2024

MUFG Transition Whitepaper 2024

-We speak in “UNITED LANGUAGE”-

Preface

MUFG recognizes the crucial role that financial institutions must play in achieving carbon neutrality. In 2021, we became the first Japanese bank to publicly declare our carbon neutrality goals, and we are engaged in initiatives to achieve neutrality by 2050. Beyond reaching our own emission-reduction targets as an organization, we have deepened our engagement with customers on this issue and, through financing, supported their transitions as well. We have also taken a leadership role in international frameworks, including chairing the working group of the Net-Zero Banking Alliance (NZBA), where we fully voice our opinions.

In 2022 and 2023, we collaborated with our customers to research, create, and publish two MUFG Transition Whitepapers in English, sharing our learnings and insights with all interested parties. In our Whitepaper 1.0 (2022), we showcased how carbon neutrality – while shared as an ultimate global goal – requires individual paths to achieve it by country/region. Our Whitepaper 2.0 (2023) explored differences in policy structures and approaches toward carbon neutrality across various nations, and compiled positive technologies essential for achieving carbon neutrality in the "electricity and heat" sectors.

For six months following the publication of Whitepaper 2.0, we engaged in dialogue with government authorities and private sectors in Europe and the United States. Insights from these discussions were incorporated into the MUFG Asia Transition Whitepaper, published in November 2023, and were useful in dialogue with government authorities and private sectors in Asia. To broaden our engagement and share our findings, we have also conducted various regional seminars, hosted side events at COP28, and participated in financial-institution meetings such as the NZBA and the Asia Transition Finance Study Group, where we thoroughly discuss the realities of transition.

Through these exchanges, we have reaffirmed how important it is to truly understand the unique characteristics and distinct efforts of each region in achieving carbon neutrality. At the same time, we recognize the universal challenge of overcoming the barrier of cost pass-through. While previous Whitepapers focused on differences among countries, Whitepaper 3.0 adopts a new approach by articulating the nature of common challenges faced by Europe, the U.S., and Japan. We hope this Whitepaper will serve as a catalyst for discussions on critical international financial agendas, such as the nature of financial support for diverse pathways, public-private dialogue, and the imperative of international collaboration.

In an era of increasing division among various social and geopolitical sectors, MUFG aims to leverage our global network of diverse stakeholders to create connections that bridge differences and contribute to a shared, sustainable future. In this spirit of connectivity, we will continue to engage in discussions on the role of financial institutions in supporting carbon neutrality, and advance our contributions to decarbonization through dialogue and engagement with stakeholders.

Mitsubishi UFJ Financial Group, Inc.

President & Group CEO

Hironori Kamezawa

Acknowledgement

MUFG is grateful to Japan's leading companies, government authorities, and academics for their advice and guidance in the creation of this whitepaper. The paper was made possible through the insights, perspectives, and advice provided at joint forums held both in Japan and abroad, as well as at multiple bilateral meetings held globally. MUFG also acknowledges the contribution of Boston Consulting Group (BCG) for its background and market analysis.

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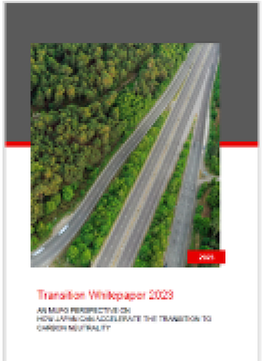

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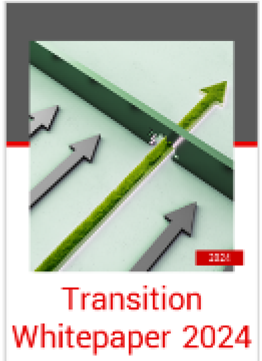

Price pass-through/ global collaboration

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Common challenges in price pass-through of CN technologies, faced by Europe, the U.S. and Japan

Highlights of each whitepaper

Since 2022, MUFG has published an annual "MUFG Transition Whitepaper", making this the third edition. Through discussions globally and with Japanese industrial leaders, we have worked to develop a mutual understanding of the situations and challenges we all face. Our aim is to reflect the fact that carbon neutrality (CN) is a global issue but that different stakeholders have different concerns and speak in different “languages”. If each stakeholder's assertions are presented in their own language or interpretation, it can lead to mutual misunderstanding. Thus, it is essential not only to understand what our customers are saying but also to imagine, inquire, and strive to understand the background and intent behind their assertions. Then, we need to verbalize this understanding, supported by objective data, and share what we have learned. All of the feedback we have received informs the thinking expressed here.

This repeated process of consultation and synthesis is how we have developed the "MUFG Transition Whitepaper". We have continued this activity for three years, and we express it as "We speak in “UNITED LANGUAGE”." In the initial stages of discussions, we strive simply to understand. But we try to convey our messages in a language that everyone can understand. This is how we develop a common language through our engagement, which is the world view pursued in MUFG Transition Whitepaper 3.0.

In Whitepaper 1.0, published in 2022, we shared two messages that we learned from our customers. The first is that while CN is a global goal, the approaches and timelines for achieving that goal differ across regions, mainly due to local/regional market characteristics. The second is that in addition to examining individual sectors, we need to consider vertical and horizontal linkages between industries through value chains within each country. Based on these two ideas, we created an English language version of the whitepaper, which we used to advance dialogues with government authorities, industries, academia, investors, and the financial sector. Through these dialogues, we realized in advancing CN that “electricity and heat,” which connects the “energy source” and “production processes” is a global common driver.

Thus, in Whitepaper 2.0, published in 2023, we focused on “electricity and heat.” We compiled seven technologies contributing to CN under “electricity and heat” into a "Positive Technology List." To explore how to provide financial support through investment rather than divestment, we researched policy approaches in different countries.

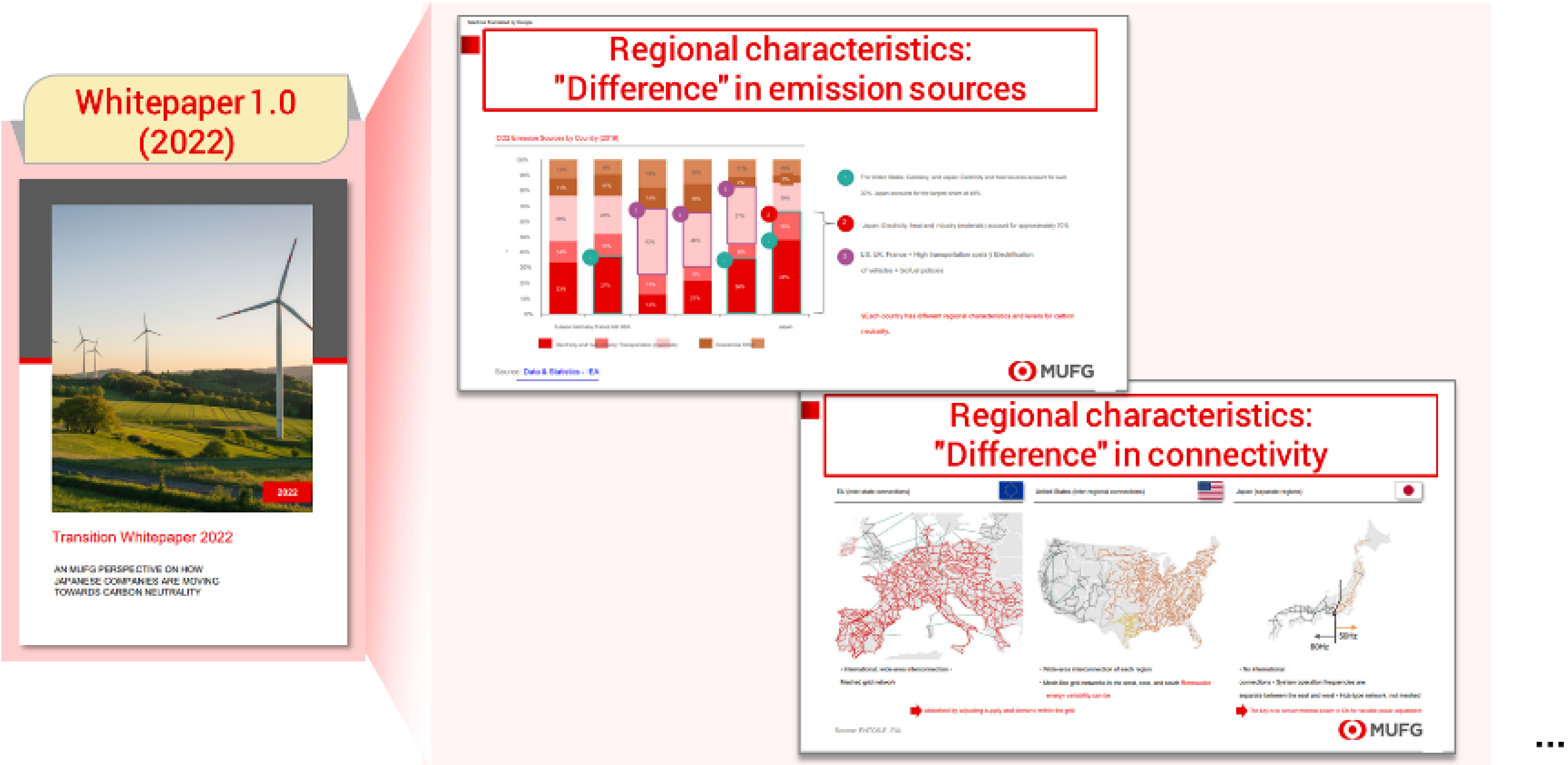
Looking back, we can say that Whitepaper 1.0 and Whitepaper 2.0 highlighted the differences between regions and countries. We recognized these differences, respected each other's approaches, and have had repeated dialogues about what kind of financial support would be effective. We still do not have a definitive answer. We believe the only truth is that it is crucial to continue these activities.

Since the publication of Whitepaper 2.0, we have conducted tours in Europe, the United States (the U.S.), Asia, Oceania, and Japan. We collected data on the progress or lack of progress in implementing CN technologies in various countries and the status of each technology. A common issue we heard about was the "price pass-through barrier". To overcome that barrier, we need international cooperation, in addition to domestic efforts to reduce emissions.

Highlights of each whitepaper

Today, it is difficult to definitively state which technologies are going to be most effective on our journeys. Moreover, the content of the technology set will vary depending on the local/regional characteristics of each country. In such situations, it may be necessary to first ensure “technology optionality” in each country/region, then consider a transition that is compatible with existing infrastructure, and finally strive to secure the economic viability of new technologies, including policy support. To ensure economic viability, in addition to policy and business efforts, end-users need to understand the appropriate costs associated with CN technologies. These elements together make price pass-through feasible. This year's Whitepaper 3.0 will focus on three themes: 1) optionality, 2) economic viability, and 3) end-user awareness and understanding (regarding price pass-through). Based on these three, we make an argument for international collaboration.

