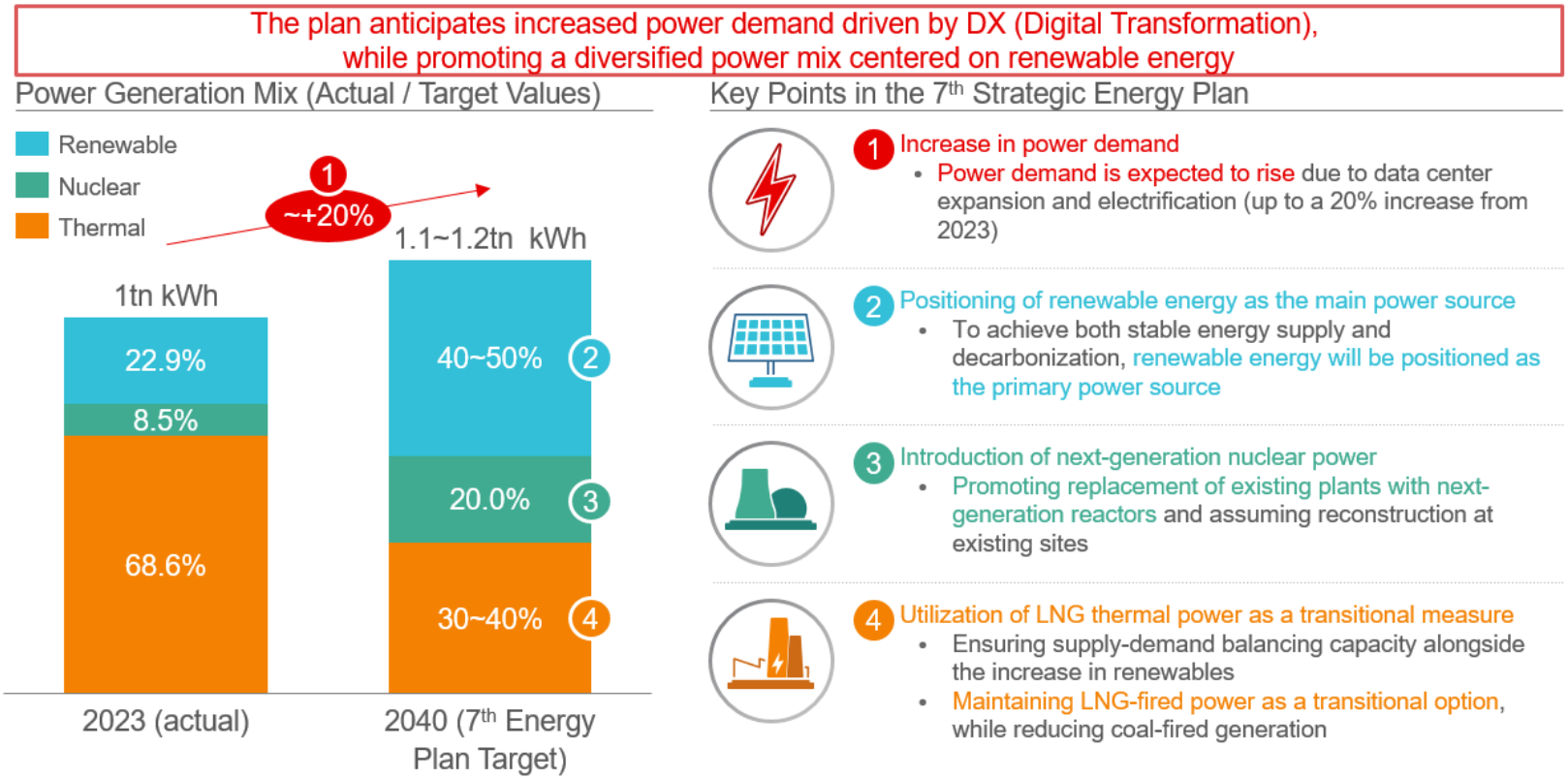
Amid heightened uncertainty about the future, including escalating international tensions and projected increases in electricity demand, the Japanese government formulated the “GX2040 Vision” to enhance the predictability of the investment environment. Positioned as a long-term policy guideline looking ahead to 2040, this vision presents strategic directions across diverse sectors. Of particular note are the two pillars that form the basis for cross-industry CN promotion: the “GX Industrial Structure” and “GX Industrial Locations”

The GX Industrial Structure’s vision aims to promote the creation of new GX businesses utilizing innovative technologies and to advance Japan's strengths by greening and digitizing the entire supply chain, from materials to products. To support this, institutional reforms to boost growth investment and the utilization of new financial methods (e.g., debt guarantee systems by the GX Acceleration Agency) were proposed.

Meanwhile, a policy for the GX Industrial Locations has been announced to promote the development of new industrial locations and decarbonized power sources in suitable locations nationwide in order to concentrate demand around clean energy supply bases. This is expected to lead to the implementation of location-linked investment promotion measures that link the energy supply capacity of each region with industrial concentration.

Source: Ministry of Economy, Trade and Industry

Trends in the Past Year: The 7th Strategic Energy Plan

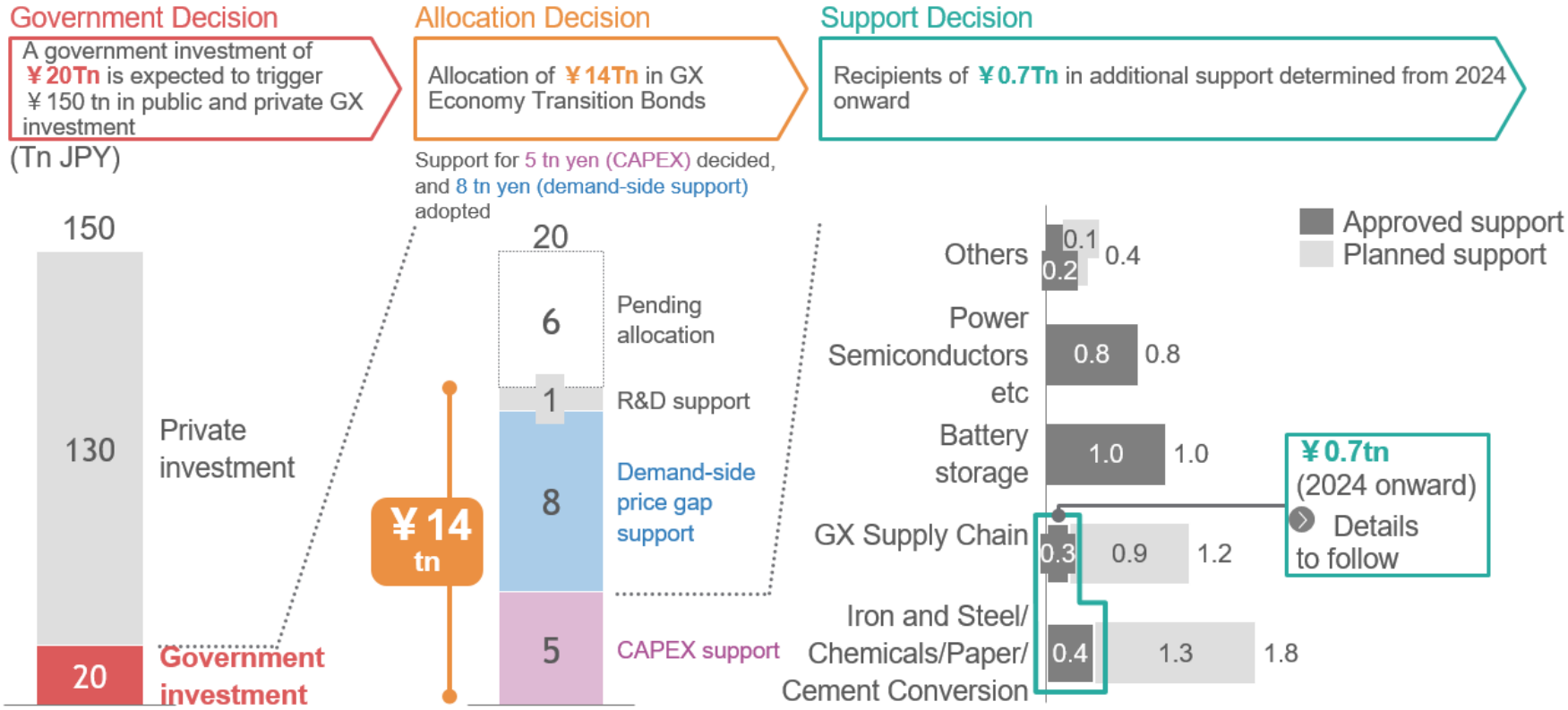


The 7th Strategic Energy Plan, formulated around the same time, projected that electricity demand by 2040 would increase by approximately 20% compared to 2023 due to the progress of digital transformation (DX). It outlined a policy to maintain a diverse power source mix while placing renewable energy at its core.

To achieve both stable energy supply and decarbonization, this plan explicitly states the policy of introducing next-generation nuclear power, based on the premise of replacing existing plants, while also advancing the phase-out of inefficient coal-fired power generation. Meanwhile, it incorporates the view that LNG (liquefied natural gas) thermal power will continue to be utilized as an important power source during the transition period. Thus, the 7th Strategic Energy Plan is characterized by presenting a realistic transition strategy for Japan's energy mix.

Source: Agency for Natural Resources and Energy Outline of the Basic Energy Plan; METI HP

Trends in the Past Year: Policy Support through GX Climate Transition Bonds

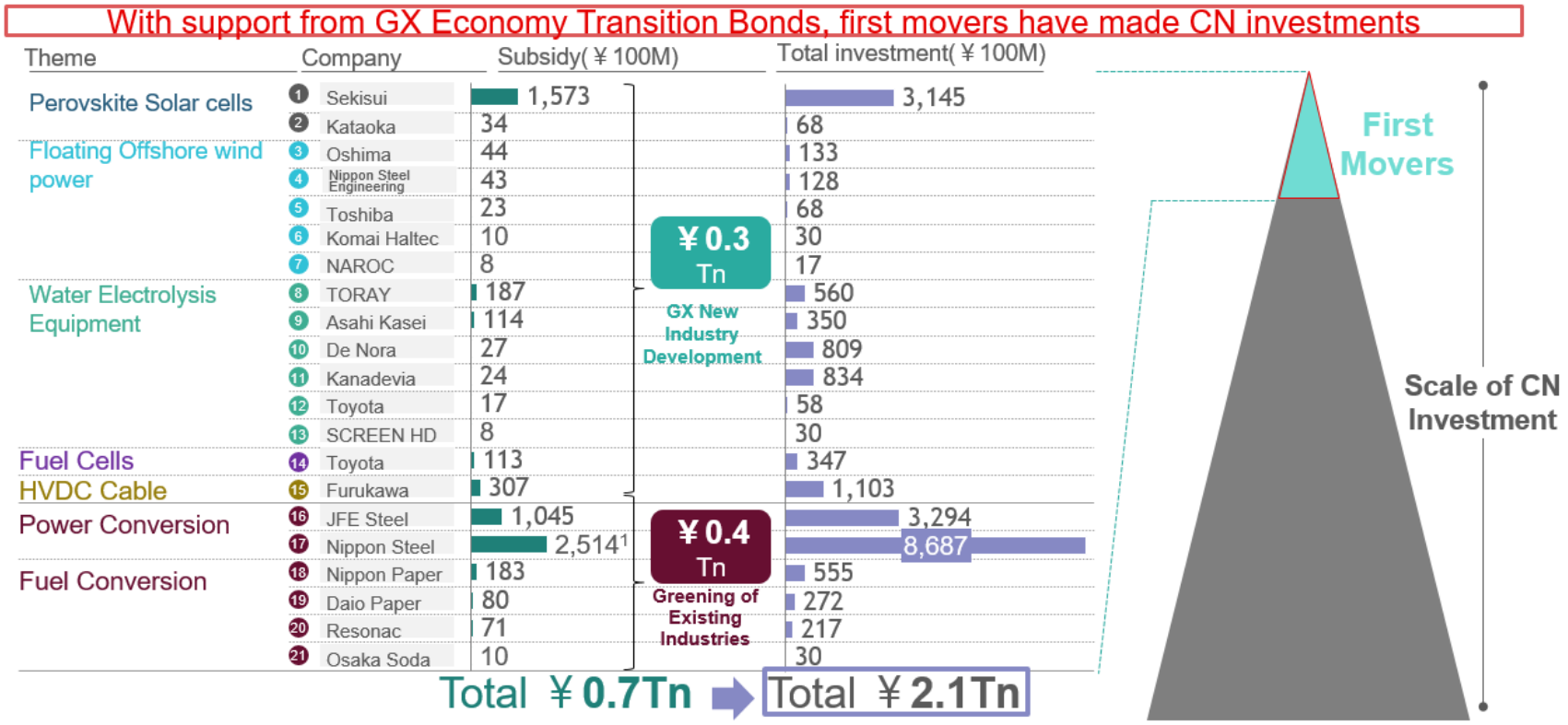


Policy support utilizing GX Climate Transition Bonds is now fully underway. As part of its GX-related investment plan for 2024 and beyond, the government aims to leverage 20 trillion yen in government investment to catalyze approximately 150 trillion yen in total GX investment from both public and private sectors.

Of this, approximately 14 trillion yen of the 20 trillion-yen government investment allocation has already been earmarked. Specifically, for 2024 and beyond, about 0.7 trillion yen has been allocated for capital expenditure (CAPEX) support, and recipients for the 8 trillion yen allocated for consumer support are being sequentially determined. This signifies that the expansion of GX-related investment through public-private partnerships has entered a substantive phase.

Source: GX Implementation Office, Cabinet Secretariat

Policy Support through GX Climate Transition Bonds (From 2024 onward) has Spurred Investments



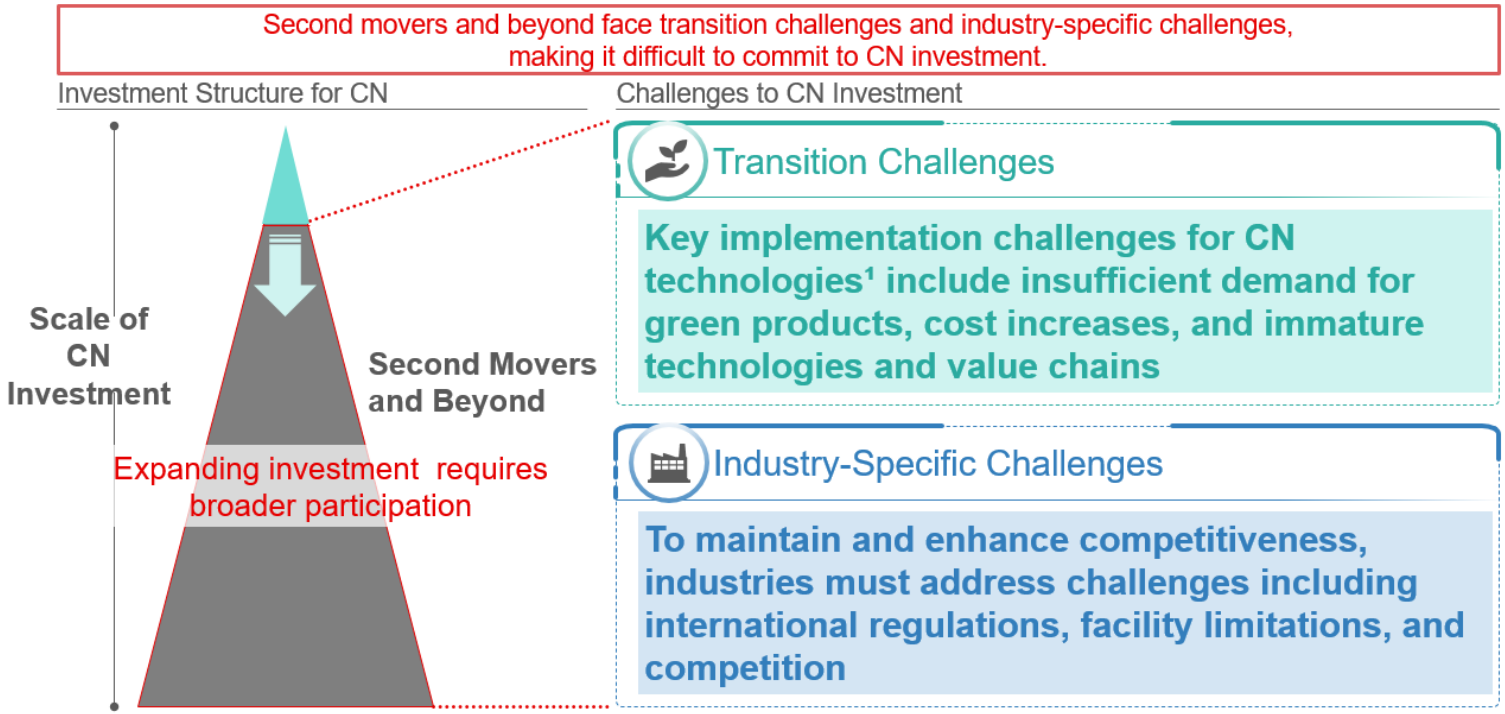
Looking at the policy support projects for GX Climate Transition Bonds decided after 2024, the breakdown of support is 0.3 trillion yen for launching new GX industries and 0.4 trillion yen for greening existing industries, for a total of 0.7 trillion yen. Adding private investment to this, it is expected that a total of approximately 2.1 trillion yen in public and private investment will actually be mobilized. This indicates that GX Climate Transition Bonds are having a certain seed money effect and generating concrete fund circulation.

However, these movements are still at a stage where they can be positioned as pioneering efforts by the “first movers” among the overall investment toward realizing CN for Japan as a whole. In promoting GX and CN going forward, it is important to build on these pioneering examples and evolve to a stage where a wider range of companies take investment action.

---

1. 179.9 billion yen invested in the Yahata area of the Kyushu Works, 42.8 billion yen in the Hirohata area of the Setouchi Works, and 28.7 billion yen in the Shunan area of the Yamaguchi Works; Source: GX Implementation Office, Cabinet Secretariat; Fiscal Year 2025 GX Supply Chain Development Support Program; Support Program for Energy and Manufacturing Process Transformation in Industries Where Emissions Reduction is Difficult2025;2024

Second Movers and Beyond Face Transition and Industry-Specific Challenges



For Japan to accelerate its transition toward achieving carbon neutrality, it is important that companies beyond the “second movers”—those still hesitant to commit to investment—enter the fray. Analysis of domestic companies conducted during the preparation of Whitepaper 4.0 revealed two main challenges these companies face in advancing CN investments.

The first challenge is the “transition challenge” inherent in the process of shifting to CN itself. Specifically, when considering the introduction of hydrogen, ammonia, or e-methane during fuel conversion, structural constraints include: (1) increased costs due to the conversion, (2) no guarantee the market will accept the additional costs after conversion, and (3) an underdeveloped supply chain making stable procurement difficult. These challenges overlap with the price pass through barrier discussed in last year's Whitepaper 3.0 and remain a major factor hindering investment decisions for many companies. The second challenge involves “industry-specific challenges” that each sector must overcome to maintain and enhance its competitiveness while addressing transition challenges.

These challenges stem from each sector's unique technological structure, supply chains, cost composition, and international competitive environment, making uniform solutions difficult to apply. Previous whitepaper series primarily focused on transition challenges, positioning their resolution as key to expanding CN investment. However, Whitepaper 4.0 recognizes that simultaneously addressing the industry-specific challenges faced by each sector will lead to more effective support.

---

1. Examples include hydrogen, ammonia, CCUS, renewable energy, and next-generation nuclear power

Challenges and Strategies for Advancing Japan's GX

Global Trends

Progress in carbon neutrality (CN) initiatives that contribute to industrial competitiveness and national security

Japan's Direction

Through our dialogues with various clients, we have recognized two challenges in advancing further investments.

One is the "transition challenges" encountered when advancing the transition. These include issues such as increased costs due to fuel switching and uncertainty about whether demand will accept the value even after switching.

The other is the "industry-specific challenges" that each industry must address to maintain and strengthen its competitiveness while advancing the transition
There is no one-size-fits-all solution for these challenges. The relationships involved, the order of response, and the timeframe differ by sector.

Thus, in addition to "transition challenges" shared across sectors, stakeholders in Japan must take into account "industry-specific challenges". In addressing these, Japan should promote CN initiatives that reflect its industrial strengths and should do so with a sense or urgency.

Industry-specific challenges
(Challenges to consider when advancing the transition)

×

Transition challenges
(challenges relating to the predictability and profitability of CN projects)

To advance CN competitively and quickly, both sets of challenges must be addressed

Challenges and Strategies for Advancing Japan's GX

Analysis of overseas trends reveals that countries have advanced their CN in areas that enhance their industrial competitiveness and national security. These countries are promoting CN not merely as an environmental policy, but as part of broader efforts to reconstruct their industrial locations and establish technological supremacy, pursuing consistent measures in both policy and investment. Meanwhile, in Japan, under the GX policy and guided by the GX2040 Vision and the 7th Strategic Energy Plan, government-backed CN investment began. However, due to the uncertainty in the international business environment stemming from inflation and the emergence of a second Trump administration, companies remain cautious in their investment decisions.

Domestic industries continue to advance efforts toward achieving long-term CN goals. However, to expand CN investments further, it is important to envolve not only first movers but also the participation of second movers and subsequent companies that currently face challenges and are hesitant to commit to investment. Unless this broadening of the base progresses, the driving force for promoting GX across Japan as a whole will not be sufficiently enhanced.

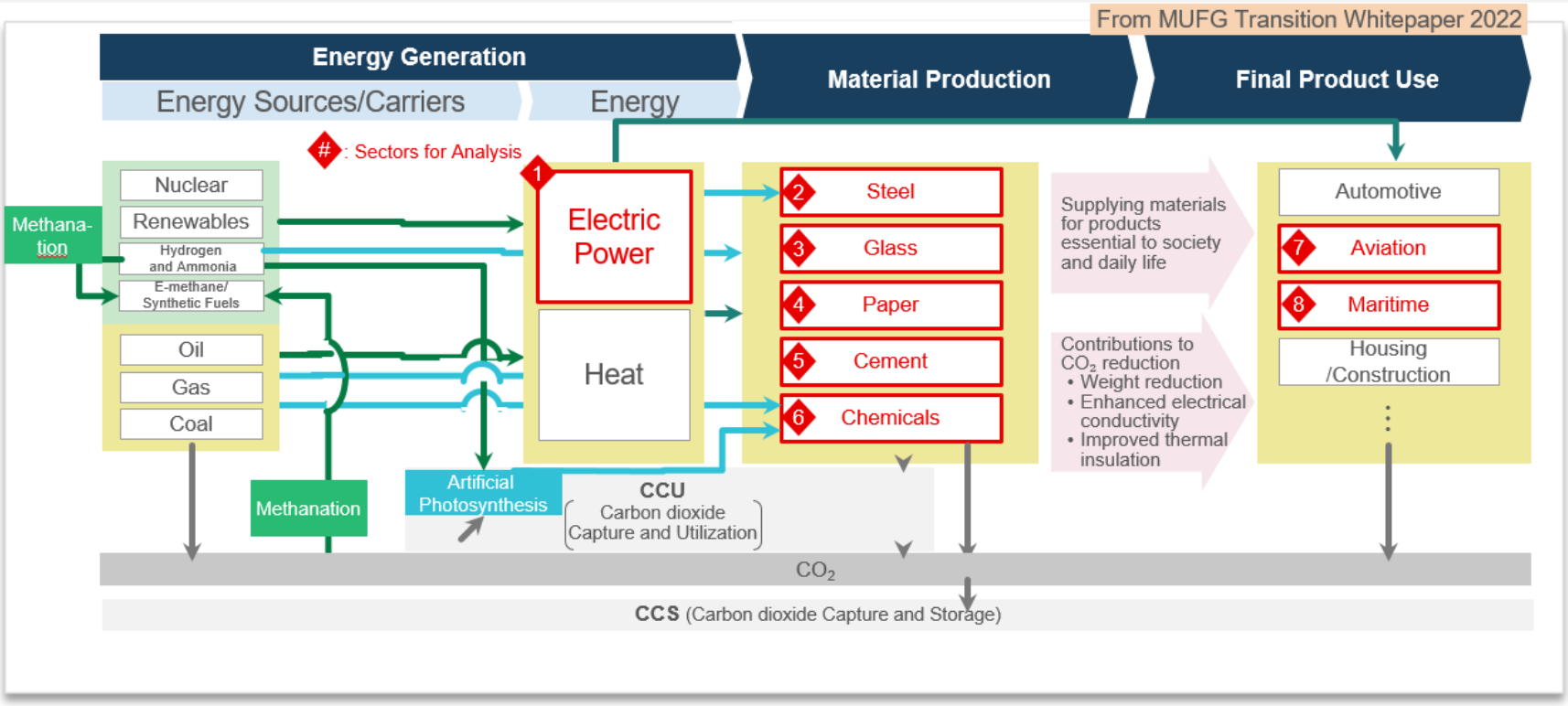
Furthermore, as major countries and regions strengthen their carbon neutrality efforts based on industrial competitiveness and national security, Japan also needs to develop a GX strategy that incorporates these perspectives. As CN adoption advances in major countries and regions, CN transformation is important to enhance industrial competitiveness and security. Nevertheless, proceeding without considering the challenges faced by each sector could actually lead to a decline in competitiveness. In addition to the transition challenges common to all sectors, it is therefore crucial to consider the industry-specific challenges faced by each sector in Japan.

This chapter maps and analyzes the challenges faced by Japan’s major sectors and the directions for their resolution from both industrial and CN transition perspectives.

Challenges and Actions by Sectors

Target Sectors for Challenge Analysis

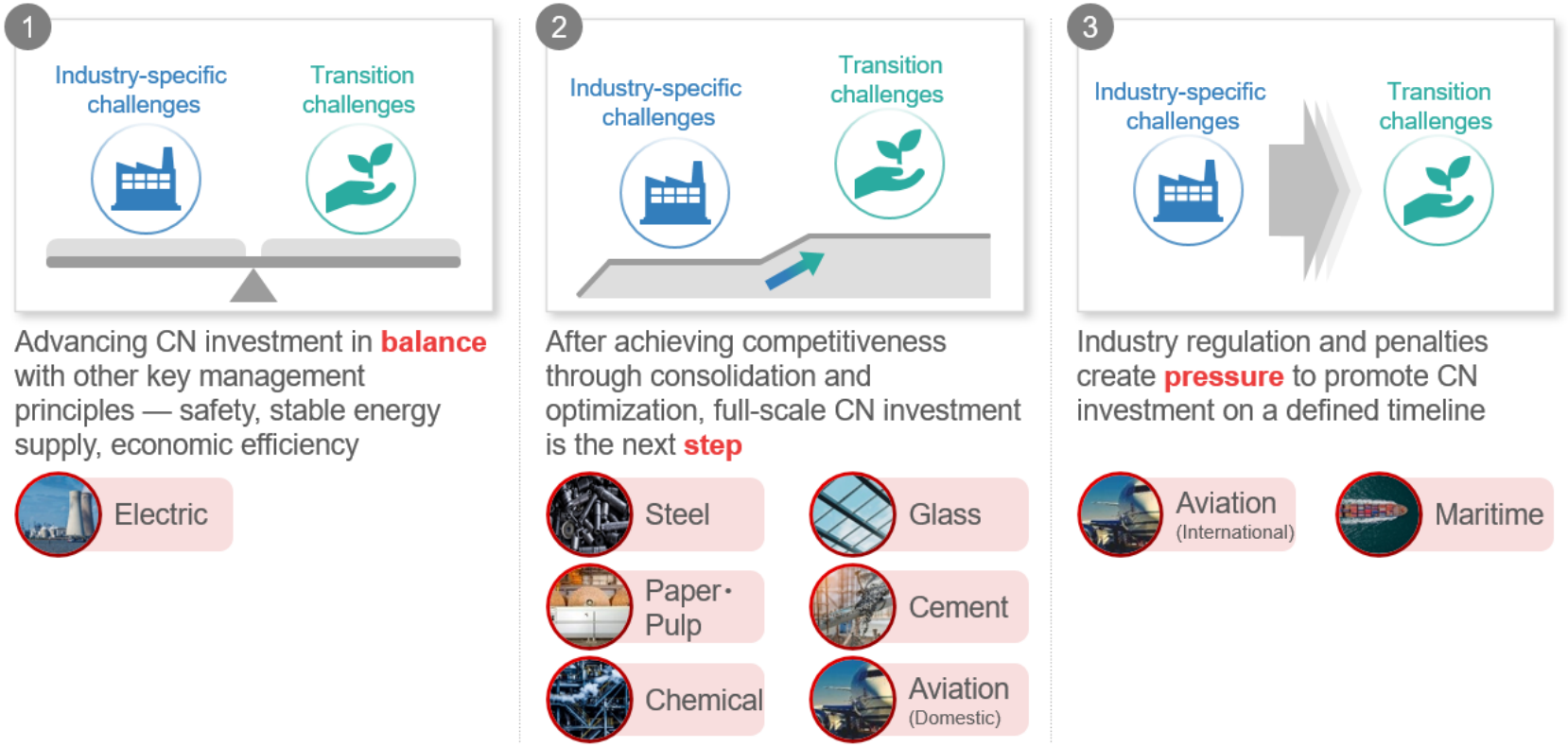
Analyzing the characteristics of Japan's major emitting sectors for their Transition Challenges, Industry-specific Challenges



This chapter examines Japan's major high-emitting sectors. Previous whitepapers described the industrial linkages—(1) using energy sources to produce electricity and heat, (2) using electricity and heat to produce materials, and (3) using those materials to manufacture final products. In Whitepaper 4.0, we focus on eight high-emitting sectors within this value chain and, taking their specific characteristics into account, identify issues from the perspectives of "transition challenges" and "industry-specific challenges," then set out directions for their resolution.

Source: MUFG Transition Whitepaper 2022

The Relationship Between Transition Challenges and Industry-Specific Challenges



The Relationship Between Transition Challenges and Industry-Specific Challenges

It should be noted that none of these challenges can be addressed with a single solution. Industry-specific challenges and transition challenges are interrelated, and their interdependencies, priority for response, and timeframes vary significantly across sectors. Responses across Japan's major industries reveals that transition challenges and industry-specific challenges manifest differently by sector, with certain patterns emerging in their interrelationship. Whitepaper 4.0 categorizes these relationships into three broad types.

The first category (“balance type”) includes sectors like the power industry, where future demand growth is certain. To maintain Japan's overall industrial competitiveness and their own competitive edge, these sectors must simultaneously advance responses to transition challenges while balancing “S+3E” (Safety, Energy Security, Economic Efficiency, Environment). These industries face structural constraints of advancing decarbonization while bearing supply responsibilities, requiring the simultaneous achievement of stable energy supply and environmental goals.

The second category (“step type”) includes sectors like the materials industry, where domestic demand is declining and Chinese players are entering the market, causing the market environment to shift. For these sectors, steps such as optimizing domestic production systems are necessary before fully committing to transition challenges. In other words, addressing industry-specific challenges including restructuring the business foundation takes precedence over transition-related challenges.

The third category (“pressure type”) comprises sectors such as maritime and aviation, which face pressure to address transition challenges due to the international regulations. Failure to advance the transition within a set timeline may result in penalties or operational constraints.

It is crucial for financial institutions (FIs) like MUFG, industry, and government to correctly recognize the relationship between these „transition challenges“ and „industry-specific challenges“, and to jointly advance initiatives toward their resolution, taking into account the circumstances each sector faces.

The significance of categorizing sector-specific challenges

By incorporating a perspective that links "industry-specific challenges" with "transition challenges,"

Companies

For companies,
even when resolving "transition challenges" requires time, deepening stakeholder understanding that prioritizing solutions to "industry-specific challenges" ultimately contributes to advancing the transition. Furthermore, enhanced mutual understanding between companies in different sectors is expected to foster greater collaboration.

Government

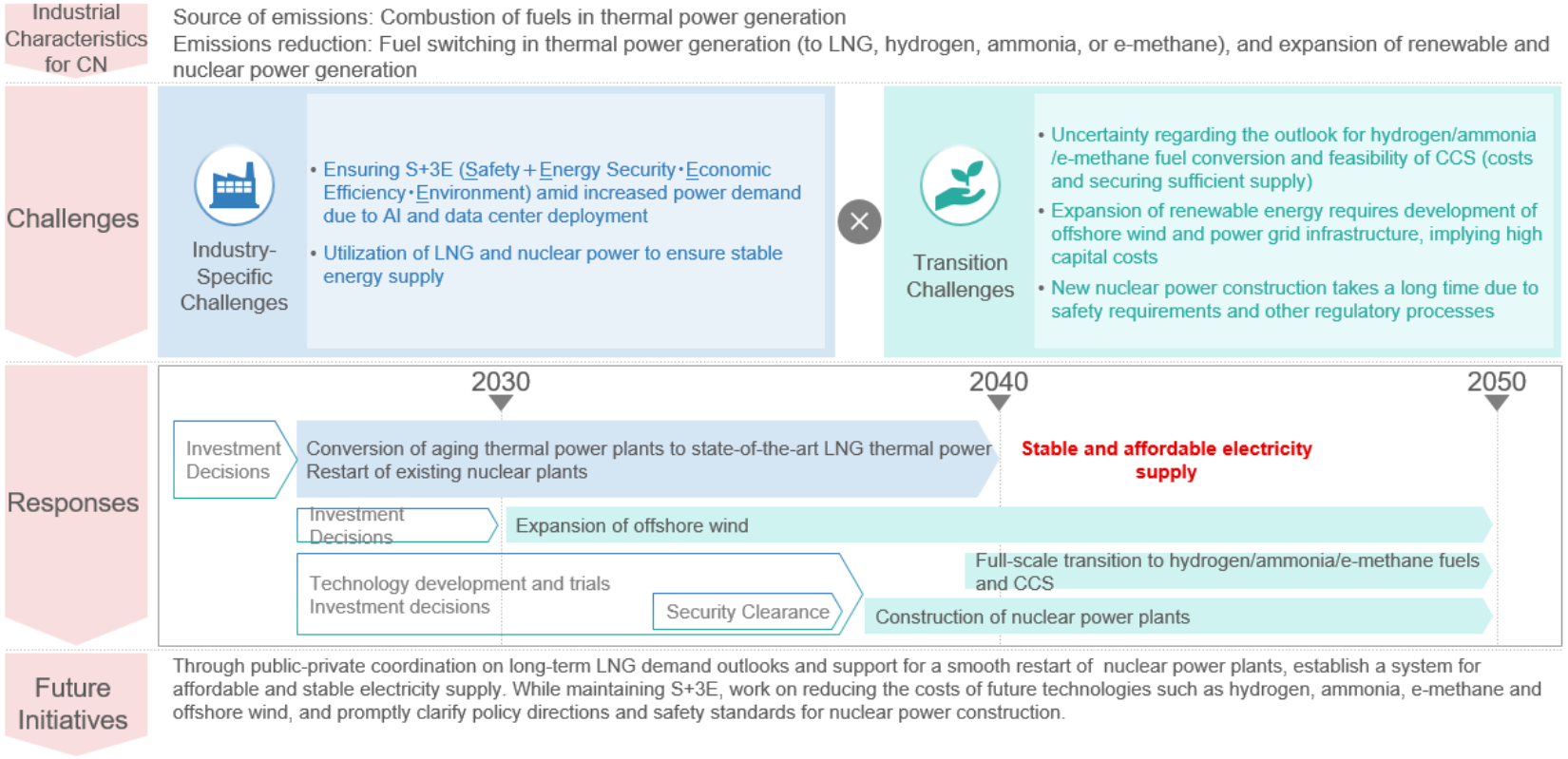
For the government,
considering not only policy support for "transition challenges" but also the "industry-specific challenges" that drive solutions to these issues will lead to more effective policy support.

Financial

For financial institutions,
viewing support for corporate transition as encompassing not only investment assistance for CN technology but also solving "industry-specific challenges" enables further promotion of transition. Furthermore, since CN initiatives often extend beyond supporting individual companies to assist the transformation of entire industrial clusters, understanding each sector's challenges and characteristics enables the facilitation of collaboration among stakeholders and the provision of optimal financial support.