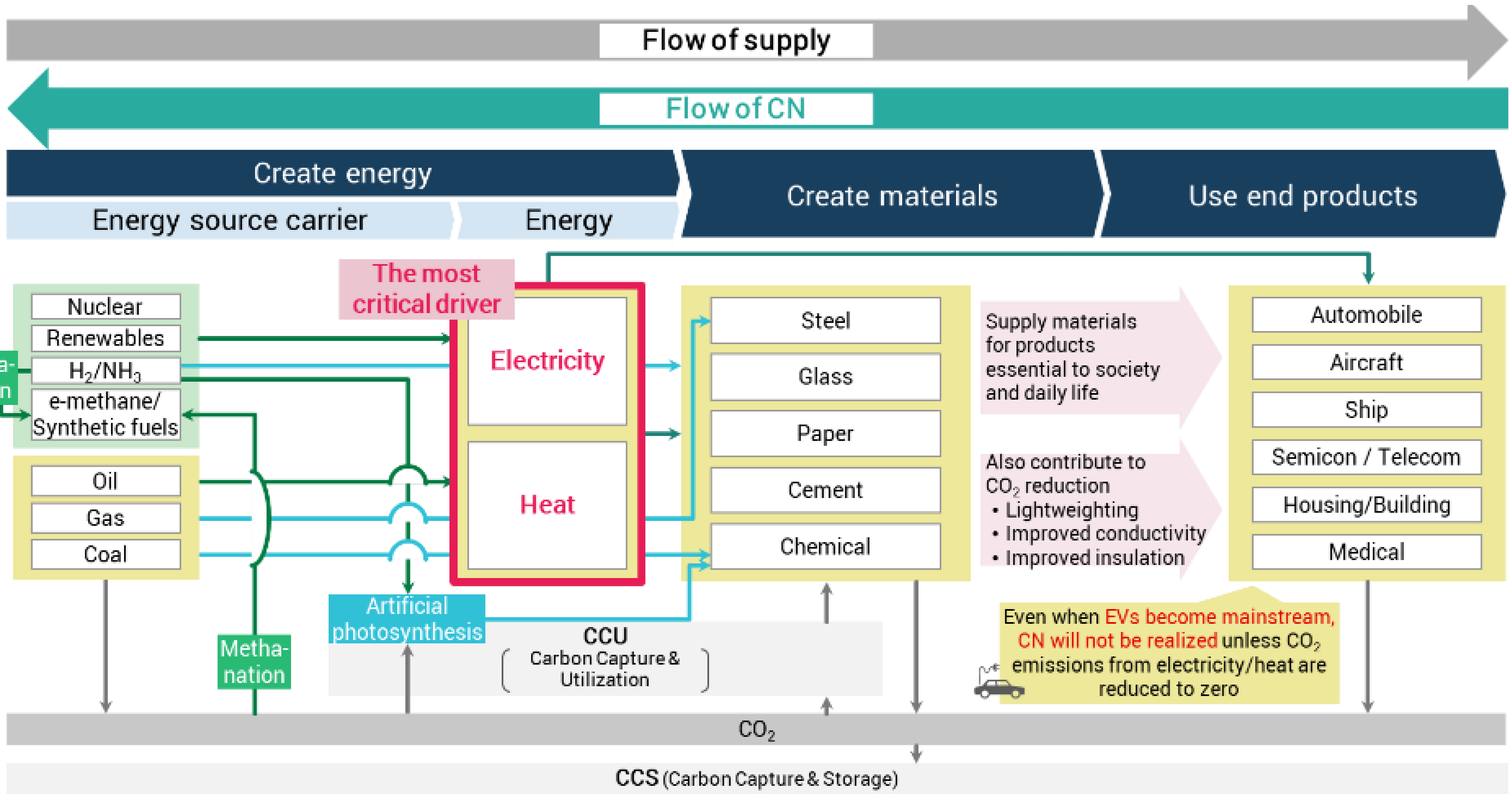
MUFG transition whitepaper 1.0: regional characteristics



In 2022, we published Whitepaper 1.0, which highlighted two messages; first that individual countries' journeys toward CN depend on specific regional characteristics.

Note: In MUFJ Transition Whitepaper 2022, regional characteristics are analyzed based on (1) emission source, (2) connectivity, (3) security, and (4) sociopolitics.
Source: MUFG Transition Whitepaper 2022, MUFG Transition Whitepaper 2023

MUFG transition whitepaper 1.0: Interdependency among industries



Source: [MUFG Transition Whitepaper 2022]

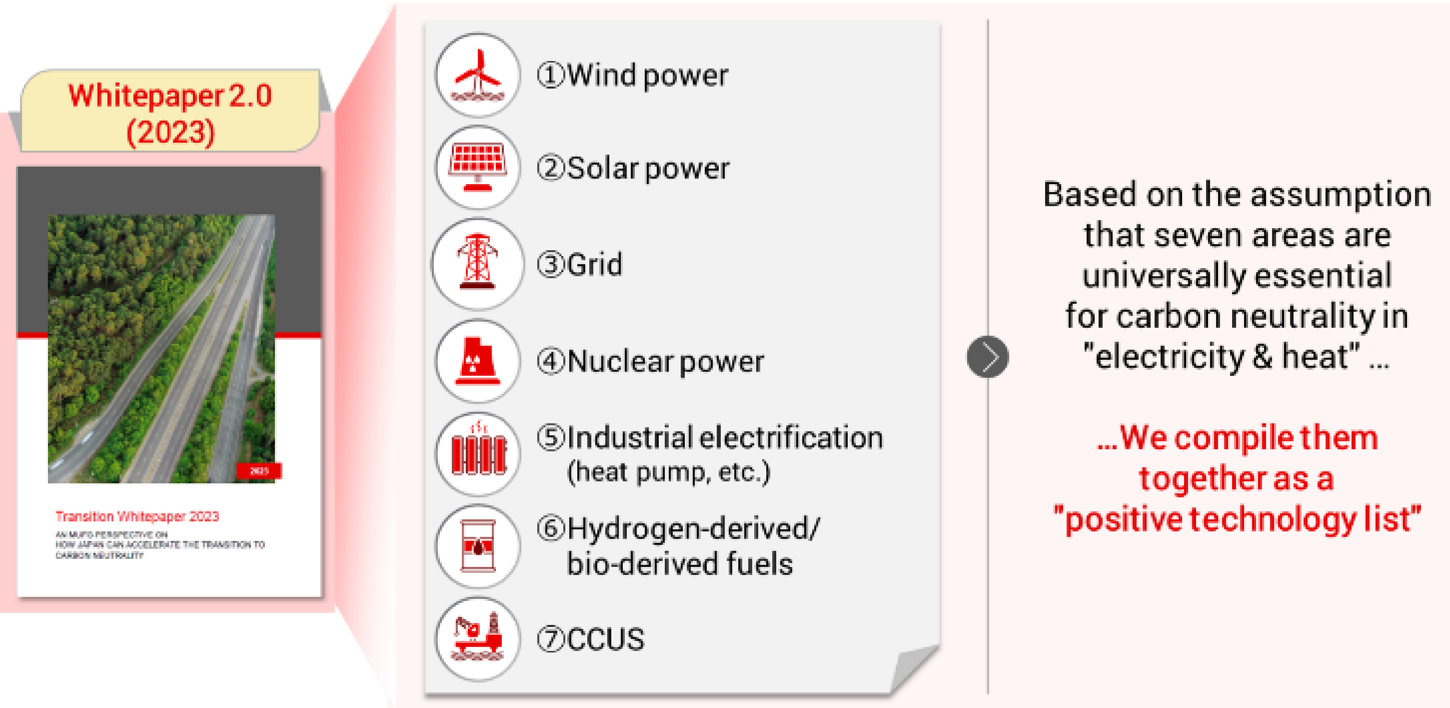
MUFG transition whitepaper 1.0: Interdependency among industries

The second is that any useful analysis must consider the vertical and horizontal linkages between industries, alongside individual industry-specific factors. We also emphasized the importance of industrial linkages.

The global industrial economy has been built on: (i) using energy sources to create electricity and heat, (ii) using electricity and heat to create materials, and (iii) using materials to create final products. Though demand for the final product comes from end-users, a limited signal is given by end-users on the choice of energy sources to manufacture the product. Thus, international cooperation has helped complement each country's strengths across borders to make the product economically viable.

On the other hand, CN efforts require a more prominent “reverse approach” from end-users. Appetite for CN and emissions reduction is stronger among end-users and public opinion, which means that efforts start with the "final product." Achieving CN for final products requires CN for materials, which in turn requires CN for electricity and heat, and achieving CN for electricity and heat requires energy transformation. For example, simply introducing EVs in automobiles cannot achieve CN overall if the energy source’s CN is not realized. Thus, we highlighted that electricity and heat, which connect “energy sources” and “production processes,” are crucial in industrial linkages. In Japan, we found that CN of “electricity and heat,” accounts for 50% of CO_2 emissions.

MUFG transition whitepaper 2.0: positive technology list



In Whitepaper 2.0 we focused on the electricity and heat sectors, finding that CN technologies being implemented globally are concentrated in seven areas: wind power, solar power, transmission and distribution, nuclear power, industrial electrification, hydrogen-derived and bio-derived fuels, and CCUS. We used these seven to compile a "Positive Technology List." We give the list the name because our focus is not on divestment but on investment in our customers' ideas and strategies to reduce emissions. The Positive Technology List was designed to be flexible, enabling updates in response to changing circumstances.

Source: MUFG Transition Whitepaper 2023

MUFG transition whitepaper 2.0: carbon neutral (CN) policy approach in each country

Regulation/rule-making

- Create a new competitive environment through regulation
- Emphasize rule-making and require compliance and disclosure to corporates within and outside of Europe

Incentive-giving/market-oriented

- Provide incentives without excessive market intervention
- Aim for self-sufficiency with abundant resources and economic power

Industry-government collaboration

- Develop strategies/roadmaps through collaboration
- Emphasize "diversity" by incorporating various perspectives

Aggregation

- Limit the number of operators through an aggregation system (monopoly supply, licensing, open call, tender)

Source: [MUFG Transition Whitepaper 2023]

MUFG transition whitepaper 2.0: carbon neutral (CN) policy approach in each country

Also in Whitepaper 2.0, we highlighted the differences in policy approaches among countries, understanding of which is essential in considering the nature of financial support required to roll out the Positive Technologies. In Europe, there is a focus on regulation to move the industrial sector towards low emissions. The U.S. introduced economic incentives, for example through tax credits, which complemented reliance on market principles. Japan published 22 technology roadmaps and the Green Transformation (GX) policy (overall policy support framework). It also adopted an approach for industry-government collaboration to reach consensus across multiple industries. Singapore introduced an aggregation system to promote industry-government collaboration with specific businesses.

In our eyes, there is no superior or inferior policy support, but there are differences, which must be respected as stakeholders consider the most effective approach to providing financial support in each geography.

Emphasis on dialogues when developing whitepapers

Dialogue with the industries (MUFG forum)

Dialogue with the authority in the U.S. and Europe

International advocacy

Emphasis on dialogues when developing whitepapers

The MUFG Transition Whitepapers have been developed by adhering to three basic principles: The first is to “start with the customer's voice.” We listen to our customers, admit when we do not understand, and study until we do. We build on what we have learned and strive for a bird's-eye view of what is happening across industries. We share the voices of customers from one industry with customers from another.

The second is to “prove the customer's voice.” Even if the customer's voice is a qualitative suggestion, we look for quantitative data to support it. If the customer's voice differs from the data, we go back and ask the customer again. In this way, we combine data with the customer’s voice and feelings.

The third is to “speak for ourselves.” We constantly engage directly with stakeholders, including government authorities, industries, academia, and financial institutions, with the whitepaper in hand. We verbalize our understanding to the best of our ability and seek candid feedback. We visited Europe, the U.S., Asia, and Oceania, and conducted one-on-one meetings and held private forums with multiple companies, as well as attending public forums such as United Nations Framework Convention on Climate Change’s Conference of the Parties (COP). We continuously exposed our understanding to the outside world and worked to understand better. As a result of these activities, we can summarize the current situation in the U.S., Europe, and Japan, first focusing on economic trends.

Executive Summary

MUFG ‘s Transition Whitepaper 3.0 (2024) is the latest in a series of annual publications in which we offer our perspective on the dynamics shaping the global transition to carbon neutrality (CN). In each of the three papers in the series, we have developed our thinking based on the feedback we have received and on our evolving understanding of the challenges and opportunities facing companies and policy makers. In our most recent paper, we discuss market and policy conditions in the major economies and set out our perspective on possible options for moving forward, focusing in particular on the intersection of policy, investment, and consumer demand.