Incorporating a perspective that connects industry-specific challenges with transition challenges across industries, this approach may foster collaboration and lead to optimal support for companies, governments, and financial institutions

Examples (1) : Challenges and Approaches (Power)

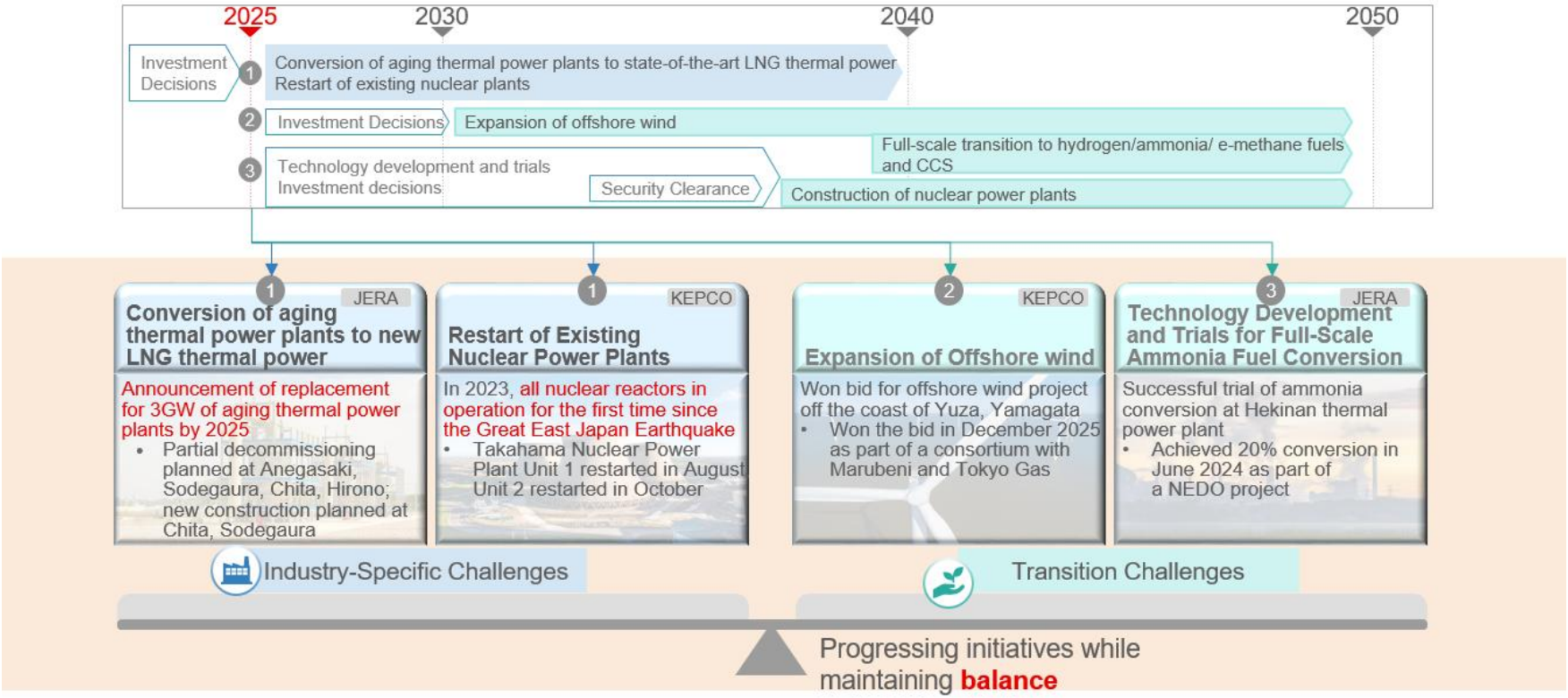


The power sector is required to establish a stable and economically viable power supply system amid anticipated future increases in electricity demand. While balancing the so-called S+3E framework, it must also address transition challenges as one of its key tasks.

The power sector is addressing the critical challenge of stable electricity supply by partially advancing fuel switching from inefficient aging thermal power plants to state-of-the-art LNG thermal power and restarting nuclear power plants. However, even in this area, there remains the difficulty of determining how to proceed with investment while accounting for uncertainties regarding future power demand growth and the composition of the power supply mix.

In parallel, efforts are progressing—with public and private sectors coordinating—to introduce and expand hydrogen, ammonia, and offshore wind power. However, transition challenges such as high costs and ensuring investment predictability must be resolved.

Domestic Industry Initiatives (Power)

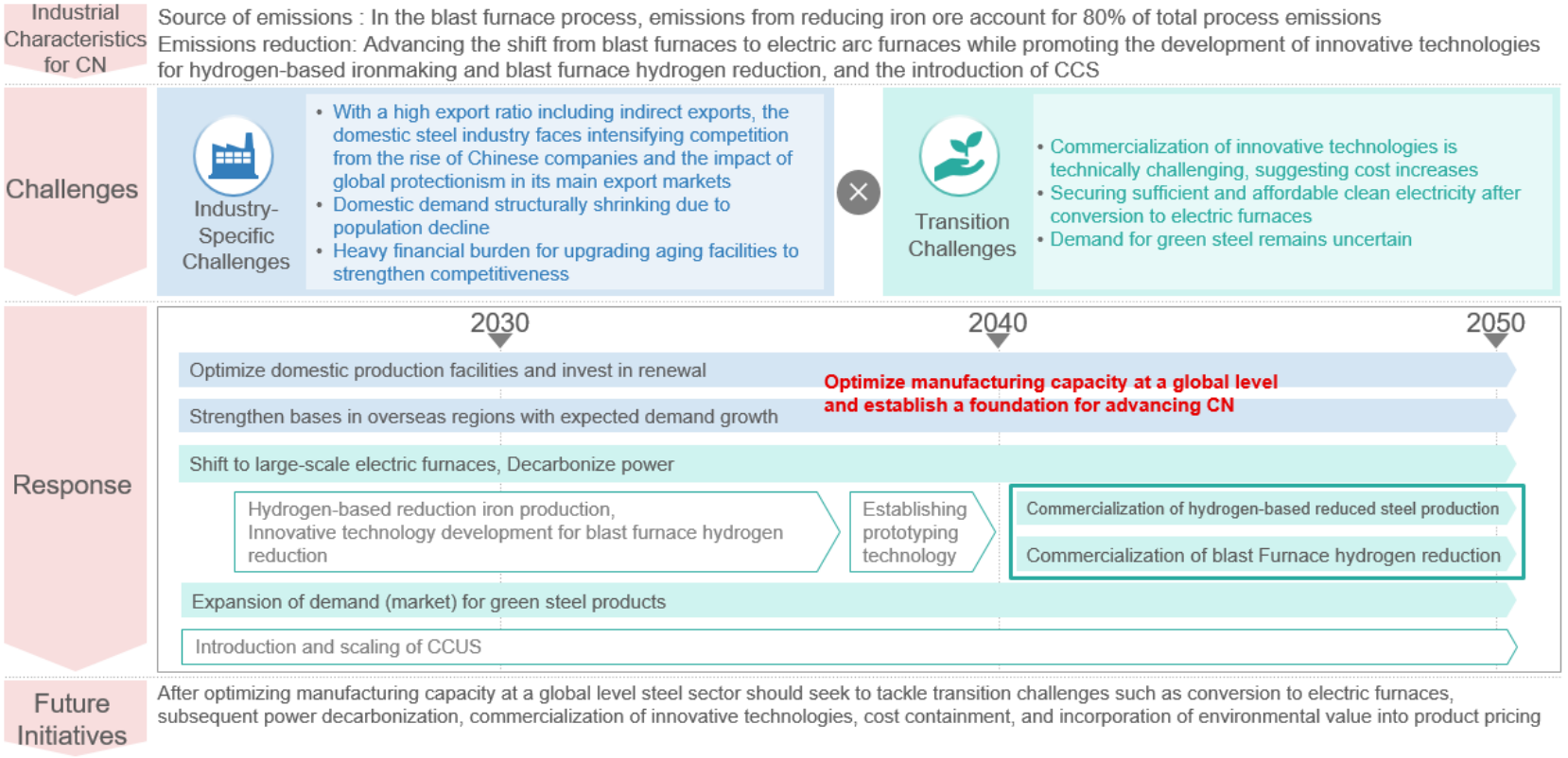


Several examples of corporate initiatives addressing these “industry-specific challenges” and “transition challenges” are presented. JERA, while advancing its shift from inefficient aging thermal power plants to state-of-the-art LNG thermal power generation, announced in 2025 plans to replace 3GW of aging thermal power plants. The breakdown includes partial decommissioning at Anegasaki, Sodegaura, Chita, and Hirono, alongside new construction plans at Chita and Sodegaura. Kansai Electric Power achieved full operation of all its nuclear reactors for the first time since the Great East Japan Earthquake, with the restart of Takahama Unit 1 in August 2023 and Unit 2 in October 2023.

Furthermore, progress is being made in implementing decarbonization technologies to confront both industry-specific challenges and transition challenges. Kansai Electric Power won the bid for the offshore wind power project off Yura Town, Yamagata Prefecture, and is advancing environmental surveys and technical demonstrations both domestically and internationally. JERA successfully conducted the world's first large-scale demonstration of 20% ammonia conversion at the Hekinan Thermal Power Station, accelerating the practical application of fuel conversion technology.

Source. JERA pdf; KEPCO HP; JERA HP; Marubeni HP

Examples (2) : Challenges and Approaches (Steel)

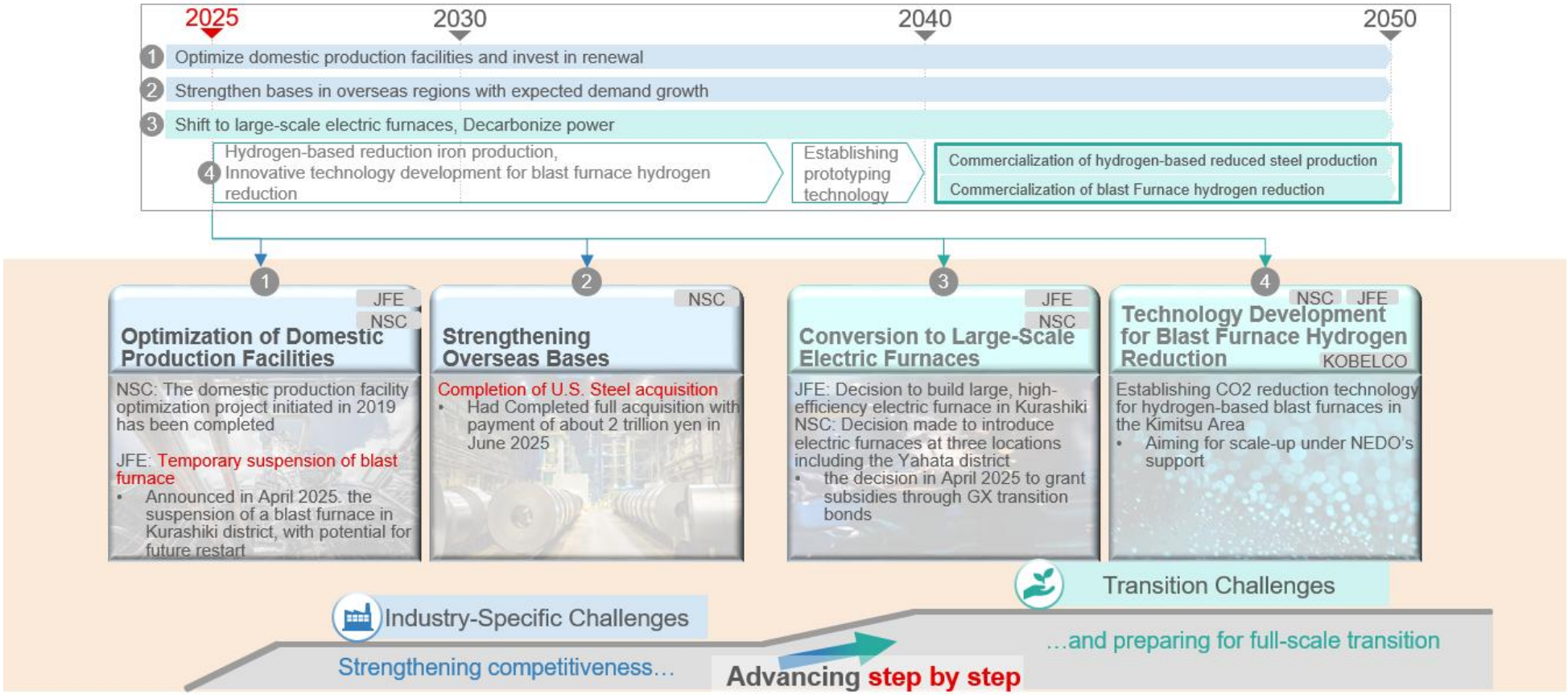


The steel sector faces industry-specific challenges, including intensifying competition due to the rise of Chinese companies in key export markets and declining demand in the domestic market caused by population decline. It has also been significantly affected by the impact of global protectionism.

Transition challenges include the high difficulty of establishing practical application technologies for innovative technologies such as hydrogen reduction, the expected increase in costs, and the uncertainty surrounding demand for green steel.

It is essential to optimize global manufacturing capacity by strengthening overseas bases and rationalizing production systems. After establishing the foundation for CN conversion, efforts must be made to achieve commercial-scale implementation of fuel conversion and innovative technologies while controlling costs. At the same time, it is important to proceed with expanding demand for green steel as a way to pass on environmental value to prices.

Domestic Industry Initiatives (Steel)



Source: Nikkei (1/2); Nikkei (2/2); NSC HP; NSC Press Release; JFE HP

Domestic Industry Initiatives (Steel)

In the steel sector, efforts to address industry-specific challenges and transition challenges are progressing in parallel while adapting to changes in the competitive environment.

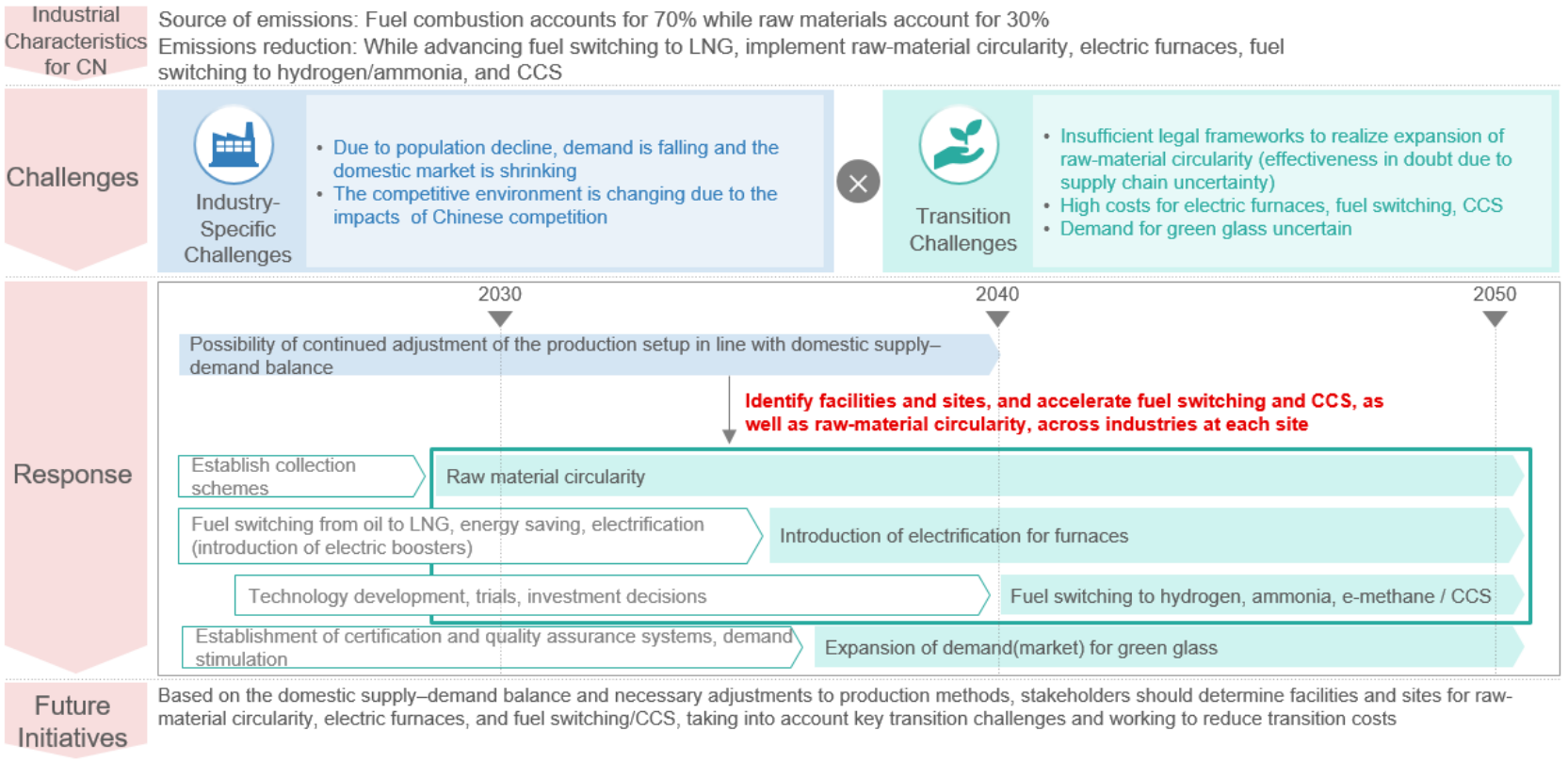
For responses to industry-specific challenges, both Nippon Steel and JFE Steel are advancing the optimization of their domestic production systems. Nippon Steel initiated and completed its optimization in 2019, while JFE Steel announced plans to temporarily reduce its domestic crude steel production capacity by approximately 20% by suspending operations at its Kurashiki blast furnace in April 2025. These moves represent part of a business restructuring responding to domestic and international supply-demand shifts, intended to reinforce the industry's foundation.

Efforts to enhance international competitiveness are also advancing. Nippon Steel merged with U.S. Steel as part of its strategy to strengthen overseas bases, completing the transaction in June 2025. This is expected to advance the restructuring of its global supply chain and the optimization of its manufacturing bases.

Preparations for addressing transition challenges are steadily moving forward as the next step. For the shift to large-scale electric arc furnaces, JFE Steel decided to introduce a large, high-efficiency innovative electric furnace in the Kurashiki area, while Nippon Steel decided to introduce electric furnaces at three locations, including the Yahata area. Both companies received support grants from the GX Climate Transition Bonds in April-May 2025.