Following the publication of Whitepaper 2.0 (2023), MUFG met with stakeholders involved in the roll out of carbon neutral technologies in Europe, America, Asia, and Oceania. Our discussions focused on two of the most important industries for decarbonization - electricity and heat. We saw that different countries have adopted unique policy approaches to transitioning in these areas but face a common challenge: how to achieve scale up of carbon neutral technologies at a cost that works for end-users.

We face a chicken and egg situation: To boost consumer demand for low carbon products and technologies, the cost needs to come down dramatically, but to reduce the cost, production must be scaled up. Further, for banks to provide finance, businesses must be viable. Around the world, we saw some success stories in solving this paradox, but only in limited regions and technologies. More often, we found that recent trends in inflation had lifted the costs of technology investment and raised the price for end-users to a level that is beyond the reach of all but a few. In Whitepaper 3.0 we discuss how companies, financial institutions, and policy makers might address this challenge.

To understand the dynamics around technology innovation and related economics, we start in Whitepaper 3.0 with three related but distinct lenses: (i) Expanding technology options (optionality), (ii) ensuring business profitability (economic viability), and (iii) raising consumer awareness and understanding (end-user awareness and understanding). Equally, we believe that successful technology roll out is contingent on establishing a system that nurtures technology over the long term through three pillars - public-private partnerships, financial support for scaling, and end-user awareness and understanding to foster willingness to accept price pass-through.

The report emphasizes the importance of enhancing global understanding of the challenges we face and of collaboration between the public, private, and academic sectors, and private finance. It proposes that risks relating to potential greenwashing should not be addressed by countries or companies alone but rather resolved through international initiatives to advance a framework that speaks in a common global language. In this regard, it will be critical for policy not to stifle investment in decarbonization or transitioning efforts, which would exacerbate the challenges we face.

Global Trends

There can be no serious understanding of the challenges of the CN journey without an appreciation of the economic and geopolitical landscape. Right now, globalization is facing headwinds, amid flat international trade volumes and falling cross-border M&A transactions. Meanwhile trade policy is increasingly restrictive, with economic blocs taking the place of global multilateralism. Moreover, climate change policies and industrial policies are becoming increasingly intertwined.

U.S. Trends

The U.S. has introduced a range of economic incentives for low-emissions technologies involving both renewable energy and fossil fuels. Most notable are long-term tax credits (income support or referred as a “P/L support” in this whitepaper) under the Inflation Reduction Act (IRA) and subsidies (capital investment support or referred as a “B/S support” in this whitepaper) mainly through the Infrastructure Investment and Jobs Act (IIJA). These have served to crowd in private finance in sectors including solar power, electric vehicles (EVs), and energy storage. All told, there has been around $200 billion of investment, leading to the creation of more than 180,000 jobs. Still, private finance’s progress varies by technology. While it is advancing in mature technologies such as EVs and solar power, it is lagging in less mature technologies including hydrogen and CCUS (carbon capture, utilization, and storage). The higher costs of these emerging technologies make it difficult to achieve economic viability in the current market environment, necessitating further policy support and financing incentives. In short, while income and capital investment support can act as catalysts for private finance in viable technologies, they have not been as effective where the pathway to profitability is less certain.

European Trends

Europe is promoting CN primarily through regulation. The region has laid the foundations for a circular economy, aiming not only to promote the effective use of resources and adoption of recycling technologies but also to encourage self-sufficiency. The Critical Raw Materials Act sets targets for recycling rates, aiming to reduce Europe’s reliance on imports of strategic materials. Meanwhile, inflation, particularly rising construction costs, has become a significant obstacle, leading to profitability challenges in sectors such as offshore wind. With private finance on the sidelines, some planned projects have been withdrawn, in some cases leading to significant financial penalties. Thus, there appears to be a clear distinction between sectors where investment is progressing and those where it is not. Again, cost pass-through remains a significant obstacle to progress.

Japan Trends

Japan’s approach to achieving CN is based on the Green Transformation (GX) policy, which provides technology-neutral policy support to ensure a broad range of options. Companies receive a combination of income and capital investment support in sectors including hydrogen, ammonia, CCUS, offshore wind, and solar power, with the aim of stimulating private finance for scale up. The GX Basic Policy, published in February 2023, outlines roadmaps for 22 technological fields, with an emphasis on policy support tailored to specific stages of technology development.

Technologies in the R&D and demonstration stage of development require long-term government-led support, to which the government has responded with capital investment funding through the Green Innovation (GI) Fund. For technologies in the scaling phase or established as economically viable, the government is providing income and capital investment support in the hope of encouraging private finance. In CCS, hydrogen, and ammonia, relevant tools include feasibility study support and price gap compensation, with public-private partnerships aimed at expanding deployment. Japan is not looking to gain first mover advantage, but rather at assessing and implementing appropriate policies. Evaluating policy effectiveness is yet to come. Looking ahead, Japan will accelerate its transition through the GX program while learning from experiences in Europe and the U.S.

Technological Progress and Financial Support

Countries around the world are taking distinct approaches to achieving CN. While Europe emphasizes regulation and disclosure, the U.S. is more weighted toward on incentives and market mechanisms, and Japan prioritizes consensus-building through collaboration between government, industry, and academia. We believe the best way forward will be for each region to recognize and respect these differences and identify appropriate routes to securing the necessary finance. Overcoming the challenge of price pass-through requires international cooperation on financing and establishment of a global framework that reflects a strong mutual understanding of the challenges at hand.

While it is impossible to predict the future with certainty, we believe there is no one-size-fits-all technology that will enable every country to achieve CN. Thus, it is essential to expand technology options (optionality), provide financial support for scaling up of projects where it makes sense (economic viability), and promote information disclosure to raise consumer awareness and understanding (end-user awareness and understanding). In this way, stakeholders can start to facilitate price pass-through and long-term technology profitability. Where there are reputational issues, such as in fuel transitions (e.g., from coal to gas), there should be an internationally coordinated framework for transition support.

Successful technology implementation will be predicated on an understanding of the total cost of integrating renewable energy, whose outputs vary depending on environmental conditions. Stakeholders must therefore take into account additional costs, such as those necessary to support supply adjustment when the wind does not blow or the sun does not shine. This total cost analysis will provide stakeholders with a realistic estimate of the cost of technology roll out.

By way of example of the cost equation, fluctuations in the output of renewable energy are currently being managed with transmission and distribution systems, energy storage, and thermal power generation. To optimize capital allocation, these elements can usefully be categorized as “adjustment capacity.” Moreover, even in the transmission and distribution sector, there is a need for a broader analysis that takes into account all of the relevant factors. One such would be to consider whether to “transmit through electricity” (watts) or “transmit through data” (bits). In other words, companies and policy makers should consider, in the case of new data centers, whether they should be located near power generation plants or vice versa (watts-bits consideration). A holistic perspective that goes beyond individual technologies is essential.

A vital collaborative tool in the provision of funding for long-term investment is blended finance, which involves structuring optimal allocations for each stage of a project, from early development to the start of operations, with both public and private financial institutions involved to reduce risks. That said, it is important to recognize the limits of this approach. Providing funding to loss-making businesses will only exacerbate losses. Thus, blended finance is effective if it functions as either a mechanism to turn deficits into profits (through domestic and international subsidies, taxes, and price pass-through via electricity rates etc.) or a mechanism to scale profits into larger profits (through the cooperation of first-loss takers, investors, mezzanine, junior, senior financiers etc.).

Finally, accurate monitoring of CO_2 emissions will play a critical role in the transition. We believe that satellite data can support broad, efficient, and objective monitoring of CO_2 emissions, reductions, and absorption. Through this data, it may be possible to create a new carbon market that will further stimulate investment and funding.

Conclusion

Through our work on the MUFG Transition Whitepaper, we have asked a fundamental question—what is sustainability? To us, it means being truly sustainable. To be truly sustainable, you must subscribe to "ultimate accountability," which means understanding where you stand in the broader movement of society and what you are doing and/or trying to do right now.

In the past, MUFG's and many companies' main focus was on the immediate business partners—evaluating the price and quality of the services and products we offered and how we differentiated from our competitors. Our vision was always putting the immediate transaction at the center of our thinking. However, we have started to grasp a broader context, which leads to several questions: how much greenhouse gas is emitted by the supply chain to which we belong? As efforts to reduce emissions and use virgin materials advance, are our actions aligned with the potential supply chains of the future? Have we expanded our imagination to consider working conditions (human rights) in the supply chain, as well as our impact on natural capital (biodiversity)? Do we understand how the services or products we provide are made and how they are used?

We have come to believe that we must assess our business through the following three lenses: climate change and the circular economy, human rights, and biodiversity. Through these lenses, we can also see ourselves more clearly. And if we consider the bigger picture and the Earth as a whole, we must understand the importance of international collaboration to find optimal solutions in a world of limited resources. By zooming in and out like this, we sharpen our understanding of the interplay between abstract and concrete. And we see that sustainability is the lens that enables us to move forward.

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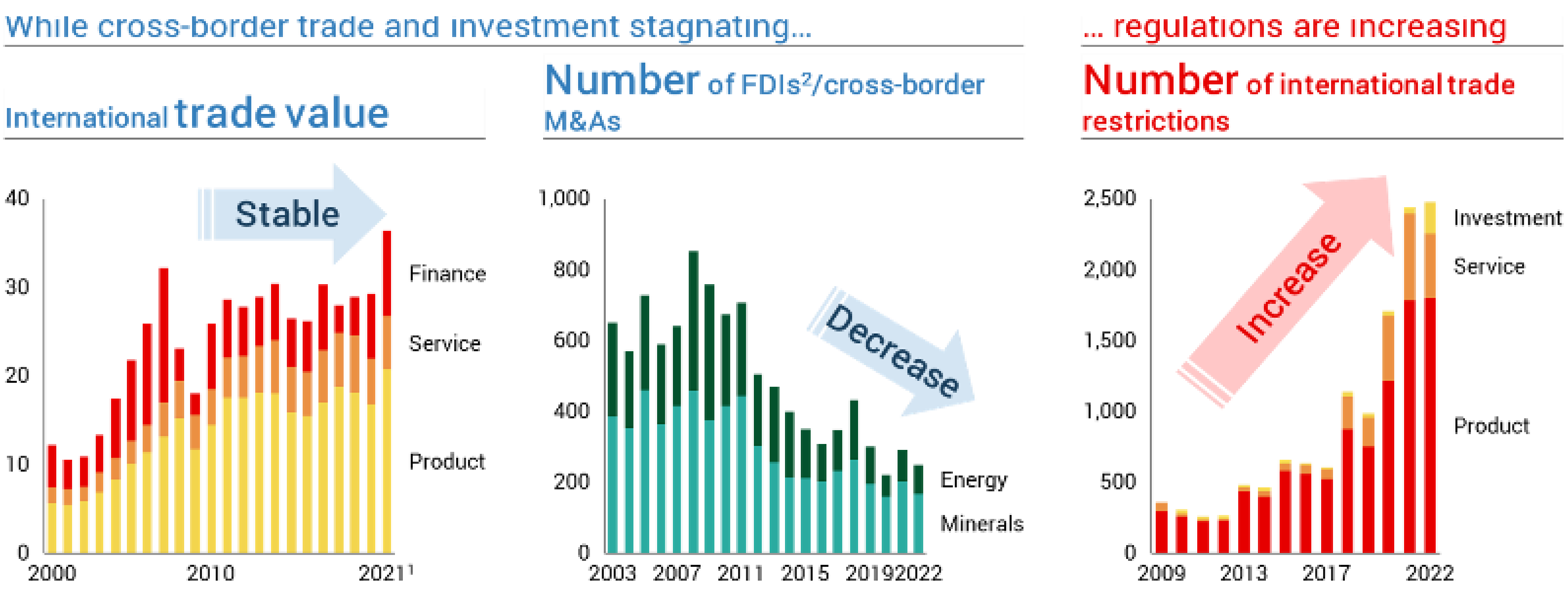
1.Global economic trends

Transition from globalization to bloc economies



As the world moves toward the bloc economies, countries have started to **introduce industrial policies** to **strengthen their competitiveness** in the global market by **linking climate change policies**

The world is moving away from a period of economic multilateralism. International trade volumes that continued to expand until 2010 have been flat in recent years, while foreign direct investment and cross-border M&A are declining. Meanwhile, the number of regulations restricting international trade has sharply increased. Moreover, climate change policies are increasingly linked to industrial policies and competition has swayed from technology to policy.

1: The surge in 2021 is in reaction to relaxation of activity restrictions after COVID-19; 2: Foreign Direct Investment
Source: IMF (1/2); IMF (2/2)

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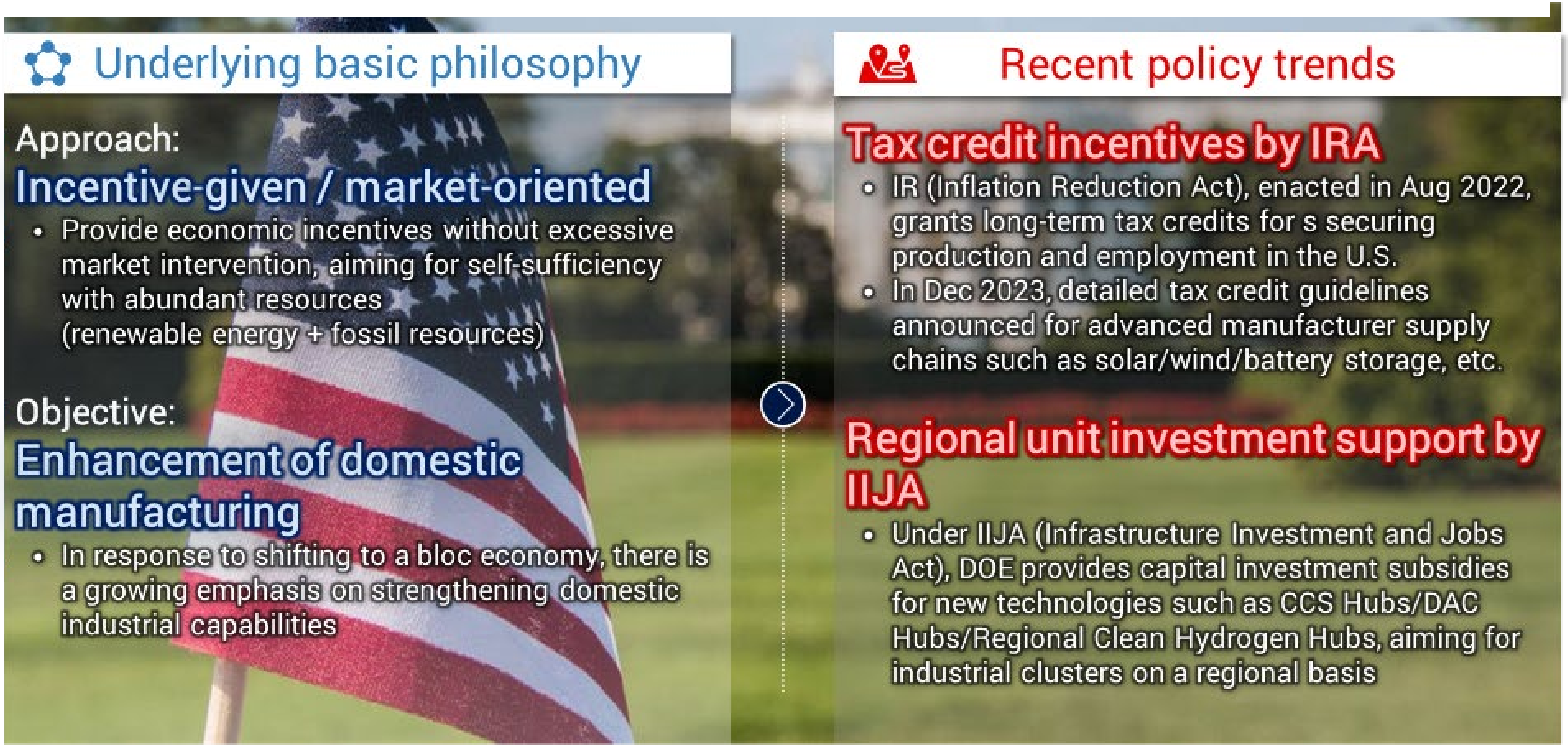
2. Current status and challenges in decarbonization of the United States and Europe

1.United States

CN policy approach overview



CN policy approach overview

The U.S. appears to be taking an approach to CN based on economic incentives and adherence to market principles. There are two major pieces of federal legislation - the Inflation Reduction Act 2022 (IRA) and the Infrastructure Investment and Jobs Act 2021 (IIJA). These are designed to accelerate adoption of transition technologies through financial incentives. The IRA provides long-term tax credit incentives, many of which are profit and loss (P/L) support for projects that promote domestic production and job security, including in supply chains for solar, wind, and batteries. The IIJA specifies that balance sheet (B/S) support (subsidies for development/equipment investment) will be provided by the U.S. Department of Energy (DOE) for new technologies such as carbon capture and storage (CCS) Hubs, direct air capture (DAC) Hubs, and Regional Clean Hydrogen Hubs aiming to concentrate industries on a regional basis. Economic incentives come with bonus credits for domestic production and job creation in the U.S. Apart from economic incentives, there is minimal market intervention, leaving companies to utilize the U.S.'s abundant natural resources (renewable energy and fossil fuels) to achieve CN self-sufficiency.

IRA: Overview of detailed tax credit system for several clean technologies projects

Aim to improve investment predictability through tax credit (P/L support[1]) for a wide-range of technologies — P/L support

Technology	PTC[1]	ITC[2]	Base	Bonus: Prevailing Wage	Bonus: Domestic Employment	Bonus: Domestic Production	Bonus: Energy community	Base + Bonus
1 Solar/ Wind		✓ (48)	6%	5x		+10%	+10%	50%
1 Solar/ Wind	✓ (45)		0.3 cent/kWh	5x		+10%	+10%	1.8 cent/kWh
2 Battery storage		✓ (48)	6%	5x		+10%	+10%	50%
3 Grid Connection		✓ (48C)	6%	5x		(N/A)		30%
4 Nuclear	✓ (45U)		0.3 cent/kWh	5x	(N/A)			1.5 cent/kWh
5 Hydrogen	✓ (45V)		$0.6/kg	5x		(N/A)		$3.0/kg
6 SAF	✓ (40B)		$1.25/gallon	Up to +$0.5/gallon based on lifecycle GHG emissions				$1.75/gallon
7 Clean Fuel	✓ (45Z)		$0.35/gallon (aircraft) $0.20/gallon (non-aircraft)	5x		(N/A)		$1.75/ gallon (aircraft) $1.00/gallon (non-aircraft)
8 CCUS	✓ (45Q)		$17/t-CO2 (CCS) $12/t-CO2 ($CO_2$ Use)	5x		(N/A)		$85/t-CO2 (CCS) $60/t-CO2 ($CO_2$ Use)
9 DAC	✓ (45Q)		$36/t-CO2 (CCS) $26/t-CO2 ($CO_2$ Use)	5x		(N/A)		$180/t-CO2 (CCS) $130/t-CO2 ($CO_2$ Use)
10 EV		✓ (30D)	0	North American production requirement & Material sourcing requirement from the U.S. or its FTA countries				$7,500

Types of tax credit (Tax code section)

The IRA has three main characteristics. The first is that the policy support covers a wide range of technologies, including not only renewable energy but also low-emission technologies utilizing fossil fuels. The second is that it is a strong incentive for P/L support (tax credits). The third is that bonus points are awarded for domestic production and job creation within the U.S. as additional incentives.

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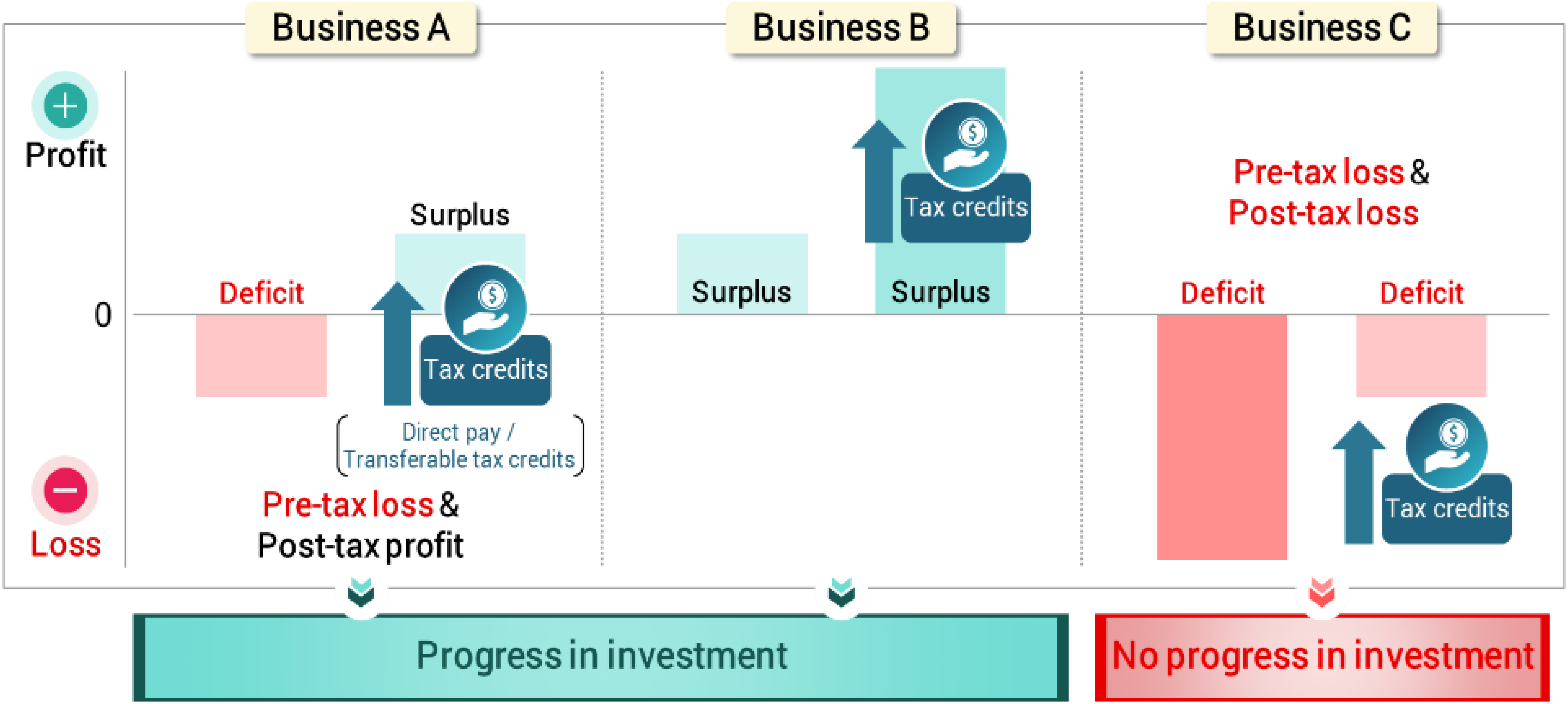
1. P/L (profit & loss) support means incentives that aims to improve cashflow of a project
2. Production Tax Credit: Deduct a certain amount of corporate tax per year of electricity generated/produced over the first 10 years of operation;
3. Investment Tax Credit: Deduct a certain percentage of capital investment from corporate tax; 4. If GHG emissions is 0.45 kg-CO_2/kg-H_2 or less
Source: The White House; METI

Characteristics of the U.S. policy support (tax credits)

Through P/L support type of tax credits, businesses shifting from deficit to surplus/surplus to greater surplus see progress in investment, while businesses remaining in deficit even after the support face difficulties in making progress



Characteristics of the U.S. policy support (tax credits)

Through PL support, projects such as the two on the left in the diagram above can benefit from: 1) turning a loss into a profit or 2) increasing profitability. These projects are able to secure financial viability, making it easier to attract private investment.