Furthermore, a consortium comprising Nippon Steel, JFE, and Kobe Steel is receiving support from NEDO to develop blast furnace hydrogen reduction technology. In December 2024, they successfully utilized hydrogen reduction technology at the blast furnace in the Kimitsu area, achieving a world-first 40% reduction in CO_2 emissions, achieving the initial target ahead of schedule.

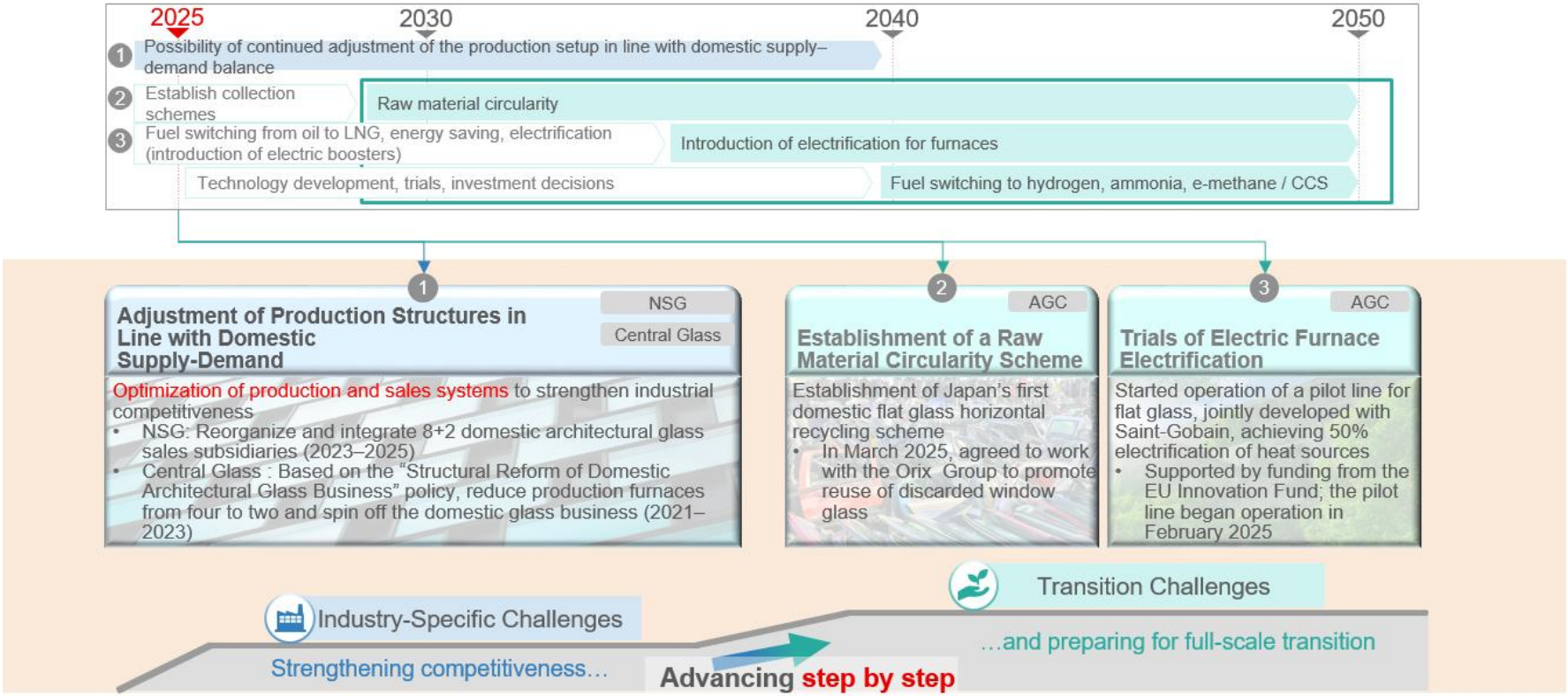
Examples (3) : Challenges and Approaches (Glass)



The glass sector faces industry-specific challenges, including market contraction due to Japan's declining population and changes in the domestic competitive environment caused by the influx of low-priced products from Chinese companies.

Its transition challenges include the lack of legal systems and supply chains to expand raw material recycling. Other challenges include the high cost of electrifying furnaces that melt glass raw materials, fuel conversion, and CCS introduction, as well as uncertain demand for green glass, making it difficult to pass on costs. Therefore, it is necessary to first stabilize the market infrastructure by addressing “industry-specific challenges,” and then implement transition measures in a phased manner.

Domestic Industry Initiatives (Glass)

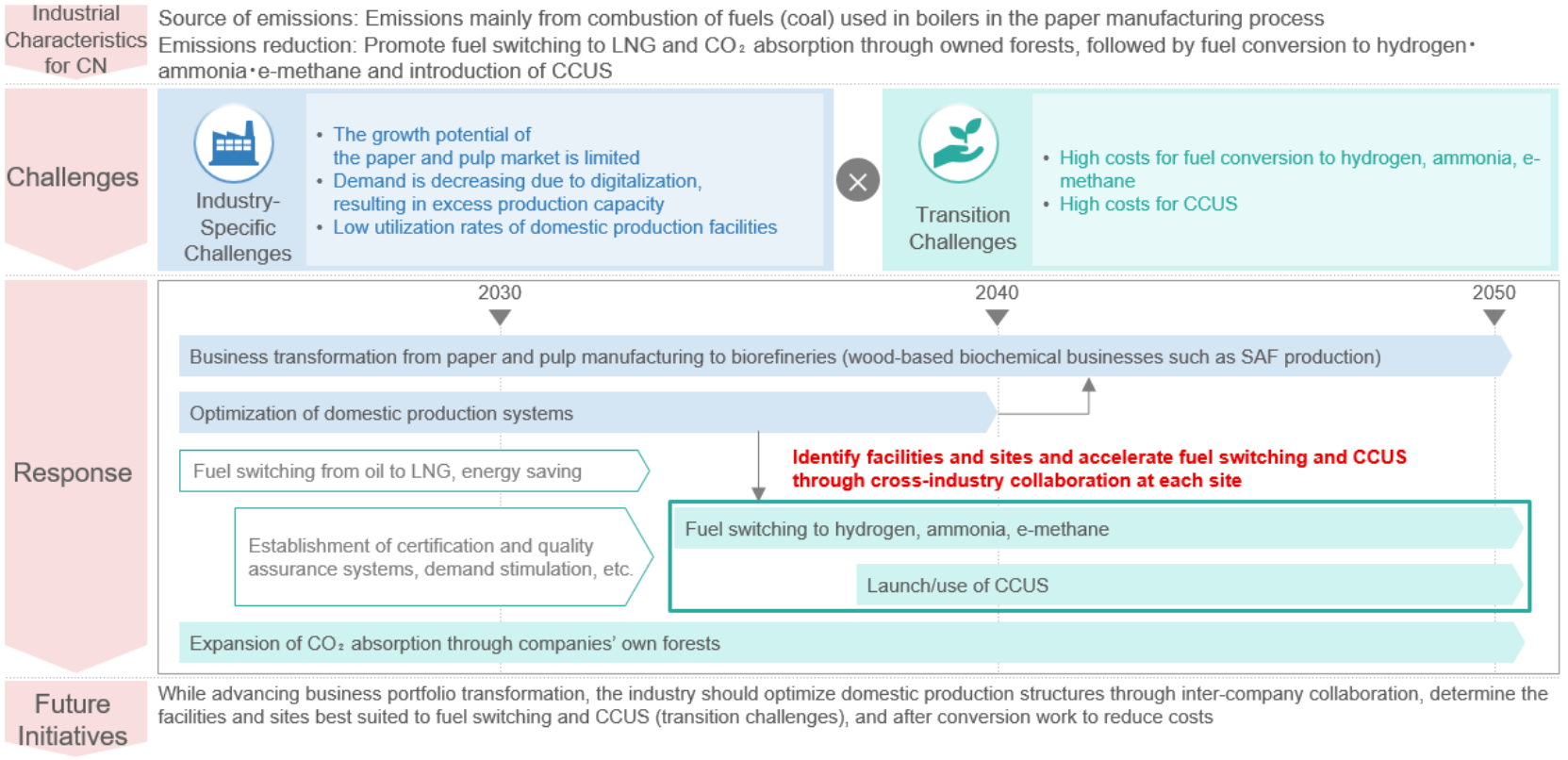


In the glass sector as well, efforts are being made to enhance competitiveness by optimizing production and sales systems in response to domestic supply-demand balance, addressing industry-specific challenges. This is being implemented by Nippon Sheet Glass and Central Glass.

Concurrently, in preparation for the full-scale implementation of future transitions, AGC is advancing preparations through initiatives such as establishing Japan's first horizontal recycling scheme for flat glass as a raw material cycle, and commencing operations of a pilot flat glass line in Europe that has achieved electrification of 50% of its heat sources, building know-how for the future commercialization of fuel switching and electrification.

Source: NSG HP; Central Glass Press Release; Nikkei; AGC HP

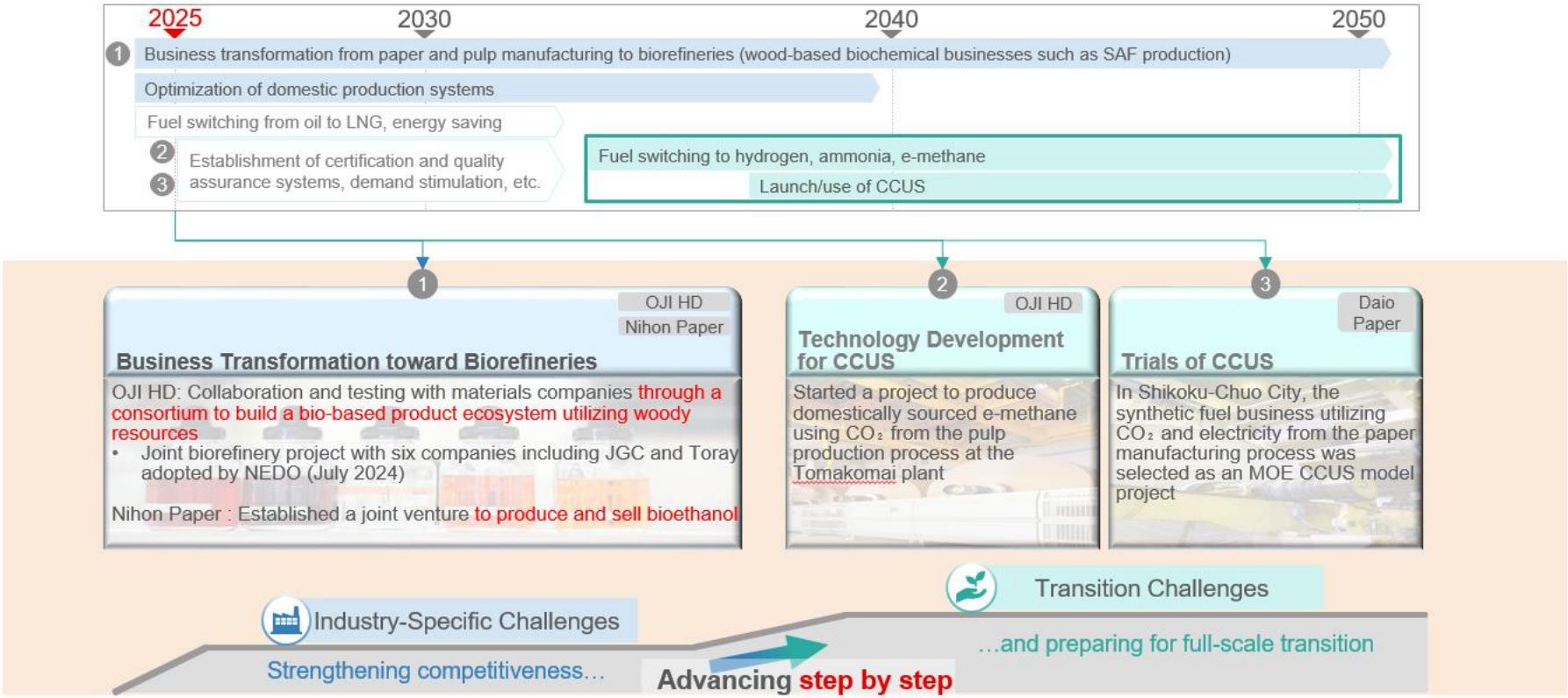
Examples (4) : Challenges and Approaches (Pulp & Paper)



The pulp and paper sector faces an industry-specific challenge of persistently low facility utilization as paper demand declines with digitalization. In response to this structural drop in demand, companies are optimizing production systems and shifting into new business areas, making the preservation of competitiveness and the rebuilding of financial foundations urgent priorities.

On the transition side, the high costs of fuel switching and CCUS are major hurdles. With large-scale investment paybacks still hard to foresee, a pragmatic approach is to first secure financial strength and then proceed in stages. In practice, firms are pursuing diversification toward biorefinery business models in parallel with productivity improvements, while also advancing efforts to expand CO_2 absorption in owned forests.

Domestic Industry Initiatives (Pulp & Paper)



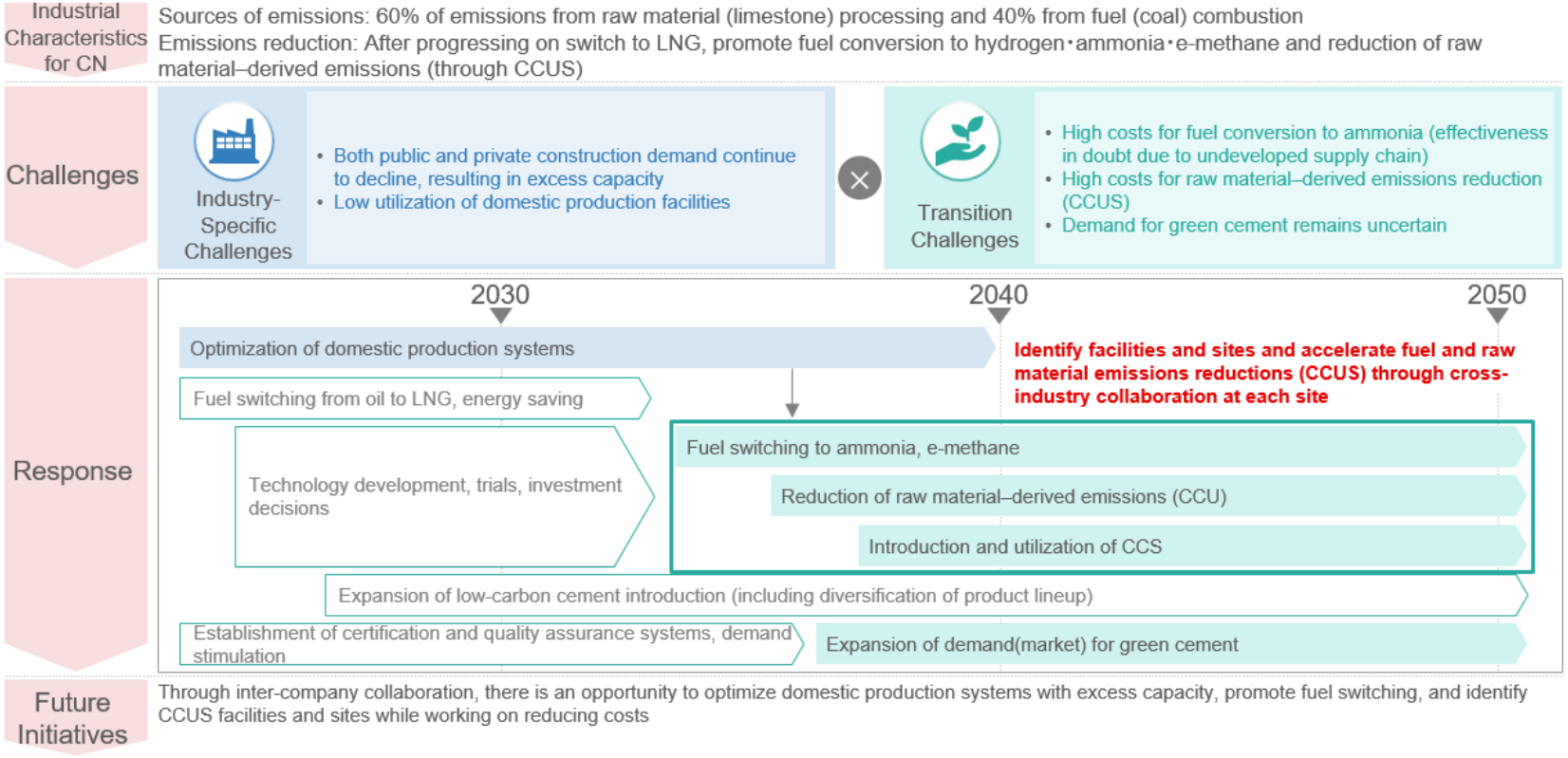
In the pulp and paper sector, companies are attempting to tackle industry-specific challenges by transitioning to biorefinery operations. Oji Paper has formed a consortium with raw material suppliers to build a bio-product ecosystem and is advancing a NEDO project.

While Nippon Paper Industries has established a joint venture to manufacture and sell bioethanol and other products, with each company strengthening its competitiveness. Companies are also advancing preparations to address future transition challenges.

Oji Paper has begun exploring a project to produce pure domestically sourced e-methane at its Tomakomai plant, utilizing CO_2 derived from the pulp manufacturing process as a raw material for fuel conversion to hydrogen, ammonia, and other alternatives. Additionally, Daio Paper has launched a synthetic fuel project in Shikoku-Chuo City utilizing CO_2 and electricity derived from the paper manufacturing process. This initiative has been selected as a CCU model project by Japan's Ministry of the Environment (MOE), accelerating its progress.