However, a question arises: "Can businesses that are operating at a pre-tax loss, with no tax liability, still benefit from tax credits?" Since tax credits reduce the amount of tax owed, companies with no tax liability typically cannot take advantage of them. The IRA has established mechanisms to address this challenge:

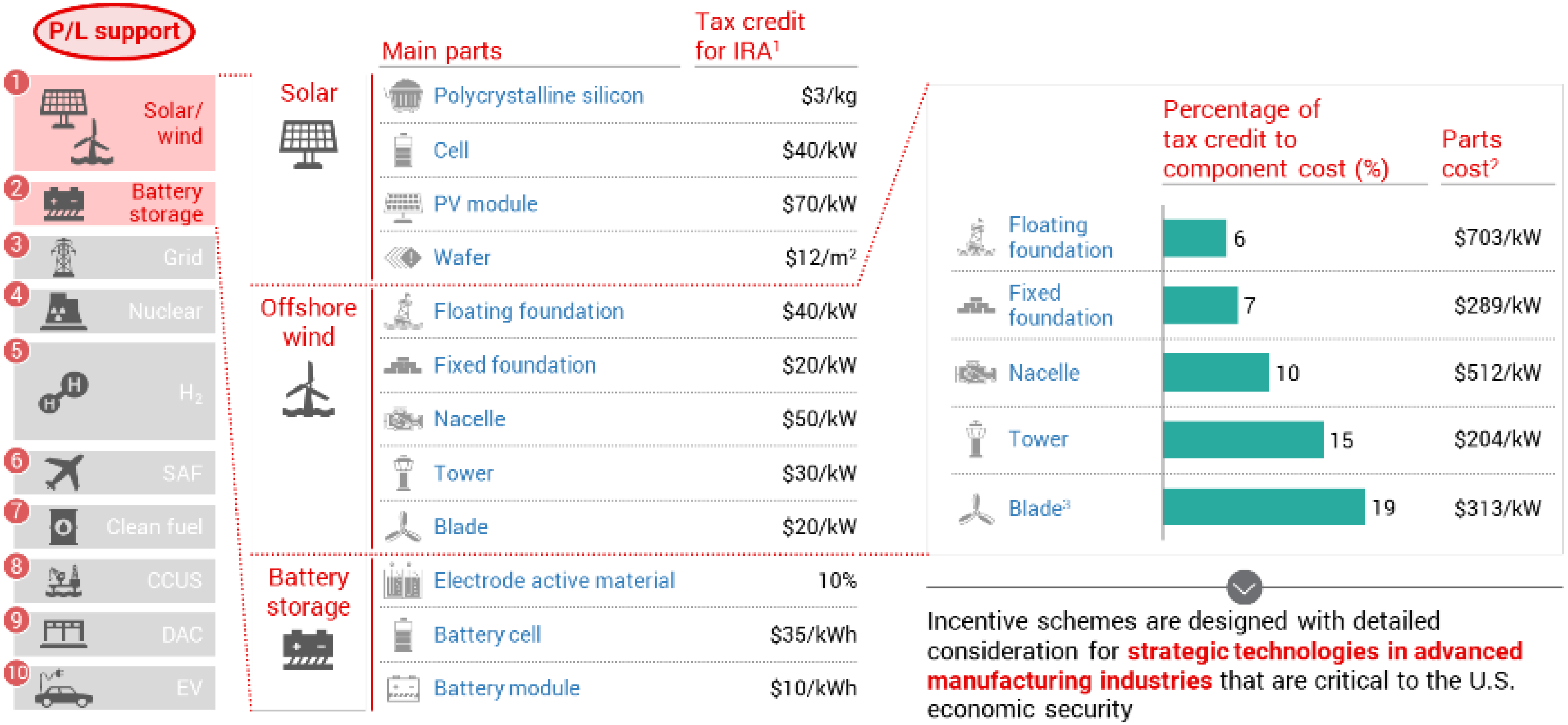
1. The ability to sell tax credit rights: Although the specific details of the transfer rules are still to be announced, even companies operating at a loss without tax liability can now sell their tax credits to third parties.

2. Direct payment of tax credit value: The IRA allows what is referred to as "Direct Payment," enabling businesses to receive the equivalent value of the tax credit in cash, rather than as a tax deduction. This means that companies, regardless of their tax position, can receive cash incentives. Through these mechanisms, even businesses that are currently making a loss can monetize their tax credits. As a result, startups and other early-stage companies are now more likely to explore investment opportunities supported by the IRA. The IRA broadens the pool of players that can utilize these incentives, fostering a culture of technological development across the entire ecosystem and promoting diversity, which is part of the U.S.'s appeal, according to one of our U.S. clients.

On the other hand, there are projects—like the one on the far right of the above figure—that remain unprofitable despite PL support. These projects cannot ensure financial viability, hindering private investment.

In summary, there are projects where PL support is effective, and others where it is not. The strength of the IRA lies in its ability to increase project predictability through PL support and to create a scenario where diverse players can benefit from tax credit monetization through resale or direct payment.

Detailed credit system in advanced manufacturing (Guidance announced in Dec. 2023)



Solar power, wind power and batteries are relatively mature technologies and whose business viability is secure. The introduction of P/L support at this stage further stimulates private investment. Thus, technologies that play a vital role in economic security have generous incentives and are also driving domestic production and job creation. We surmise that the implementation of CN technology is not only aimed at achieving clean energy but also increased national security and industrial competitiveness.

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1. Manufacturers can choose either the 45X manufacturing credit or the 48C investment credit, but this analysis covers the 45X.
2. Parts cost does not include installation cost; 3. Assumed to use 3 blades ($20/kW × 3 = $60/kW)
Source: Bricker Graydon; METI; NREL

Approach for designing incentive schemes for technologies with limited economic viability

For technologies that are relatively less economically viable, provides not only P/L support but also B/S support[2] through capital investment subsidies

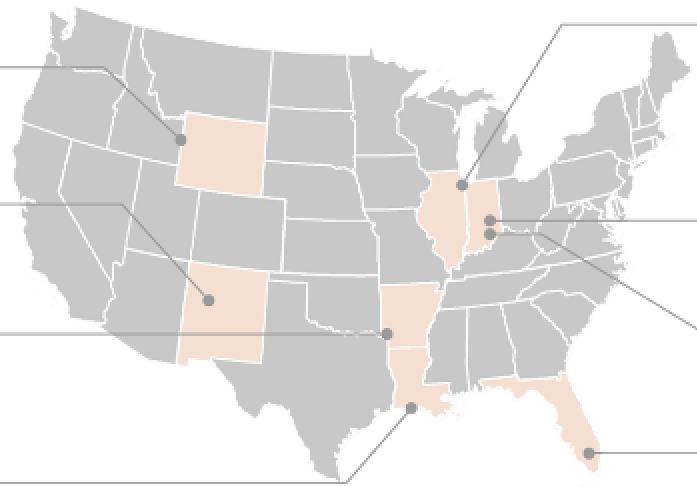
In contrast to solar, wind and batteries, less established hydrogen, CCUS, and DAC receive both P/L support from the IRA and B/S support from the U.S. Department of Energy (DOE). P/L and B/S support are implemented simultaneously. The three technologies share a common characteristic: they can reduce CO_2 emissions relating to current energy use, but they may not generate significant additional value on their own beyond that, except for some non-energy application of hydrogen or CCU products. In other words, it may be difficult to achieve economic viability without combining P/L and B/S support, and thus policy support plays a critical role in ensuring technology optionality.

1. Hydrogen with various low-emission measures;
2. B/S (balance sheet) support means incentives that aims to improve balance sheet of a project

B/S support (~$107 mm) to 8 CCS Hubs (as of May 2023)[1]

B/S support

$107 mm (¥16.1bn[3]) of B/S support[2] given to 8 CCS Hubs



1. University of Wyoming | MTR CARBON CAPTURE | $5 mm
   Dry Fork Station
   Coal-fired power station, Wyoming, ~3 MTPA
2. Navajo Transitional Energy Company | Mitsubishi Heavy Industries | N/A
   Four Corners Power Plant
   Coal-fired power station, New Mexico, ~10 MTPA
3. Southern States Energy Board | Air Liquide | $8M
   Foreman Cement Plant
   Cement, Arkansas, ~1.4MTPA
4. Entergy | Mitsubishi Heavy Industries | $9 mm
   Lake Charles PowerStation
   Gas-fired power station, Louisiana, ~2.5 MTPA
5. University of Illinois | City Water, Light & Power | $67 mm
   BASF | Linde Group
   Integrated Capture, Transport, and Geological Storage
   Coal-fired power station, Illinois, ~2 MTPA
6. Duke Energy Indiana | Honeywell UOP | $8 mm
   EFFICIENT[4]
   Gas-fired power station, Indiana, ~3.6 MTPA
7. Lehigh Hanson | Mitsubishi Heavy Industries | $5 mm
   Mitchell Cement Plant
   Cement, Indiana, ~2 MTPA
8. Tampa Electric | ION Clean Energy | $5 mm
   Polk Power Station
   Gas-fired power station, Florida, ~3 MTPA

Legend

Project name
CCUS application areas, regions/states covered by the application (including partial ones), CO_2 capture volume in million ton per annum (MTPA)

As of May 2023, the DOE had provided $107 mm in B/S support (capital investment subsidies) for CCS projects in states including Arkansas, Wyoming, and New Mexico.

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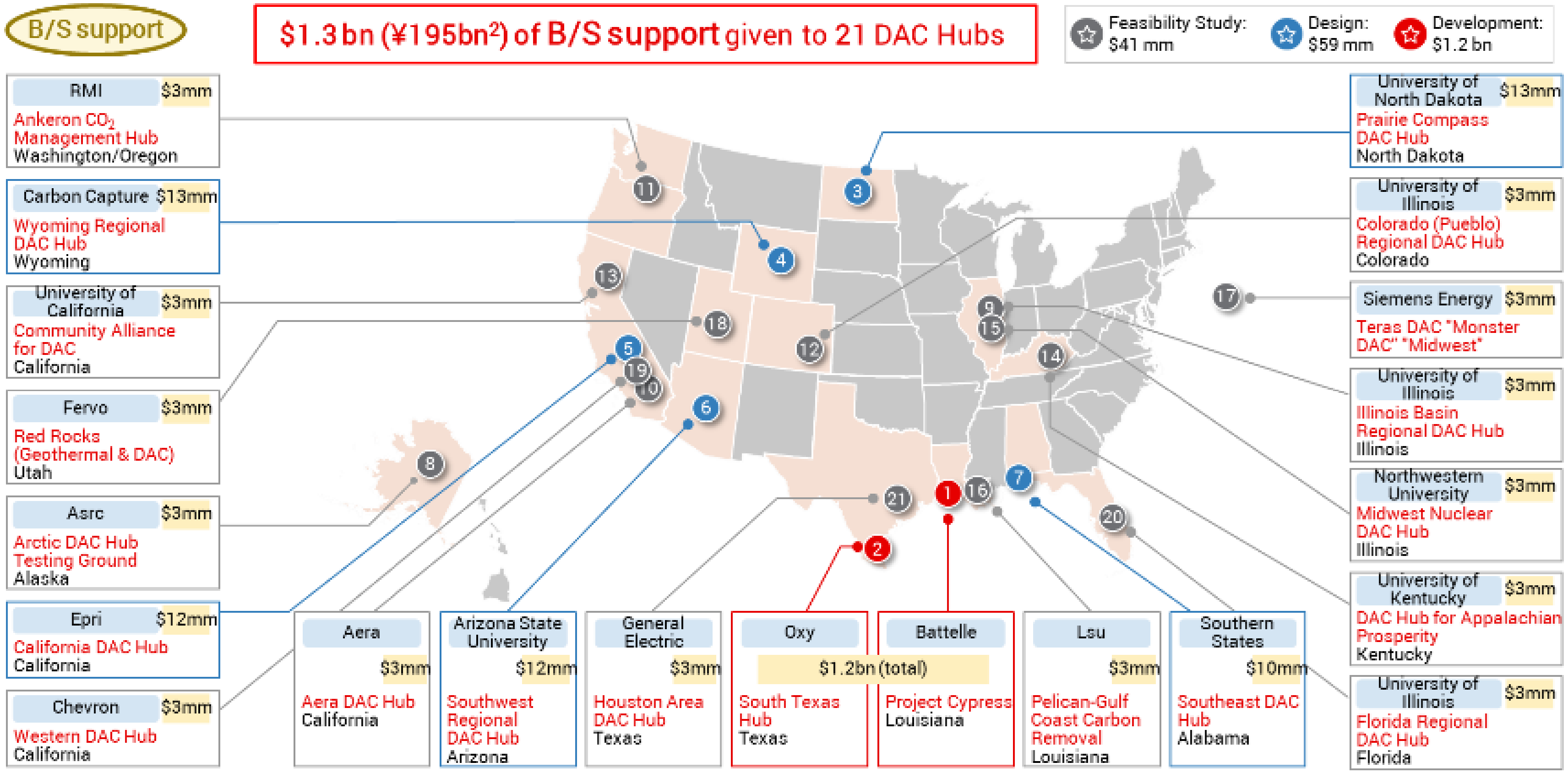
1. Hub locations on the map indicate approximate locations based on publicly available information; 2. Subsidies on facility investment costs;
3. Converted at $1=¥150; 4. Edwardsport Flex Fuel Integrated Capture for Indiana's Energy Transition
Source: OCED (1/2); OCED (2/2)

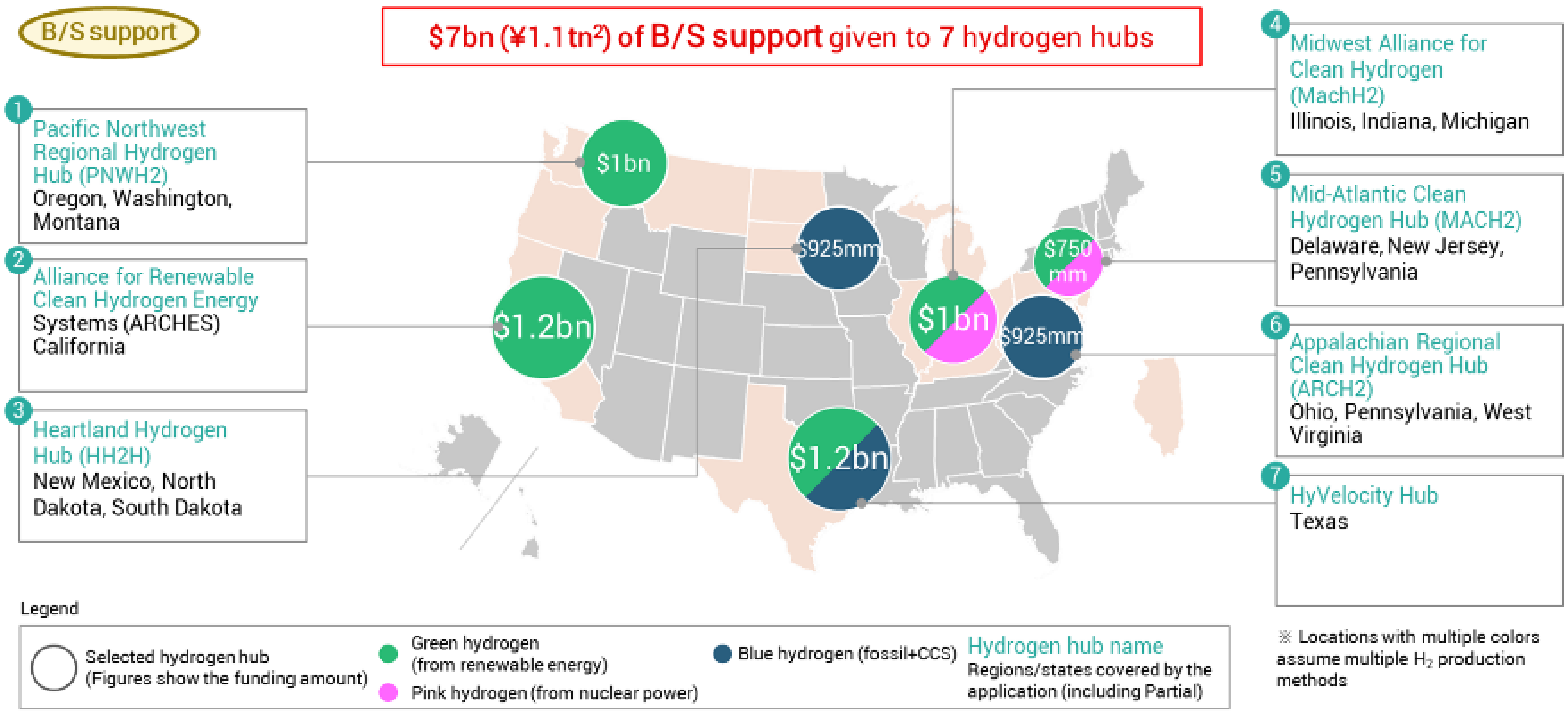
B/S support (~$1.3bn) to 21 DAC Hubs (as of September 2023)[1]



In addition, the DOE has provided $1.3 billion in B/S support for direct air capture (DAC) projects, as of September 2023. The support includes development projects for hubs (2 projects), design projects (5 projects), and feasibility studies (14 projects).

1. Hub locations on the map indicate approximate locations based on publicly available information; 2. Converted at $1=¥150
Source: U.S. Department of Energy (1/2); U.S. Department of Energy (2/2)

B/S support ($7bn) to 7 Regional Clean Hydrogen Hubs (as of October 2023)[1]



As of October 2023, the DOE had provided $7bn in B/S support for hydrogen hub projects. The support will cover projects across 16 states, promoting various hydrogen production methods, including clean hydrogen using renewable resources, blue hydrogen using fossil fuels and CCS, and pink hydrogen using nuclear energy.

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1. Hub locations on the map indicate approximate locations based on publicly available information; 2. Converted at $1=¥150
Source: U.S. Department of Energy

State of market and private investment and implementation status of policy support

EV/battery storage/solar
(emissions reduction + value added)
(Profitable phase)

Policy support

- Strengthen industrial competitiveness through domestic production with detailed incentives for each component
- Advanced manufacturing credits provide tax credits of production costs for key parts of solar, offshore wind, and battery storage

Private investment

- Growing demand has led to a wave of investment from the U.S./foreign companies
  - To reduce dependency on specific countries, foreign companies rush in to invest in building a supply chain in the U.S.
  - Infrastructure is being developed, making it possible to pass on prices, especially to high-income early adopters

H_2/CCS/DAC
(emissions reduction)
(Deficit phase)

Policy support

- Progress made with classification and introducing a framework for the commercialization support and subsidies mainly for hubs being decided
  - CCS: 8 hubs, ¥16.1bn
  - DAC: 21 hubs, ¥195bn
  - H_2: 7 hubs, ¥1.1tn
- Some say that policy support are only 10-20% of total CAPEX required

Private investment

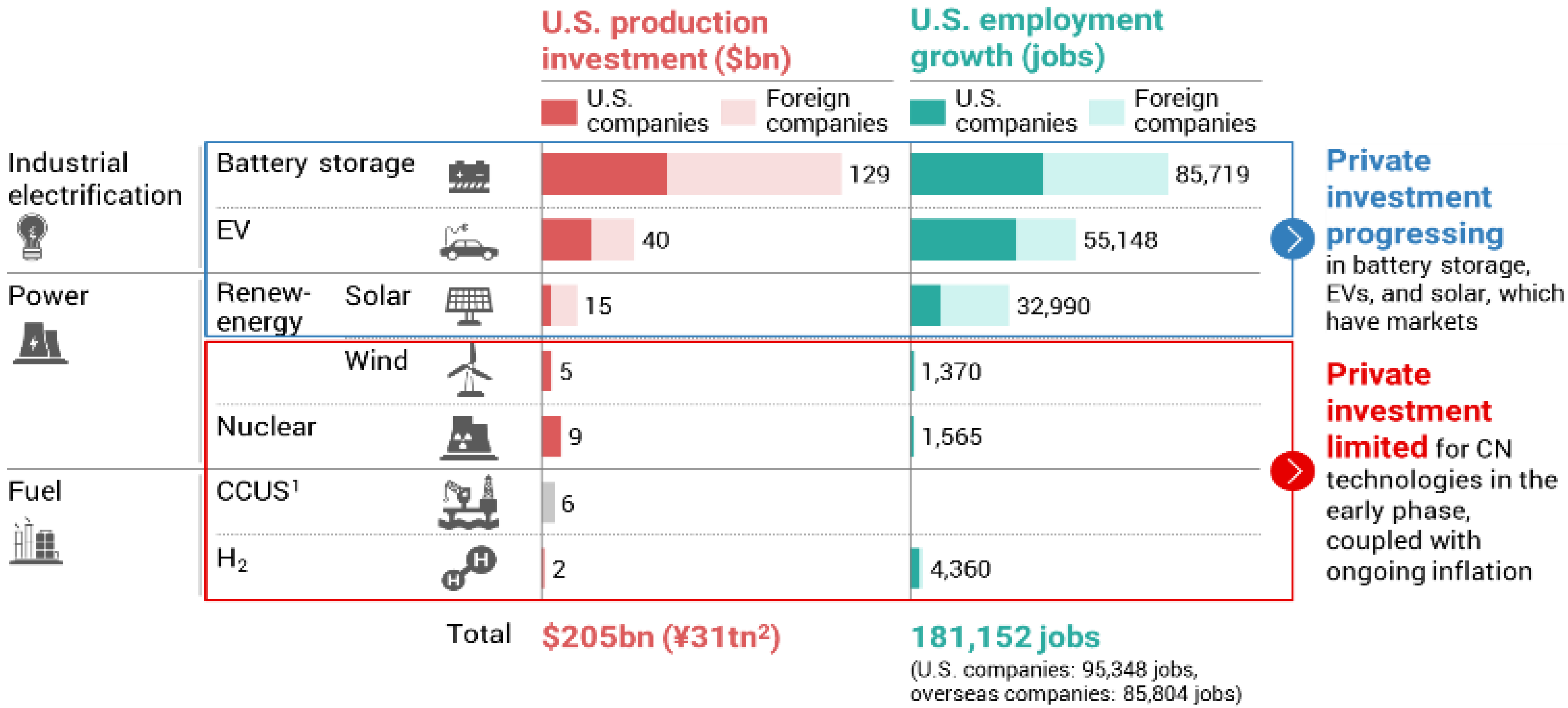
- On the other hand, private investment in actual projects is limited due to price pass-through barriers
  - Due to inflation, resource cost has increased, causing large-scale new CAPEX to stagnate
  - Struggle to acquire off-takers due to high green premiums in the nascent market

State of market and private investment and implementation status of policy support

From our conversations with customers in the U.S, we have learned that progress differs between technologies in the market growth phase (black ink above) and market introduction phase (red ink). Technologies in the market growth phase have completed technical demonstrations, and their business viability is secure. Specifically, solar power, EV, and storage batteries fall into this category. P/L support turns black ink even blacker, and policy incentives stimulate private investment. Furthermore, through the bonus incentive system, domestic production and job creation are promoted.