Source: OJI HP (1/2); OJI HP (2/2); Nihon Paper HP; Daio Paper HP

Examples (5) : Challenges and Approaches (Cement)

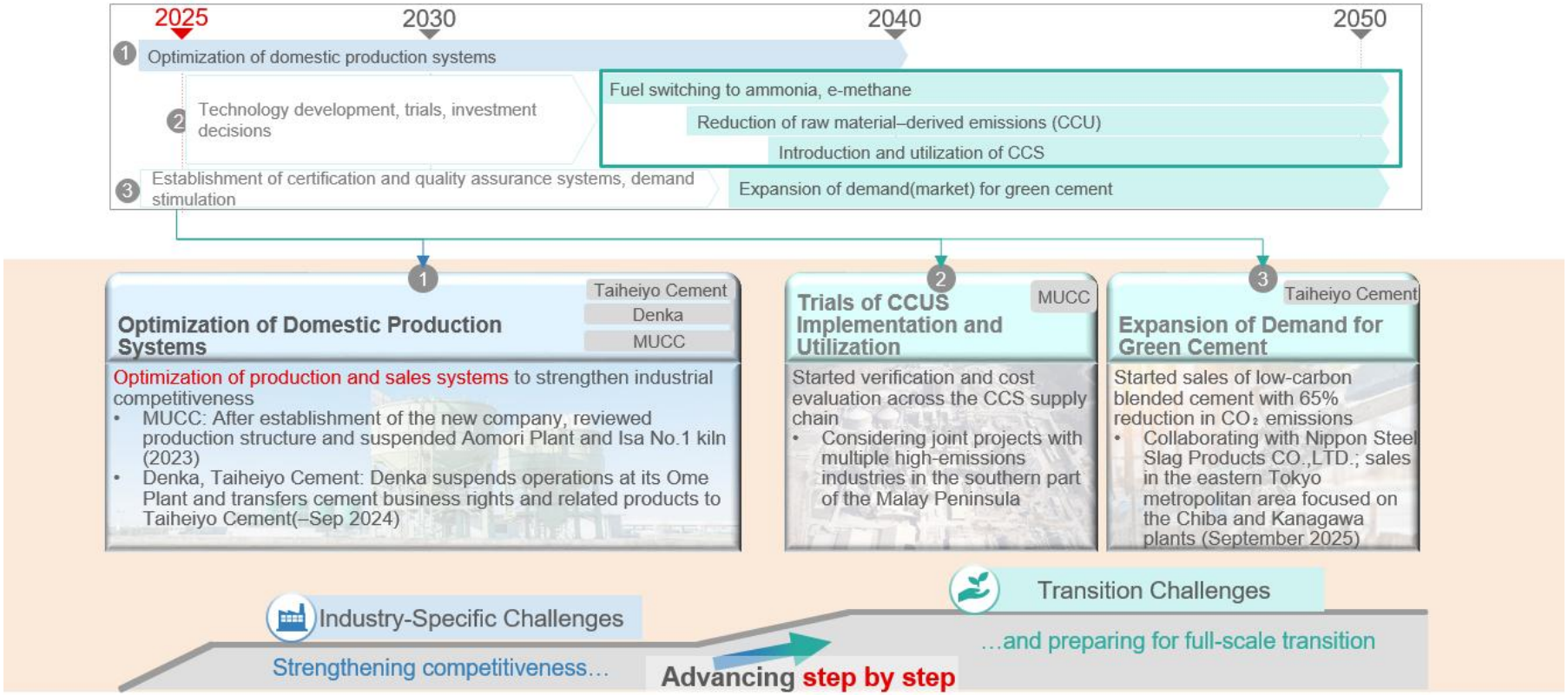


The cement sector has a distinctive structure where approximately 40% of its CO_2 emissions originate from the energy it consumes, while 60% stem from raw materials (limestone). Although it serves as a foundational industry supporting various sectors, its reliance on domestic demand means that declining domestic demand has led to excess production capacity—a challenge unique to the industry.

Advancing the transition requires tackling fuel switching and reducing raw material-derived emissions through CCU. However, these measures necessitate substantial investment and unavoidable financial burdens. Therefore, a phased approach is realistic: first optimize production systems, clarify which facilities and sites will be utilized in the future, and then sequentially address the transition challenges.

Source: OJI HP (1/2); OJI HP (2/2); Nihon Paper HP; Daio Paper HP

Domestic Industry Initiatives (Cement)



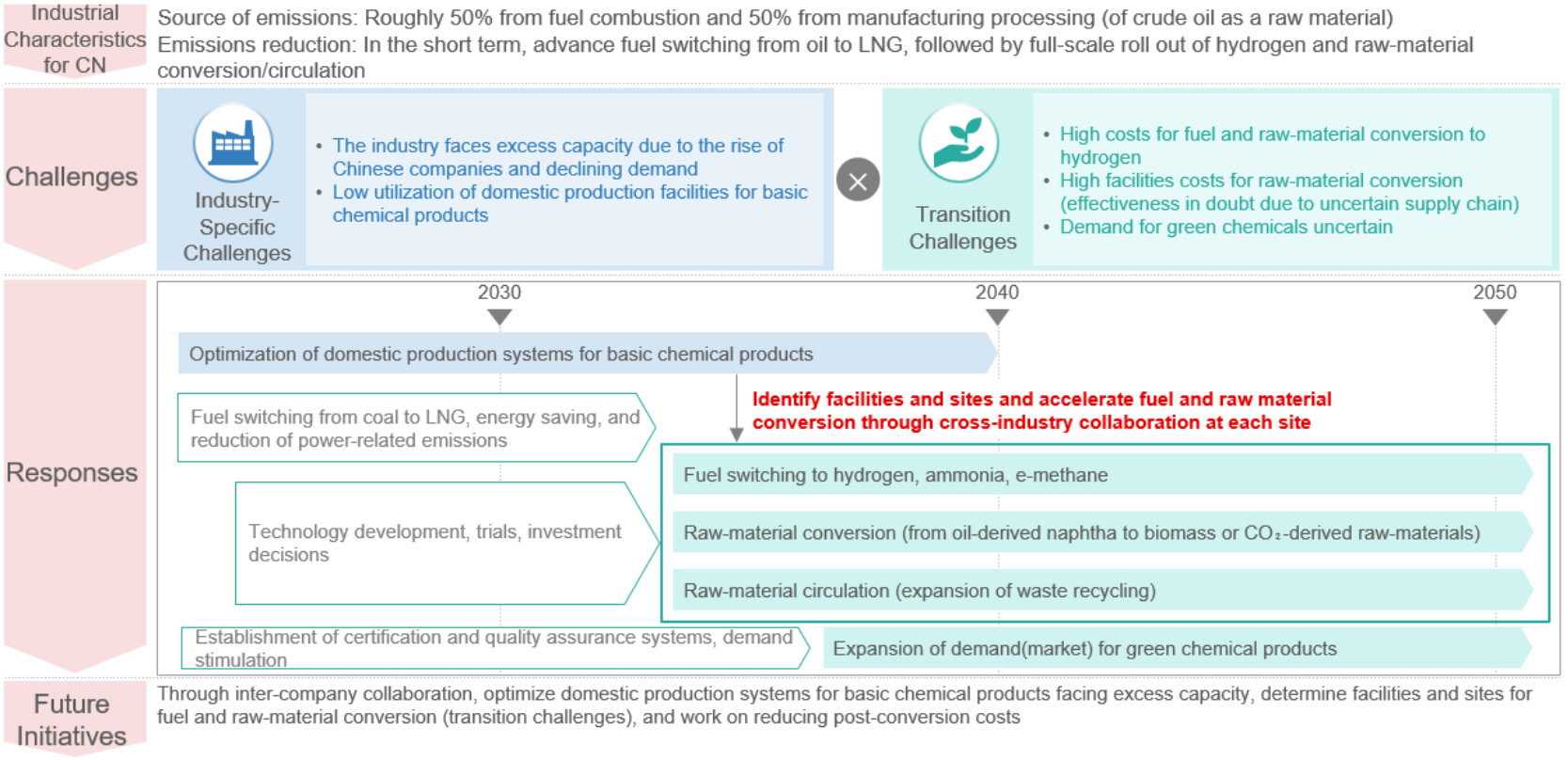
The cement sector has also been leading the way in optimizing domestic production systems to tackle industry-specific challenges. Taiheiyo Cement, Denka and UBE Mitsubishi Cement have taken decisive steps to review their production structures and strengthen their profit bases.

Addressing transition challenges have also begun. UBE Mitsubishi Cement has started verifying specifications and evaluating costs for the entire CCS supply chain.

The company is also studying the establishment of a supply chain covering separation, capture, marine transport, and underground storage in collaboration with high-emission industries in the southern part of the Malay Peninsula. Furthermore, anticipating growing demand for green cement, Taiheiyo Cement has begun sales of low-carbon blended cement that reduces CO_2 emissions by 65%.

Source: MUCC HP (1/2); MUCC HP (2/2); Taiheiyo Cement Press Release

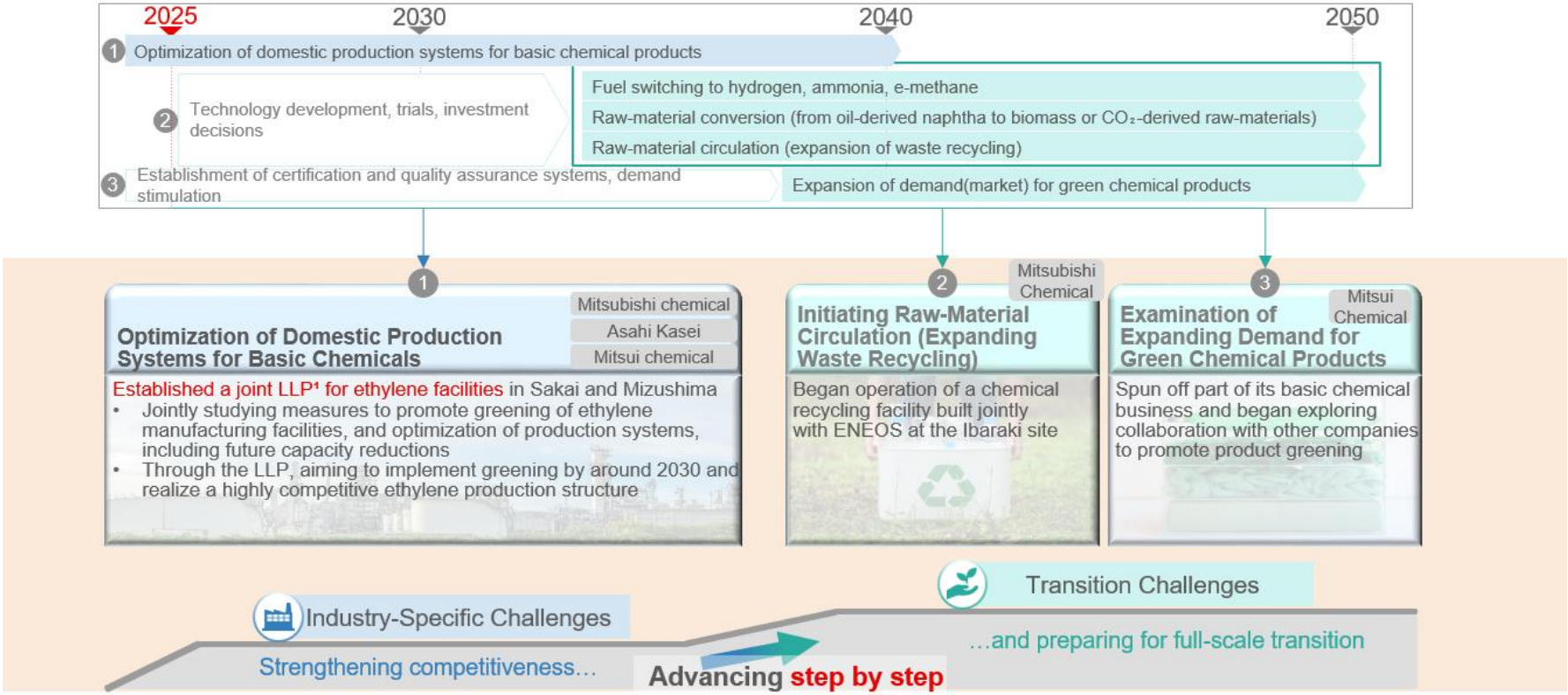
Examples (6) : Challenges and Approaches (Chemicals)



The chemical sector is also experiencing excess production capacity, particularly for basic chemicals like ethylene, due to competition from low-cost products made by Chinese companies. Its transition challenges include high costs associated with fuel and raw material conversion, as well as high equipment installation costs associated with raw material recycling, similar to other material sectors.

Furthermore, the uncertain outlook for green chemical demand also poses a challenge. In September 2025, concrete steps are underway regarding the restructuring of ethylene production facilities in western Japan, including the establishment of a preparatory organization with other industry peers. By optimizing production systems to secure financial strength, the company will then proceed with fuel conversion, raw material conversion, and raw material circularity.

Domestic Industry Initiatives (Chemicals)



As mentioned above, the chemical sector is a prime example of an industry working together to tackle industry-specific challenges. Mitsubishi Chemical, Asahi Kasei, and Mitsui Chemicals have established a limited liability partnership (LLP) for their Sakai and Mizushima ethylene facilities. They will jointly examine specific measures to contribute to greening ethylene production facilities and to optimize the production system, including future capacity reductions, in response to excess domestic production capacity.

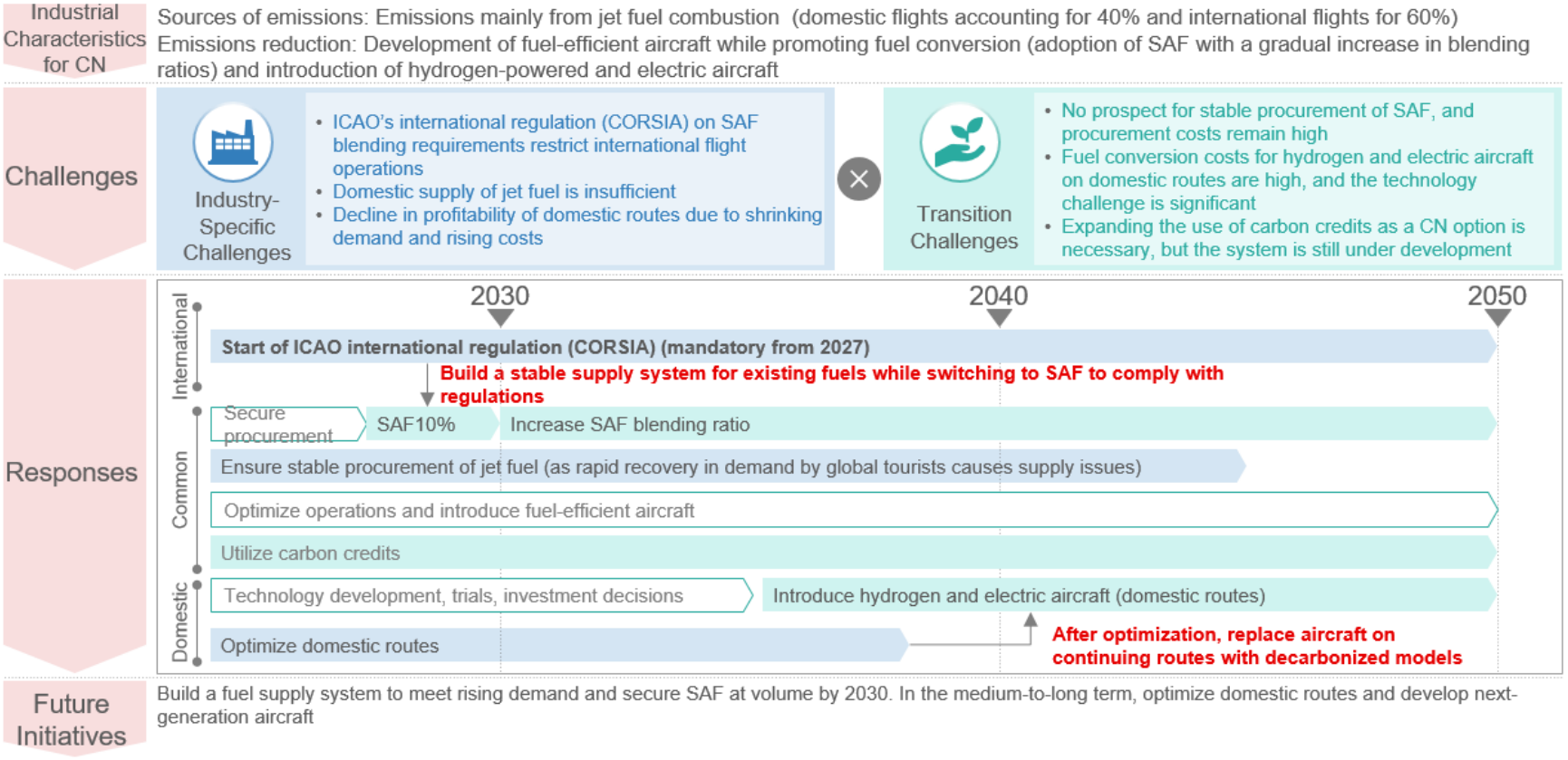
At the same time, each company is accelerating its preparations for the transition. Mitsubishi Chemical, together with ENEOS, has brought a chemical recycling facility at its Ibaraki site into operation to produce recycled oil from used plastics, which is expected to be used as feedstock for petroleum products and other items. Mitsui Chemicals, anticipating growing demand for green chemicals, has spun off part of its basic chemicals business and begun exploring ways to promote greener products through partnerships with external companies.