Technologies in the market introduction phase such as hydrogen, CCS, and DAC still appear to be in the process of technical and economic demonstration. Even with P/L and B/S support, most of the projects remain in the red and private investment has made only limited progress. Use of B/S support is limited to 10-20% of available subsidies, with private investment remaining in the red, indicating that the price pass-through barrier has not been overcome.

Upstream investment plans since the Biden Administration's IRA



Regarding technologies in the market growth phase, such as storage batteries, EVs, and solar power, we can see that private investment is active both domestically and internationally, confirming that job creation is high. For technologies in the market introduction phase, private investment is not progressing and therefore job creation effects are limited. Still, all told, the IRA has realized about $200 billion in investment and created over 180,000 jobs, confirming that the implementation of CN technology is also supporting domestic production and strengthening industrial competitiveness in the U.S.

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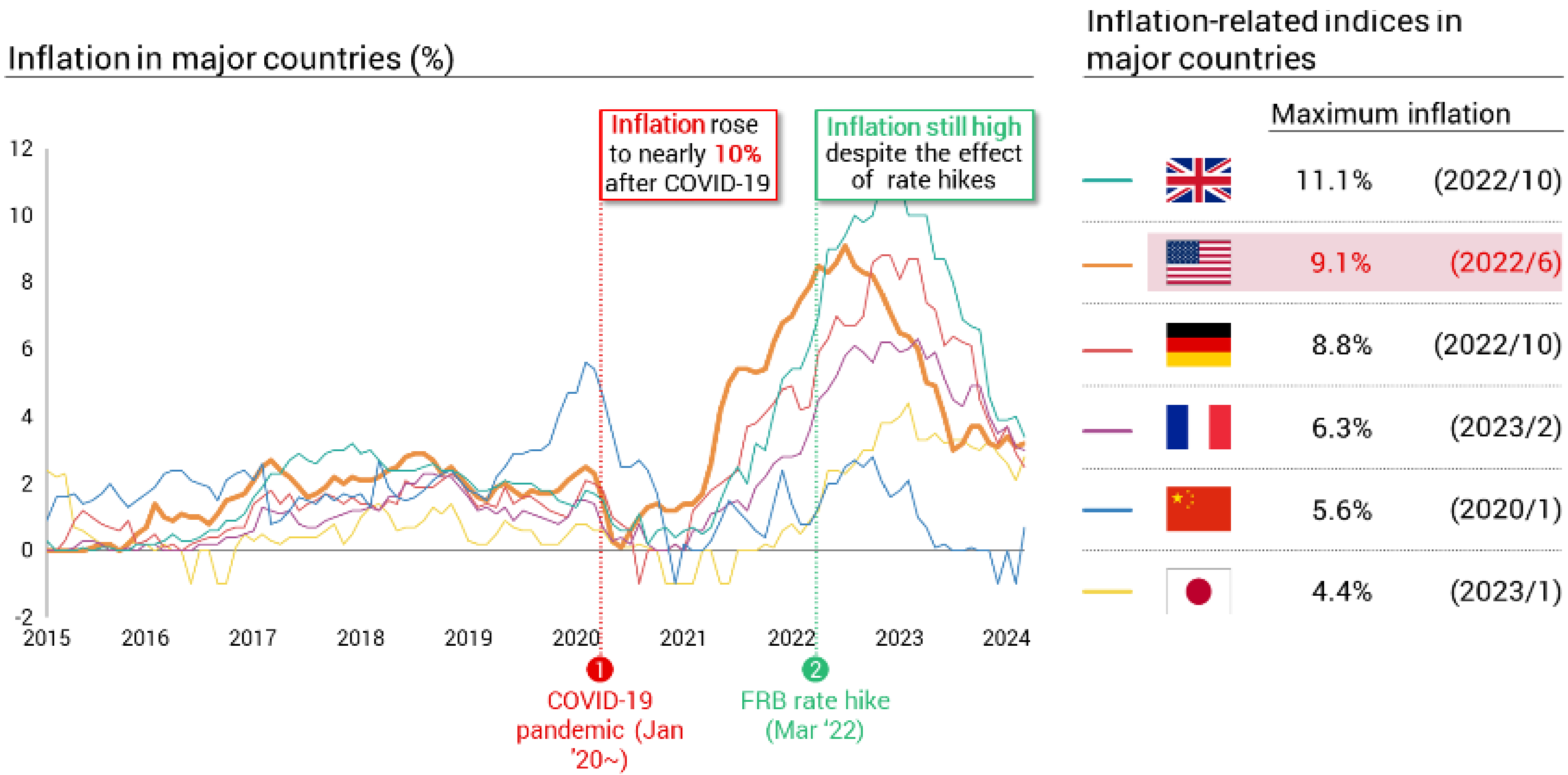
1. No breakdown of U.S. companies/Foreign companies available; 2. Converted at $1=¥150
Source: US DOE; BNEF(1/2); BNEF(2/2)

Inflation trends over the past 10 years



A significant challenge in implementing CN technology is inflation. After the COVID-19 pandemic, large-scale monetary easing led to a sharp acceleration of inflation in both the U.S. and Europe. The U.S. inflation rate reached nearly 10% between 2022 and 2023. Following monetary tightening in many countries, inflation rates seem to be stabilized. However, it remains a challenge, and the cumulative effect is a significant burden on industrial production and the daily lives of citizens.

Source: [Consumer prices - data | BIS Data Portal]

Intermediate demand index for energy costs & construction materials

U.S.: Intermediate demand index for energy costs[1]

U.S.: Intermediate demand index for const. materials[2]

Energy costs, including fossil resources, are stabilizing, creating incentives for continued use of fossil resources…

…High construction material costs have hindered the investment in large new decarbonization projects

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1. Unrefined energy sources, used for manufacturing, including coal and natural gas; 2. Construction materials (lumber, concrete pipes, architectural paints, etc.), components (metal doors, water heaters, etc.); 3. Compare Jan 2020vs. Sep 2022; 4. Compare Sep 2022 vs. Jan 2024; 5. Compare Jan 2020 vs. Jan 2024;
6. Construction material prices have soared as housing demand increased in China and the U.S.
Source: U.S. Bureau of Labor Statistics (1/2); U.S. Bureau of Labor Statistics (2/2)

Intermediate demand index for energy costs & construction materials

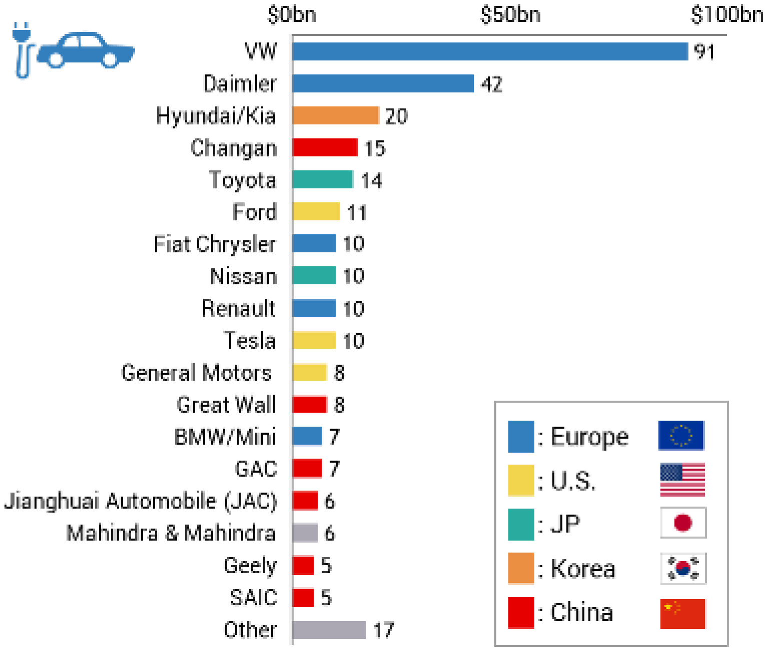
The chart on the left (above) shows trends in the U.S. Energy Cost Index for intermediate demand. Due to the COVID-19 pandemic and the Ukraine conflict, gas prices skyrocketed, causing energy costs to increase by 2.3 times. Since then, along with the adjustment of supply and demand for gas, gas prices have fallen and energy prices have stabilized.

The chart on the right depicts trends in U.S. construction material costs. Since construction materials are considered the base cost of infrastructure, they can be interpreted as the investment cost of CN technologies. The data shows that construction material costs increased by 1.4 times in the two-year period from 2021 to 2022. Additionally, factors such as wood shortages and ongoing inflation have kept construction material costs persistently high.

The U.S. IRA offers fixed-unit PL support. However, while income support is fixed, the development costs, which form base costs, have increased by around 1.4 times. This highlights the reality that, due to inflation, private investment has not progressed as expected, despite policy support from the IRA. Indeed, increased costs driven by inflation have become a significant hurdle to private investment in CN technologies.

EV investment trends of major auto OEMs

EV investment announced by major auto OEMs
(as of Sep 2019)



U.S. auto OEM EV investment decay/ reconsideration
(2023-2024)

Ford

Postponed **$12bn EV** investment, reconsidering EV strategy
- Postponed $12bn EV investment due to sluggish demand (Oct. '23)
- Reconsider EV strategy, including internal battery production(Feb. '24)

GM

Dismissed **1,300 workers** due to postponed production expansion, reconsidering EV strategy
- Postponed expansion of electric truck production, with 1,300 laid off (Oct. '23)
- Changed EV-focused strategy and launched PHV (Jan. '24)

Tesla

China sales fell **19%** due to price competition
- Sales of EVs made in China fell 19% YoY to the lowest level since Dec 2022 due to intensifying price competition with Chinese manufacturers (Feb 24)