---

1. Limited Liability Partnership

Source: Mitsui Chemical HP (1/2); ENEOS HP; Mitsui chemical HP (2/2)

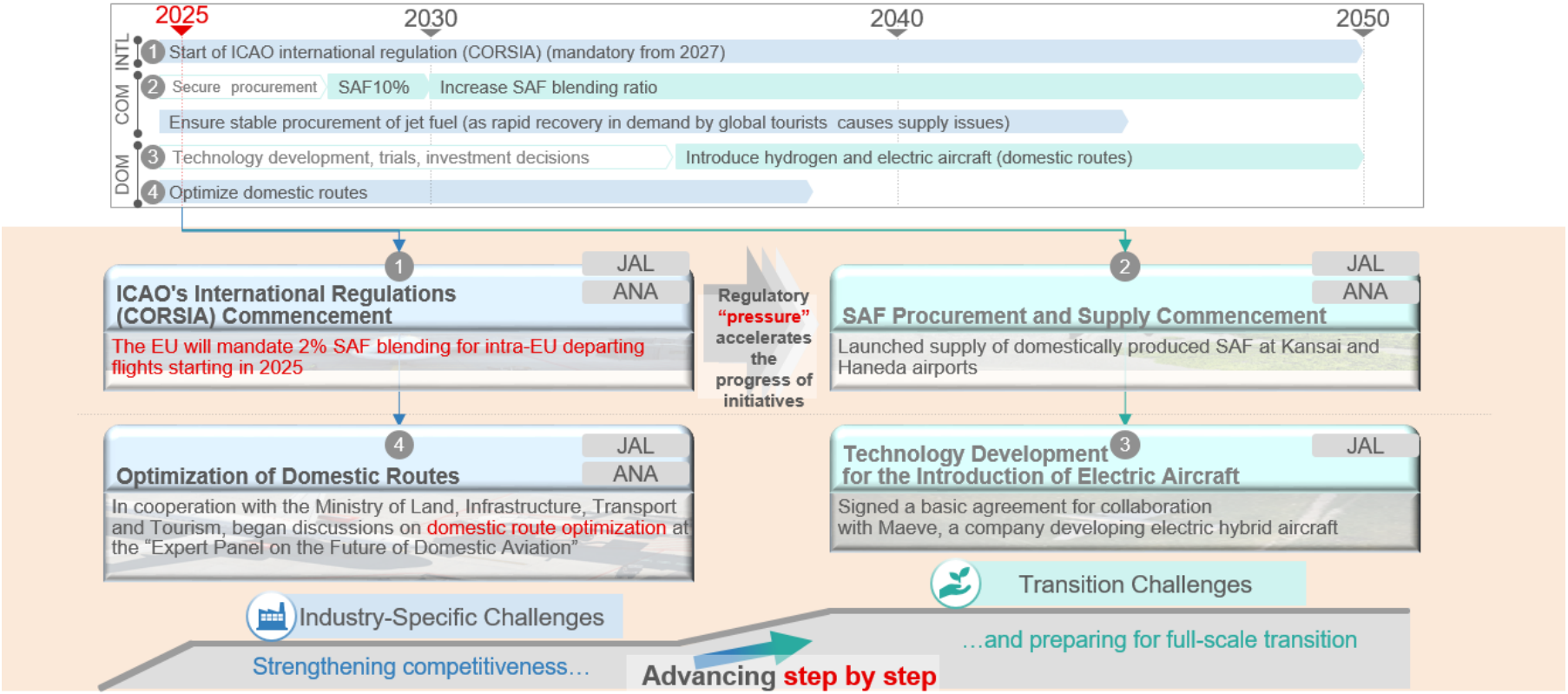
Examples (7) : Challenges and Approaches (Aviation)



The international aviation sector is facing increasingly stringent global emissions regulations imposed by the International Civil Aviation Organization (ICAO). Ensuring stable flight operations while simultaneously increasing the share of Sustainable Aviation Fuel (SAF) has become a sector-specific challenge. However, the lack of stable supply prospects and high costs for SAF itself present significant transition challenges, leading to operational constraints.

Additionally, as another industry-specific challenge, refinery operations have slowed due to declining demand for petroleum products, including gasoline, making it difficult to secure jet fuel. Furthermore, some Japanese domestic routes are unprofitable, necessitating route optimization. Until solutions to industry-specific challenges are in prospect, increasing the SAF blending ratio and introducing new equipment for carbon neutrality will remain difficult.

Domestic Industry Initiatives (Aviation)

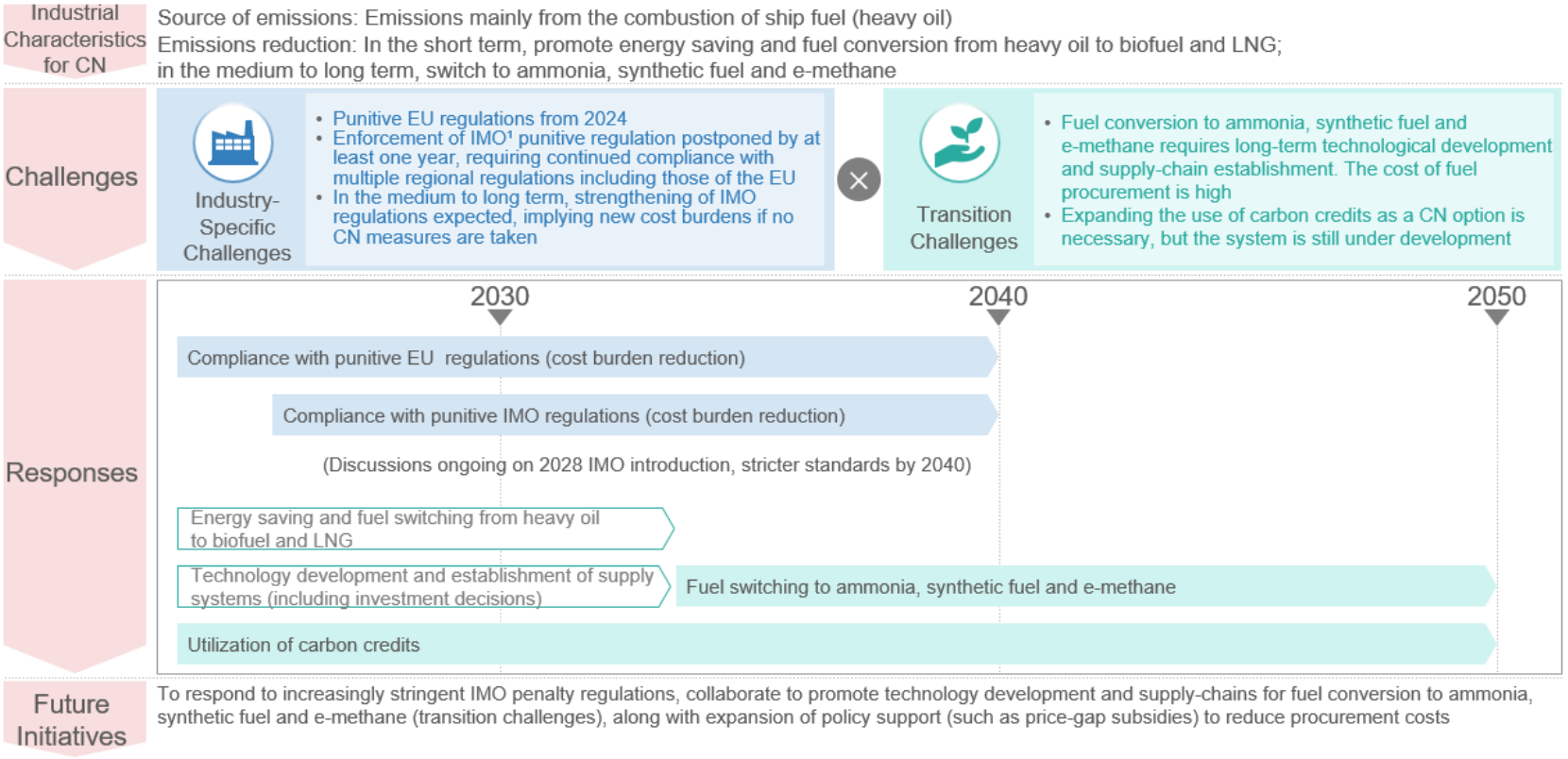


Looking at recent initiatives by Japanese companies in aviation, the tightening of international rules has helped spur action. In addition to ICAO's international regulations, EU regional regulations are being strengthened, with the EU mandating a 2% SAF blend for flights departing from within its territory starting in 2025. Regulatory pressure is accelerating progress on transition challenges, with both Japan Airlines and All Nippon Airways beginning the supply of domestically produced SAF at Kansai Airport and Haneda Airport.

Meanwhile, for domestic routes, efforts to tackle industry-specific challenges are underway through the "Expert Panel on the Future of Domestic Aviation," which is examining route optimization. As the upcoming transition gains momentum, aircraft development for introducing hydrogen-powered aircraft and electric aircraft is progressing. Japan Airlines has signed a basic agreement with the developer regarding the development of electric hybrid aircraft.

Source: JPEC Report; Expert Panel on the Future of Domestic Aviation; ANA HP; JAL HP (1/2); JAL HP (2/2)

Examples (8): Challenges and Approaches (Maritime)



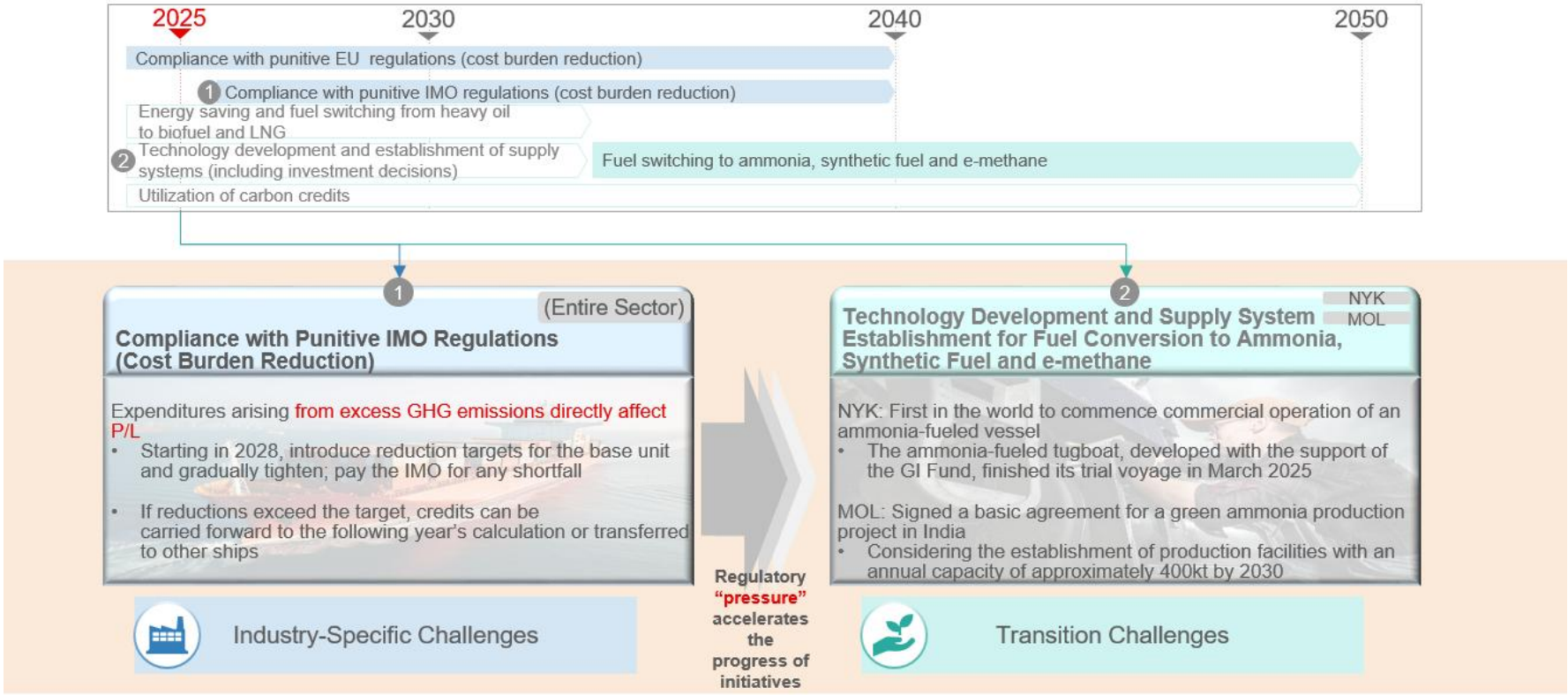
In the maritime sector, similar to aviation, global GHG emission regulations are set to be introduced by the International Maritime Organization (IMO), which has become a sector-specific challenge. These regulations will include penalties, making emission reductions a critical issue that directly impacting company profits if targets are not met. Although adoption has been postponed to 2026 due to opposition mainly from the U.S. and Middle Eastern countries, the IMO's 2030 target is likely to remain unchanged.

As a result, each company is currently tackling industry-specific challenges such as IMO regulations through measures like switching to biofuel or LNG fuel. A fuel transition from LNG to ammonia and synthetic fuels such as e-methane will be necessary in the medium to long term. While implementing this transition faces challenges such as increased costs and the time required to establish supply systems, urgent action is imperative.

---

1. International Maritime Organization: The only global organization responsible for creating international rules for ship safety and marine environmental protection

Domestic Industry Initiatives (Maritime)

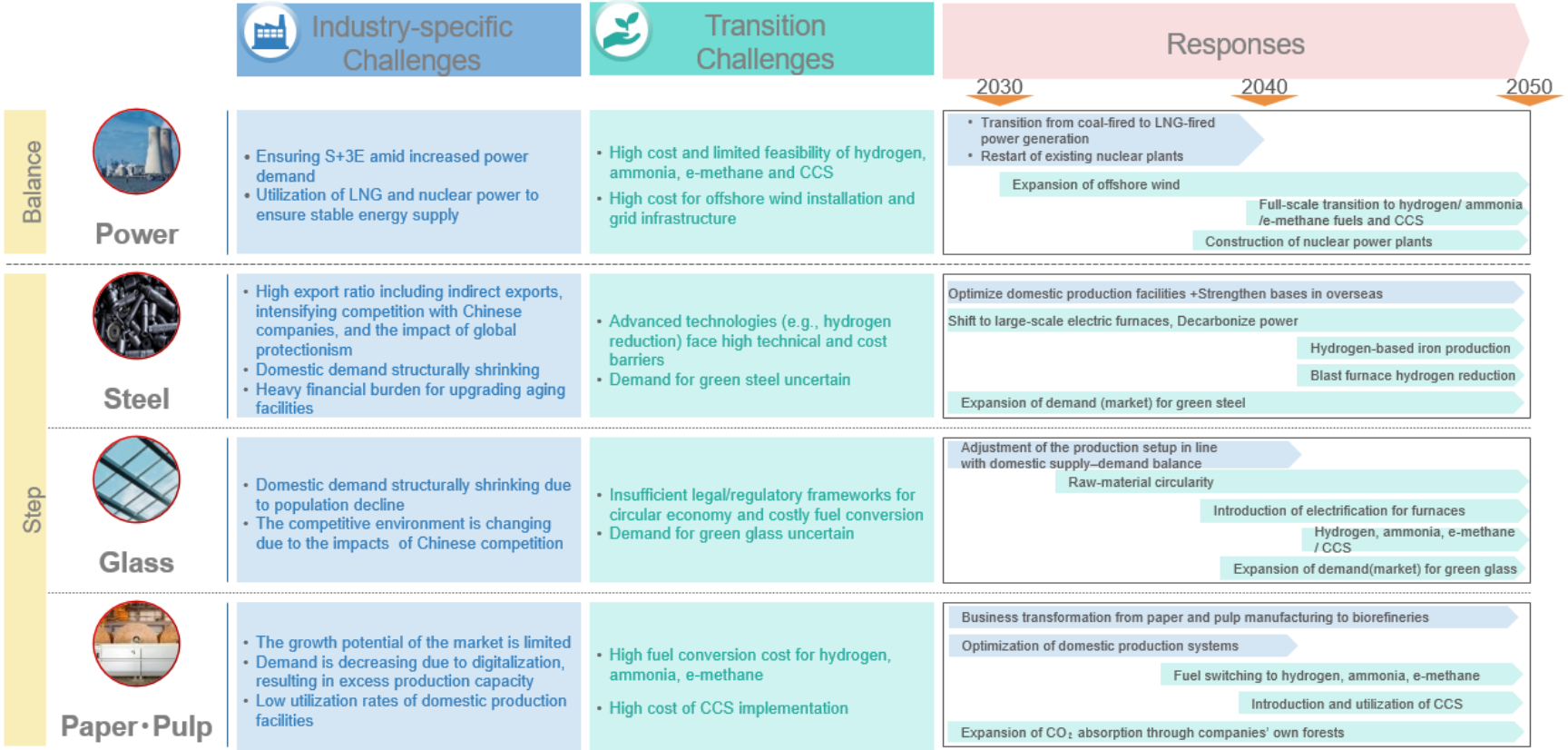


In the maritime sector, penalties imposed by the IMO are expected to result in costs for excess GHG emissions, directly impacting the P/L when reduction targets are not met. The pressure to comply with these regulations is accelerating the transition from LNG to ammonia and synthetic fuels as companies shift their fuel sources.

NYK successfully launched the world's first commercial operation of an ammonia-fueled ship, supported by the government's Green Innovation (GI) Fund, while MOL signed a basic agreement for a green ammonia production project in India, taking a decisive step toward acquiring upstream interests in the fuel supply chain.

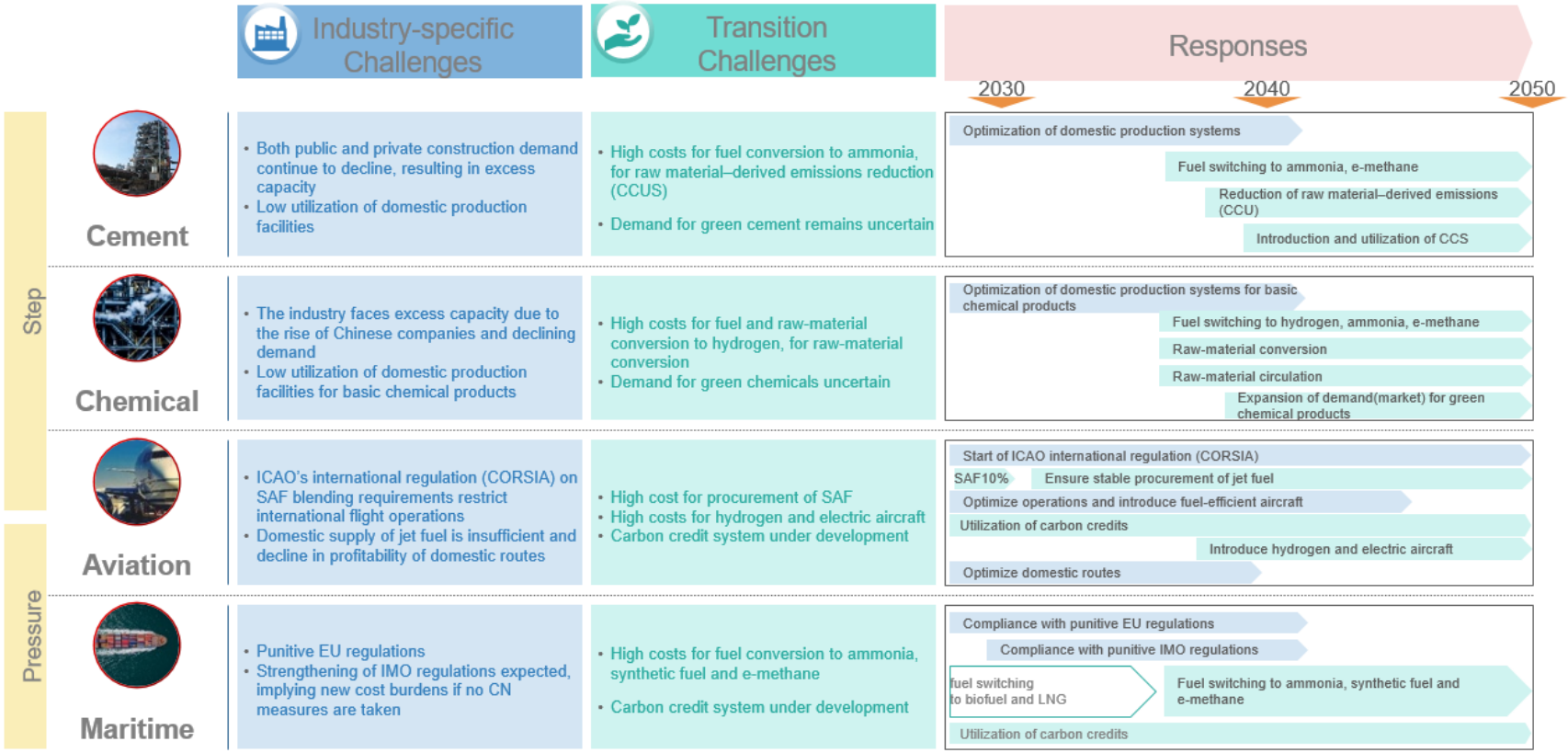
Source: ClassNK; NYK HP (1/2); NYK HP (2/2); MOL HP

Sector Overview (1/2)



When industry-specific challenges, transition challenges, and response strategies for each industry are mapped and reviewed, clear patterns emerge along the timeline of response strategies.
In balanced sectors like power, where both stable energy supply and environmental goals must be achieved, transition measures toward CN progress from the ground up, parallel to addressing increasing electricity demand. Conversely, in step-based sectors requiring fundamental restructuring of domestic industry—such as materials manufacturing or domestic aviation—rebuilding the business foundation, including optimizing production systems, precedes initiating the transition to CN.

Sector Overview (2/2)



And in pressure-driven scenarios where international emissions regulations and carbon pricing are introduced—such as for international shipping and aviation—strict timeline constraints to avoid penalties are forcing early action on CN.

Japan's Future Direction

Emerging Challenges and Future Actions

Emerging Challenges	Domestic and international uncertainties make it challenging to envisage full-scale CN implementation, But delays in GX may lead to a decline in international competitiveness. It is not easy to accelerate implementation of solutions for both industry-specific challenges and transition challenges, and corporate efforts alone have limitations. The value add associated with green materials and products is often not recognized, making it difficult to pass on costs.
Future Actions	Achieve a stable energy supply, essential for advancing CN investment, while maintaining Japan's industrial competitiveness. Promote collaboration among companies in industrial clusters, where there are concentrations of energy-intensive businesses and infrastructure requiring transformation. Foster demand for green materials and products to ensure price pass through and CN investment predictability.

Looking to full-scale CN implementation after 2030, the government and the financial sector should collaborate with businesses to tackle challenges.

Emerging Challenges and Future Actions

MUFG's assessment of the current situation, gained through dialogue with relevant companies across various sectors, can be summarized in three points.

(1) The uncertain domestic and global outlook surrounding carbon neutrality makes it difficult to anticipate the full-scale implementation of CN measures. Nevertheless, postponing investments in CN initiatives or delaying the development of supply chains carries a significant risk of undermining future international competitiveness.

(2) Under these circumstances, it is essential to address both the “industry-specific structural challenges” inherent to each sector and the “transition challenges,” such as the introduction of hydrogen, ammonia, and e-methane. These issues are highly complex and difficult to resolve, and efforts by individual companies alone have clear limitations.

(3) For green materials and products, differentiation based on performance is challenging, and the added value of being “green” is not widely recognized by consumers. As a result, passing on the additional costs to prices remains difficult.

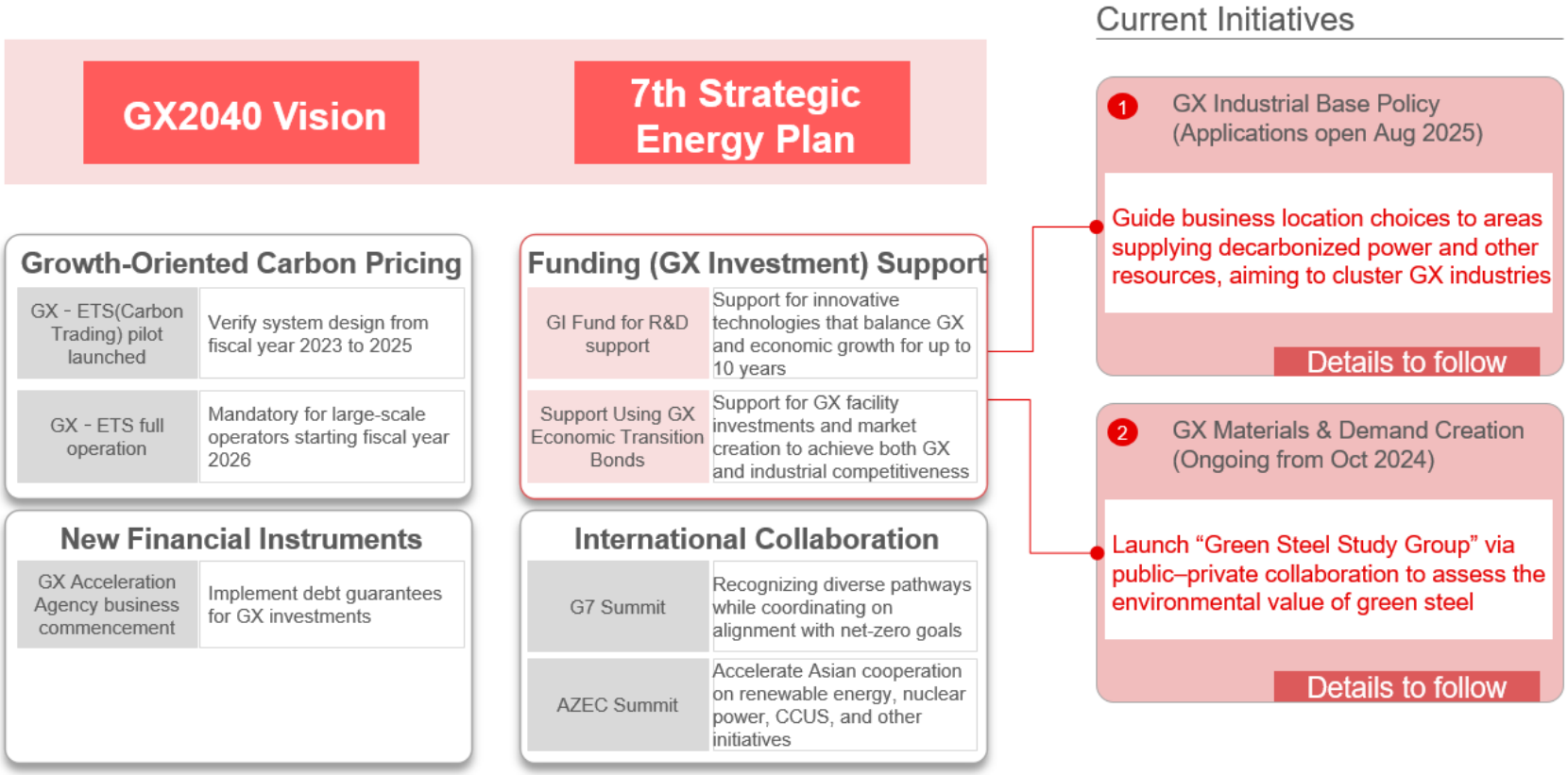
Furthermore, looking ahead to the full-scale implementation of CN measures after 2030, it is essential for the government and financial sector to work in unison with industry to tackle challenges. In particular, the following three points will become increasingly important going forward:

(1) Ensure a stable energy supply—a prerequisite for strengthening Japan’s industrial competitiveness—while incorporating transition strategies into execution,

(2) Foster inter-company collaboration within industrial clusters, where many energy-intensive businesses operate and infrastructure is aging, to accelerate problem-solving and efficiency gains, and

(3) Create demand for green materials and products by introducing systems to evaluate environmental value and promoting the added value of green products, thereby enabling cost pass-through and improving predictability for CN-related investments.

Japan Government's GX Initiatives



The Japanese government has consistently advanced CN initiatives, in close collaboration with industry. Under the GX2040 Vision and the 7th Strategic Energy Plan, it is working on four key fronts: growth-oriented carbon pricing centered on emissions trading; financial support (GX investment) sourced from the GI Fund and GX Climate Transition Bonds; new financial approaches, such as the guarantee services provided by the GX Acceleration Agency; and international cooperation at the G7 and Asia Zero Emissions Community (AZEC) summits.

Focusing on current initiatives, the government has launched the GX Industrial Locations policy to achieve both GX and enhanced industrial competitiveness. Public-private discussions are underway to foster demand for GX materials and products, building out the green market.

Source: METI(1/2); METI(2/2)

Japan Government Initiative (1) : "GX Industrial locations" Policy

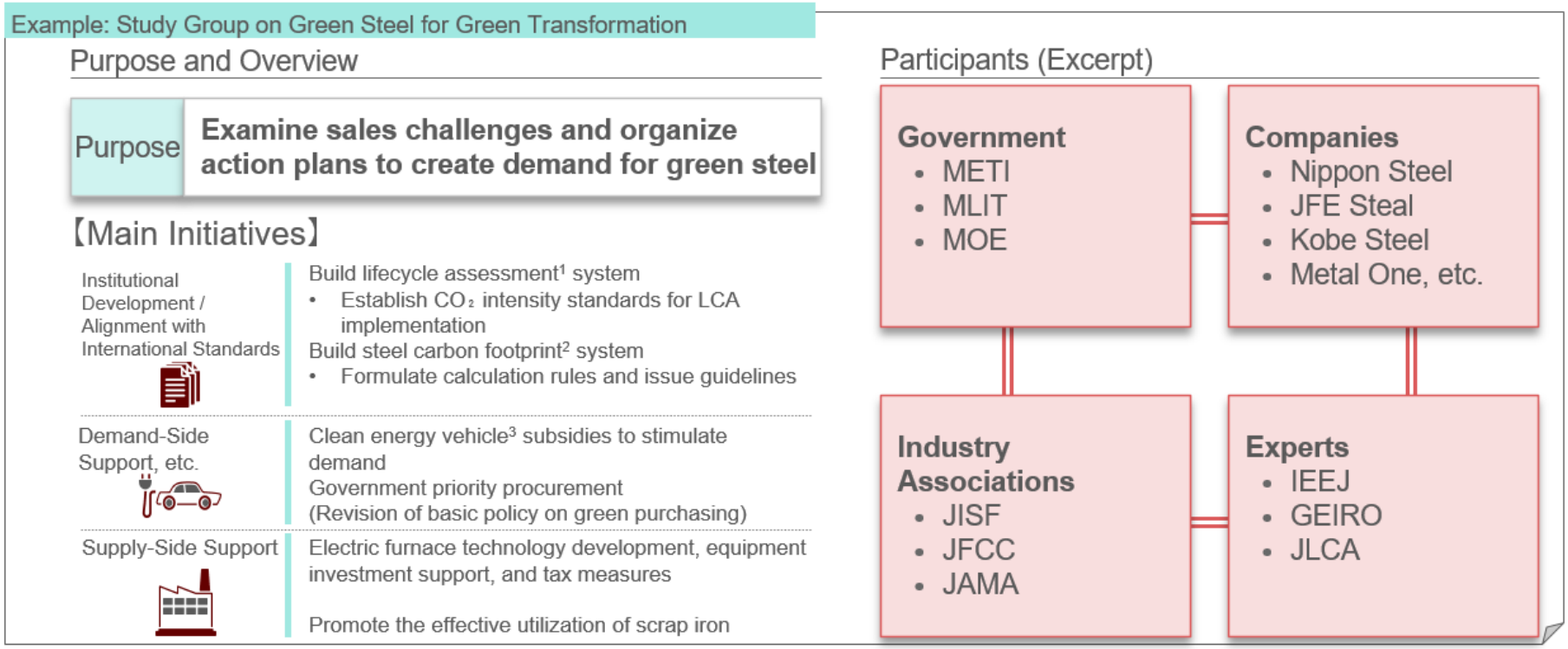
The GX Industrial Locations policy designates GX Strategic Regions and provides integrated support for infrastructure development and improved business profitability. Specifically, it will advance support through systems and subsidies for revitalizing industrial complexes, forming data center clusters, and establishing GX industrial parks utilizing decarbonized power sources—through regulatory frameworks and financial incentives

A distinctive feature of this approach is that the government will select multiple candidate sites for "globally competitive hubs" based on plans submitted by local governments and businesses, while actively working with them to refine these plans. Regions deemed to have strong potential will then be officially certified as *GX Strategic Areas* and receive targeted support.

Source: Cabinet Secretariat GX Implementation Promotion Office (1/2); Cabinet Secretariat GX Implementation Promotion Office (2/2); METI

Japan Government Initiative (2) : GX Materials and Product Demand Creation

A public-private initiative to stimulate demand for GX materials and products, with efforts underway to incorporate findings into policy



An example of a public-private initiative to create demand for GX materials and products is the Study Group on Green Steel for GX, which the government is conducting with steel-related industries. The study group is examining sales dynamics and organizing action plans to create demand for green steel. It is also facilitating the development of systems (reflecting international standards) and taking action to support both supply and demand.

Through these initiatives, the government is promoting support based on a partnership with companies, industry groups, and experts.

---

1. A method for quantitatively and objectively evaluating the environmental impact of products and services throughout their entire life cycle; 2. An indicator showing how much greenhouse gas emissions a product or service generates; 3. Refers to EVs, PHEVs, FCVs

Source: Study Group on Green Steel for Green Transformation (METI)

The Role of Financial Institution in Supporting the CN Conversion

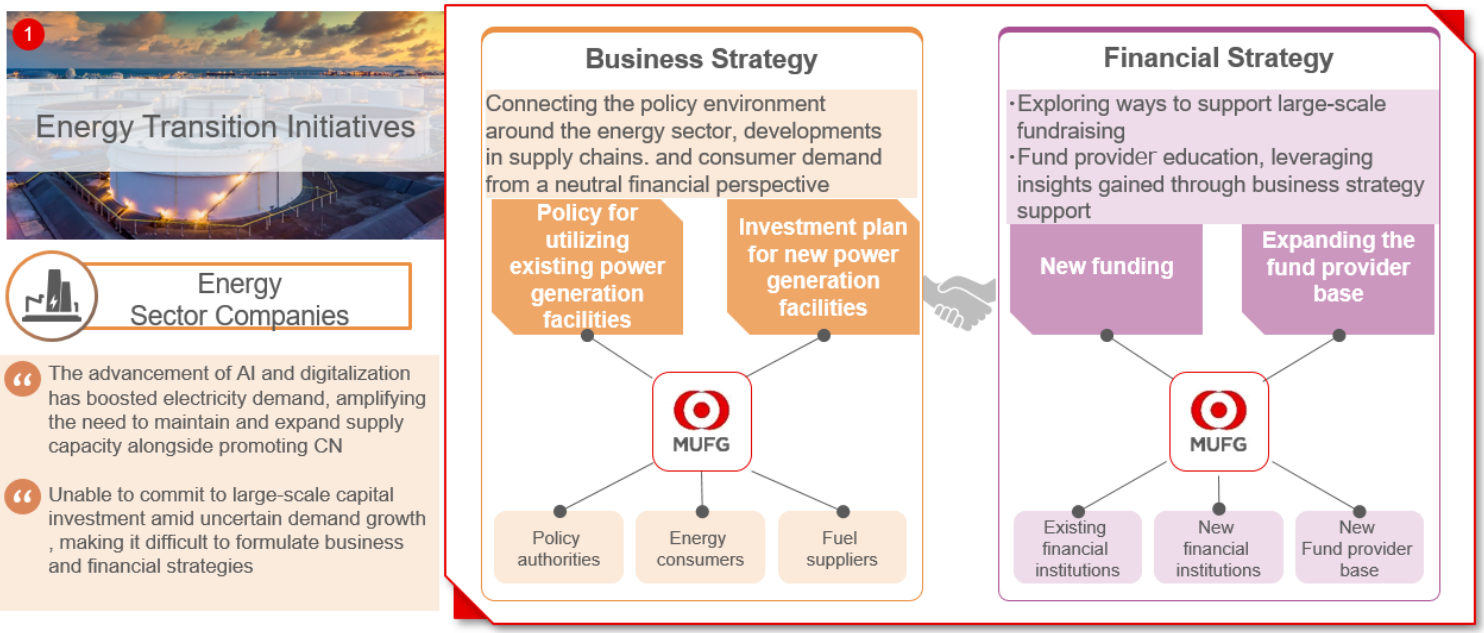
Financial institutions, as key enablers of industry, play a vital role in creating the conditions for CN investments by enhancing predictability and improving profitability. These efforts help businesses advance CN initiatives with greater confidence.

These include: (1) Energy Transition–working alongside the energy sector, which underpins all industries and requires significant long-term investment, to develop business and financial strategies that balance stable energy supply with CN objectives, (2) Industrial Cluster Transition –promoting coordinated strategies within industrial complexes, where companies are deeply interconnected through supply chains, ensuring that CN transformation is optimized across the entire ecosystem rather than at the individual company level, (3) Market and Demand Creation–supporting the development of sales strategies for green products and facilitating CN adoption across supply chains, while introducing mechanisms to evaluate environmental value and strengthen the perceived benefits of green offerings.

Beyond these initiatives, financial institutions also provide financing support during the execution phase. Through these comprehensive efforts, enabling industry's CN transition remains one of the most critical responsibilities of financial institutions. The following sections will explore each of these three initiatives in detail.

Examples (1): Initiatives for Energy Transition

Providing ongoing support for business and financial strategies in the energy sector, which requires substantial long-term investment



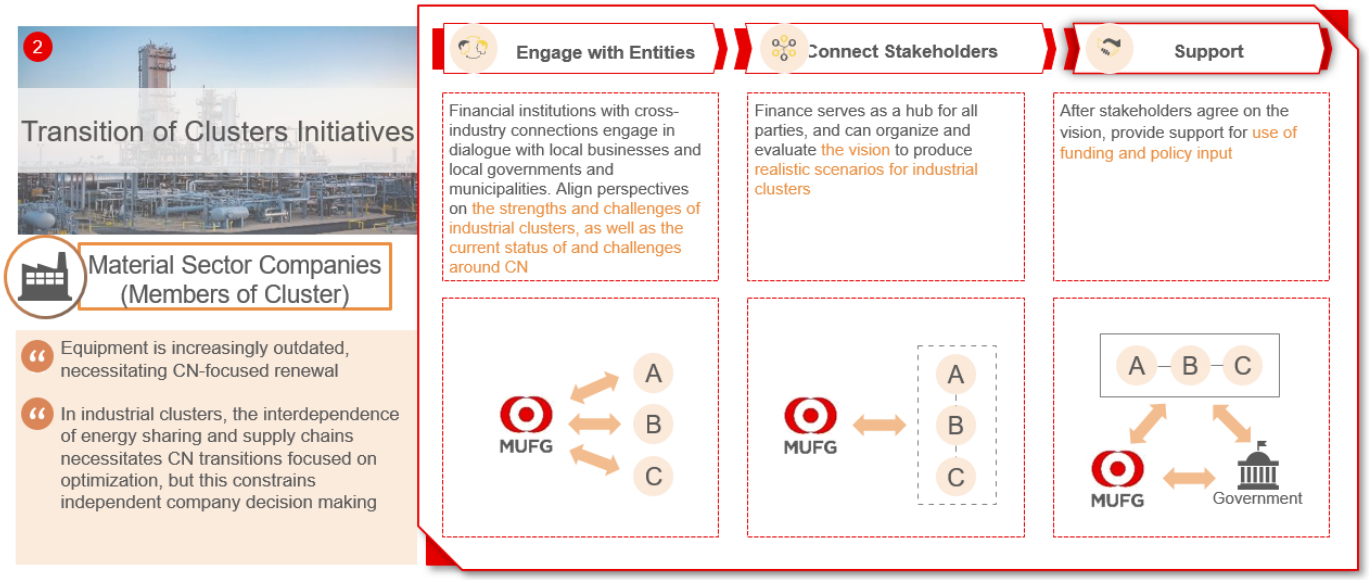
In the energy sector, a projected increase in electricity demand driven by advances in AI and digitalization has emphasized the need to maintain and expand supply capacity, as well as reducing carbon emissions. But while electricity demand is expected to rise, the specific trajectory remains uncertain. This makes it difficult for stakeholders to commit to large-scale investments and to formulate business and financial strategies.

To address this, MUFG supports the sector's transition by partnering with companies on business strategy and financial strategy. On business strategy, to leverage relationships with policymakers, major energy users, and fuel suppliers, MUFG provides neutral perspectives on policy, demand, and fuel supply. Together with energy companies, we assess the continued use of existing thermal assets and determine the timing, location, and scale of new generation investments—shaping resilient strategies that advance the transition while safeguarding a stable energy supply. This, in turn, strengthens the competitiveness of energy-dependent industries.

On financial strategy, to underpin capital-intensive, long-duration investments, MUFG uses sector insights gained through strategic engagement to broaden and diversify funding sources. Beyond existing lenders, we facilitate dialogue with new financial institutions and non-traditional capital providers, expanding access to financing and enhancing funding stability so planned projects can proceed smoothly. Through this integrated support, MUFG helps the energy sector balance CN objectives with energy security—and execute investment programs with greater confidence.

Examples (2): Initiatives for Cluster Transition

Contributing to stakeholder consensus on the vision for GX in industrial clusters, requiring holistic optimization



In industrial clusters such as petrochemical complexes, many facilities built during the Showa era are aging, creating an urgent need for upgrades aligned with carbon neutrality (CN). However, because these clusters involve energy sharing and highly interconnected supply chains, unilateral equipment transitions by individual company's risk undermining overall optimization—making decision-making particularly challenging. MUFG contributes through a structured three-step approach:

Step 1: Build a shared understanding: MUFG engages in dialogues with local companies and municipalities to identify the cluster's strengths, challenges, and CN-related issues. By consolidating these insights, MUFG develops a comprehensive and accurate view of the cluster. While regular meetings occur through local councils, MUFG's neutral position enables discovery of new perspectives—creating unique added value.

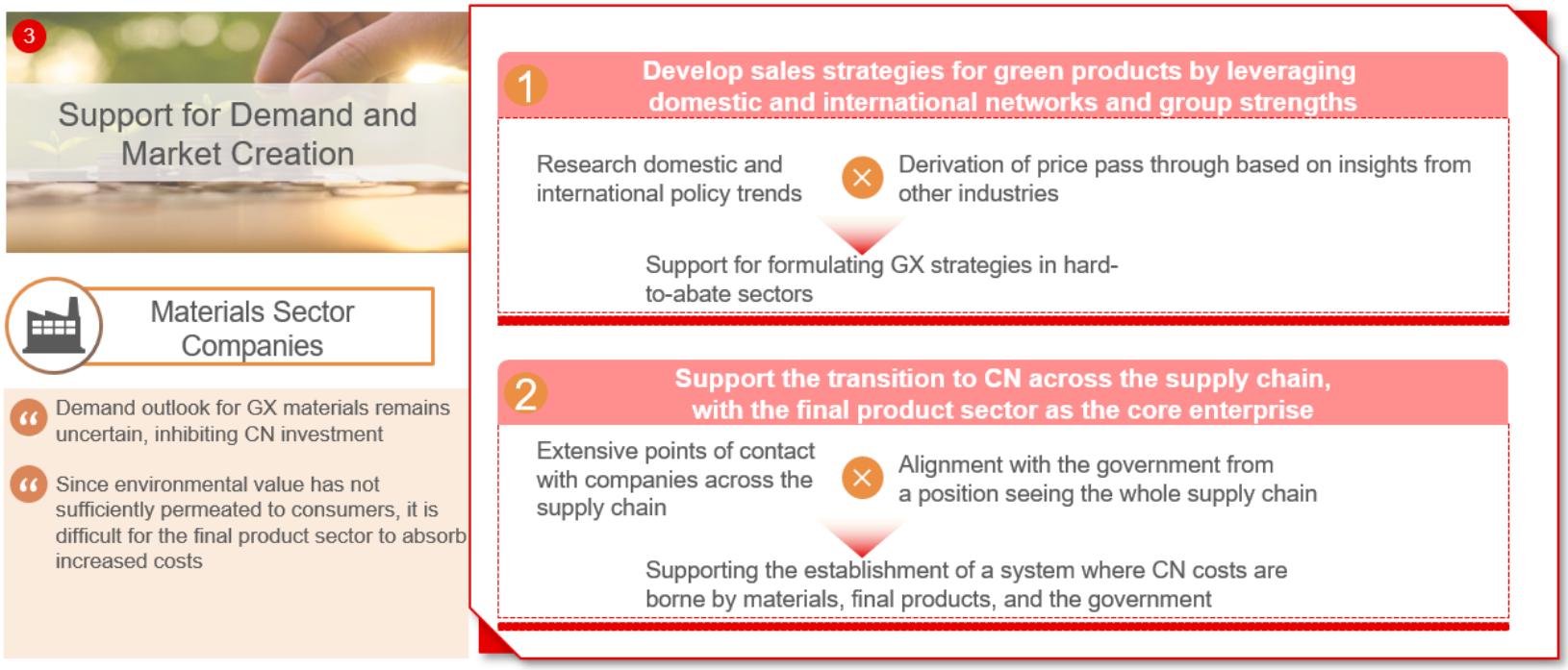
Step 2: Align stakeholders and design a future vision: Acting as a hub, MUFG connects stakeholders to explore options and co-create a realistic, optimized vision for the cluster's future. This process aligns diverse perspectives identified in Step 1. The approach varies by cluster: some are led by a dominant company, while others thrive on diversity. MUFG works collaboratively to identify the most effective path forward.

Step 3: Support implementation through financing and policy engagement: Once consensus on the future vision is reached, MUFG provides financial solutions and leverages its strong ties with policymakers to secure optimal support. Beyond its own financial capabilities, MUFG ensures access to policy incentives and funding mechanisms to enable smooth execution.

Through this integrated approach, MUFG helps industrial clusters achieve CN transformation while maintaining competitiveness.

Examples (3): Support for Demand and Market Creation

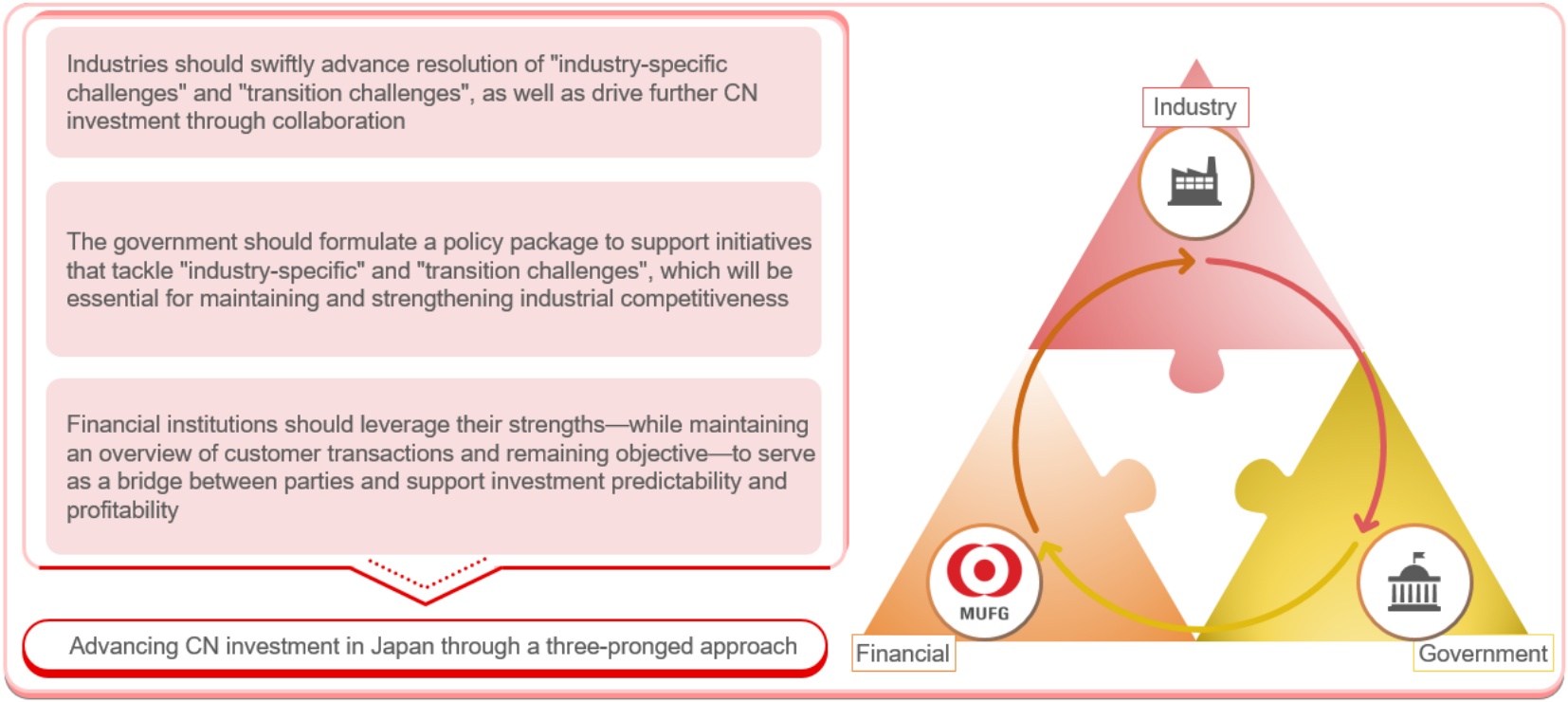
Promoting market formation by supporting green product sales strategies and CN in the supply chain



The materials sector faces the challenge of an uncertain demand outlook for green materials, making it difficult to commit to CN investment. Furthermore, few consumers are willing to pay for environmental value means companies in the end-product sector must absorb green costs. Both of these challenges stem from the fact that demand growth and market formation for green materials and products are still at an early stage. MUFG is addressing this challenge through two key initiatives:

The first is support the formulation of GX strategies in hard-to-abate sectors, utilizing domestic and international networks and group strengths. It is expected the market will grow as hard-to-abate sectors develop sales strategies for green products. The second possibility is to support CN through the supply chain, with the end-product sector in mind. By working with a wide range of companies and directly addressing structural issues, it may be possible to create a mechanism whereby materials companies, end-product companies, and the government share CN cost until consumers are willing to pay.

Industry-Government-Finance Collaboration for Further Expansion of CN Investment in Japan



To further expand Japan's CN investment, collaboration between industry, government, and FIs is essential. Through this shared approach, the parties can identify “transition challenges“ and “industry-specific challenges“ across different sectors, and thereby form a better understanding of the direction of transition. The key to sucess will be to link investment activities, policy support, and financing, which should be tailored to the realities of each sector.

Conclusion

As outlined in this whitepaper, its purpose is to revisit the pathway to CN that has been clarified in previous editions, while establishing a foundation for discussing the challenges Japan must overcome—and the strategic direction it should pursue—to accelerate CN-related investment amid a rapidly changing international environment. To conclude, the key messages of our whitepaper series are summarized in this edition. Even under heightened global uncertainty, leading countries are steadily and strategically advancing CN policies and investments, tailored to their unique national characteristics to strengthen industrial competitiveness and economic security in priority sectors. In this context, Japan likewise should pursue CN initiatives in a systematic and strategic manner, reflecting its specific conditions and long-term competitiveness and security needs.

In Japan, CN investment has begun to progress, driven by a limited number of first movers and government support. However, it is now a global phenomena that unlocking the next stage of CN investment will require broader participation from second movers and beyond. As CN investment scales up, it has the potential to reshape existing industrial structures and supply chains—changes that could significantly affect countries' industrial competitiveness and its foundations for future growth.

Amid this period of profound transformation, financial institutions must firmly fulfill their role in supporting industry. Leveraging its ability to address challenges across sectors, MUFG seeks to use the full range of financial solutions available within the Group to support customers' CN-related investments and, ultimately, to help strengthen our customers' industrial competitiveness and secure stable energy supplies world-wide.

Disclaimer

This document has been prepared by MUFG Bank, Ltd. (the “Bank”) for general distribution. It is only available for distribution under such circumstances as may be permitted by applicable law and is not intended for use by any person in any jurisdiction which restricts the distribution of this document. The Bank and/or any person connected with it may make use of or may act upon the information contained in this document prior to the publication of this document to its customers.

Neither the information nor the opinions expressed in this document constitute or are to be construed as, an offer, solicitation or recommendation to buy, sell or hold deposits, securities, futures, options or any other derivative products or any other financial products. This document has been prepared solely for informational purposes and does not attempt to address the specific needs, financial situation or investment objectives of any specific recipient. This document is based on information from sources deemed to be reliable but is not guaranteed to be accurate and should not be regarded as a substitute for the exercise of the recipient’s own judgment. Historical performance does not guarantee future performance. The Bank may have or has had a relationship with or may provide or has provided financial services to any company mentioned in this document.

All views in this document (including any statements and forecasts) are subject to change without notice and none of the Bank, its head office, branches, subsidiaries and affiliates is under any obligation to update this document.

The information contained in this document has been obtained from sources the Bank believed to be reliable but the Bank does not make any representation or warranty nor accepts any responsibility or liability as to its accuracy, timeliness, suitability, completeness or correctness. The Bank, its head office, branches, subsidiaries and affiliates and the information providers accept no liability whatsoever for any loss or damage of any kind arising out of the use of or reliance upon all or any part of this document.

This report shall not be construed as solicitation to take any action such as purchasing/selling/investing in financial market products. In taking any action, the reader is requested to act on the basis of his or her own judgment. This report is based on information believed to be reliable, but the Bank does not guarantee or accept any liability whatsoever for, its accuracy. The Bank, its affiliates and subsidiaries and each of their respective officers, directors and employees accept no liability whatsoever for any loss or damage of any kind arising out of the use of all or any part of this report. The contents of the report may be revised without advance notice. The Bank retains copyright to this report and no part of this report may be reproduced or re-distributed without the Bank’s written consent.

The Bank retains copyright to this document and no part of this document may be reproduced or re-distributed without the written permission of the Bank. The Bank expressly prohibits the distribution or re-distribution of this document to private or retail clients, via the Internet or otherwise, and the Bank, its head office, branches, subsidiaries and affiliates accept no liability whatsoever to any third parties resulting from such distribution or re-distribution.

MUFG Bank, Ltd. (“MUFG Bank”) is a limited liability stock company incorporated in Japan and registered in the Tokyo Legal Affairs Bureau (company no. 0100-01-008846). MUFG Bank’s head office is at 4-5 Marunouchi 1-Chome, Chiyoda-Ku, Tokyo 100-8388, Japan. MUFG Bank is authorized and regulated by the Japanese Financial Services Agency.

The Boston Consulting Group (“BCG”) provided MUFG with background market analysis that MUFG used in preparation of this report. The report’s recommendations do not necessarily represent BCG’s views. BCG used data from various sources and assumptions provided to BCG from other sources. BCG has not independently verified the data and assumptions from these sources. Changes in the underlying data or operating assumptions will clearly impact the analyses and conclusions. Readers are responsible for assessing the relevance and accuracy of the content of this document. It is unreasonable for any party to rely on this document for any purpose. BCG will not be liable for any loss, damage, cost, or expense incurred or arising by reason of any person using or relying on information in this report.

MUFG Bank, Ltd.
Corporate Banking Planning Department / Sustainable Business Department
1-4-5 Marunouchi, Chiyoda -ku, Tokyo 100 -8388, Japan

www.mufg.jp