Apple

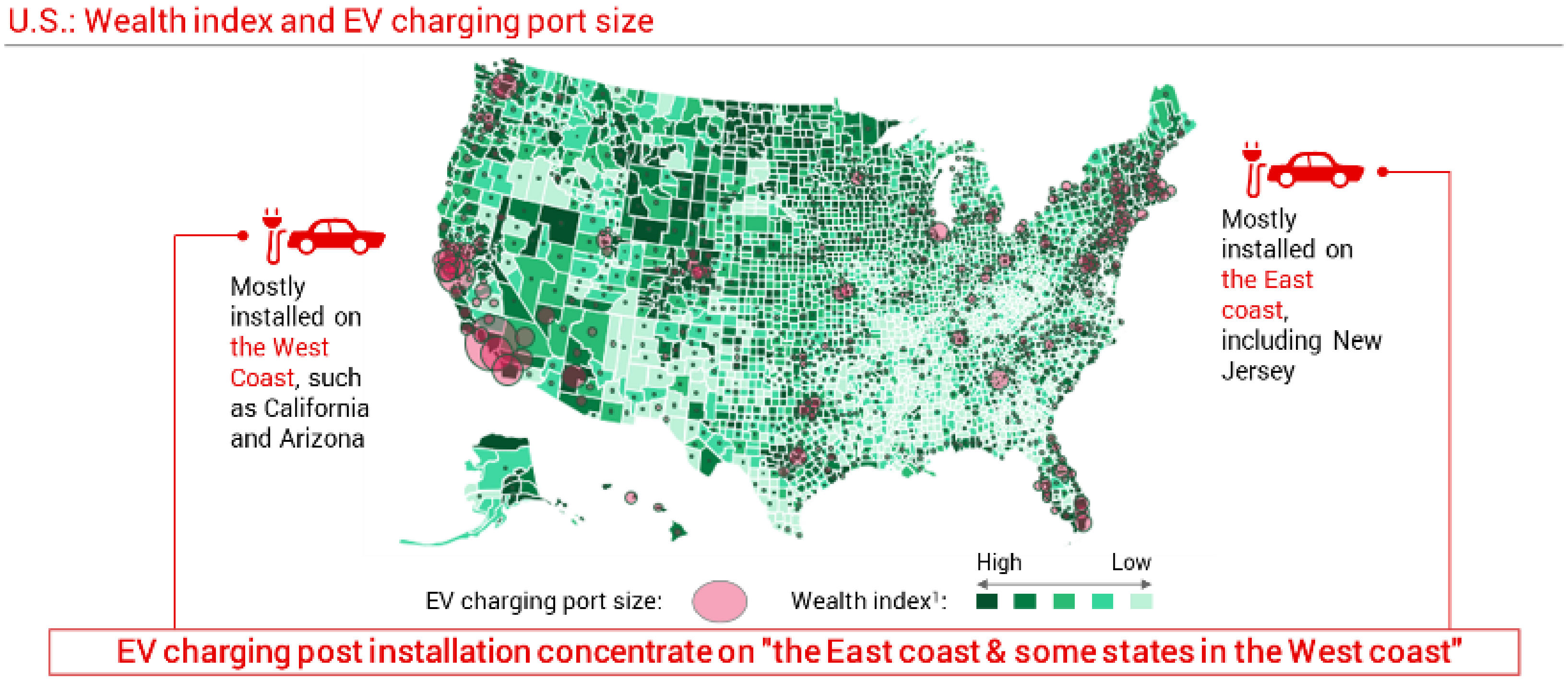
EV sales plan cancelled after over **billions of dollars** of investment
- To concentrate resources on generative AI development, stopped the plan to launch self-driving EVs after spending more than 10 years of time with over billions of dollars of investment (Mar. 24)

In the EV space, economic viability is secured and the sector is growing relatively quickly. By 2019, automakers had announced investment plans totaling over $300 billion. Many forecasts predicted a rapid acceleration in EV adoption.

However, due to a slowdown in EV demand and price competition, EV investment has plateaued. Ford, GM, Tesla, and Apple are among companies to have announced investment plan delays, employee layoffs, sales volume declines, and EV production halts.

Source: Reuters (1/3); Reuters (2/3); Reuters (3/3); Business Insider; The Register; USA Today; Automotive News; InsideEVs

Relationship between wealth inequality and EV penetration



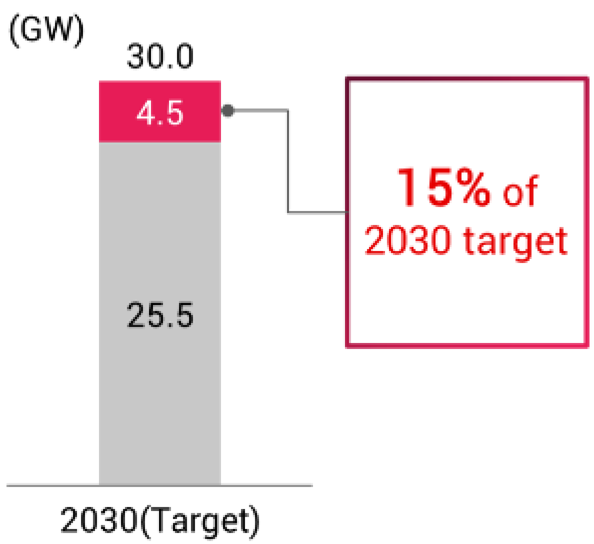
When it comes to EV charging points, they are concentrated on the East and West Coasts, which are home to many affluent populations. On a pan-U.S. basis, penetration remains low with the general public not yet accepting cost pass-through. To promote wider adoption, there will need to be improvements in functionality and design, lifestyle changes, and the introduction of low-cost EVs, as well as development in areas such as power supply equipment, security, and computing.

Note: Index based on nine factors, including per capita income, poverty, housing and education levels, unemployment rate, access to health insurance, and percentage of population receiving government services
Source: Bumper

Withdrawal cases of offshore wind projects

Project name	Results	Project overview		PPA[1] overview	
		Company	Capacity(MW)	Contract party	Rate
Common Wealth Wind (Massachusetts)	$48mm of penalty[2]	Avangrid	1,200	Eversource energy/ National grid	$76/ MWh
South Coast Wind (Massachusetts)	$60mm of penalty[3]	Shell/ OW Ocean Winds	2,400	Department of Public Utilities Common Wealth of Massachusetts	$70/ MWh
Revolution Wind 2 (Rhode Island)	Cancellation of PPA[4]	Orsted/ Eversource energy	884	Rhode Island Energy	$94/ MWh

Cancellation of PPA contracts equivalent to 15% (4.5GW) of the 2030 cumulative offshore wind installation target of 30GW

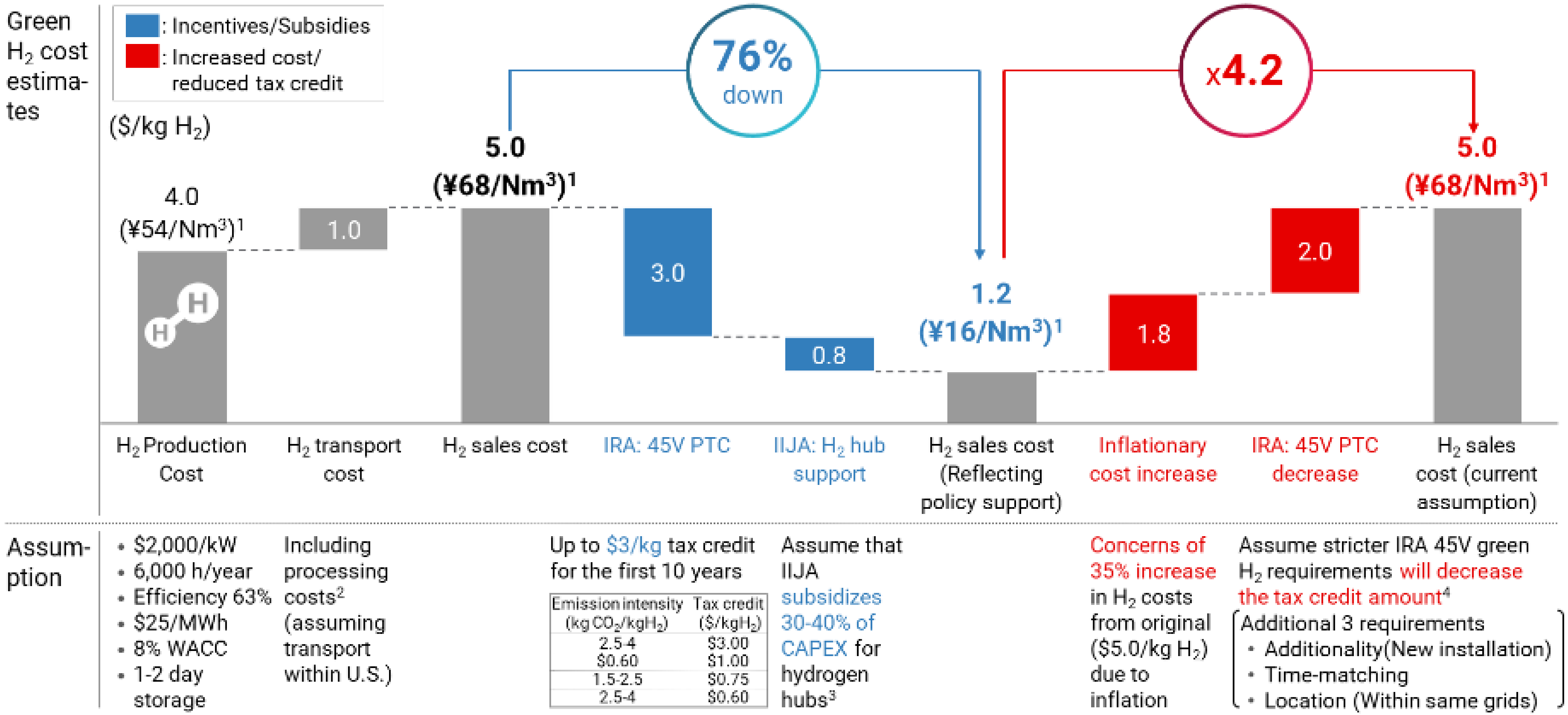


1: Power Purchase Agreement
Source: Wind Power Monthly; South Coast Wind; Renewable Energy World; Utility Dive; ; Whitehouse

Withdrawal cases of offshore wind projects

As for offshore wind, in 2023, the U.S. Department of Energy (DOE) announced its Offshore Wind Energy Strategy, a comprehensive summary of the Department's efforts to deploy 30,000 MW of offshore wind energy by 2030. A common theme in the past was that projects were developed and constructed for two to three years after operators won power purchase agreements (rights to sell electricity) through open bidding. However, abnormal inflation has lifted project costs, meaning they have far exceeded initial estimates. As a result, some operators have found it economically rational to pay substantial penalties ($48mm to $60mm) and withdraw from the projects rather than continue and bear the losses. Power purchase prices were fixed in advance, leading to significant concern over price pass through amid higher costs. Based on the publicly available information as of August 2023, 4,500 MW worth of projects have been canceled, which is approximately 15% of the DOE's target by 2030. For projects that require substantial long-term capital investment, policy support in respect of cost fluctuations will become increasingly necessary.

Green hydrogen cost estimates (for 2030)



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1. Converted at $1= ¥150, 1kg=11.14Nm³; 2. Includes compression, liquefaction, conversion; 3. Include electrolysis and BoP CAPEX, but not including renewable energy;
4. Comment of Plug Power Inc.'s CEO, Andy Marsh
Source: U.S. Department of Energy; Forbes Japan; BCG

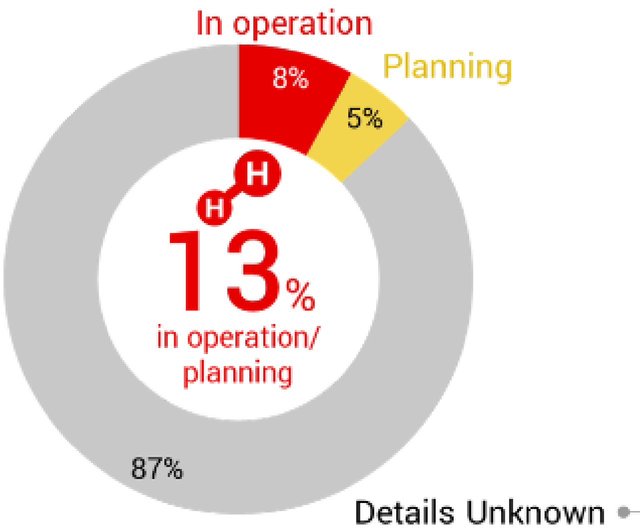
Green hydrogen cost estimates (for 2030)

In the U.S., the establishment cost of locally-produced hydrogen has been estimated at \$5.0/kg H_2 (68 yen/Nm^3). The breakdown is \$4.0/kg H_2 (54 yen/Nm^3) for production and \$1.0/kg H_2 (14 yen/Nm^3) for transportation. But at this price, there can be no economic viability, off-takes may not be established, and investments will not progress. Still, through policy support, incentives were introduced to enable the world's cheapest level of hydrogen sales cost more cheaply (\$1-2/kg H_2), equivalent to the price range for fossil fuel power.

The aim was to attract private investment and thereby reduce costs. In the event, abnormal inflation rates caused project costs to rise. Meanwhile certification demands became more stringent. As a result, with policy support, the projected cost would still be \$5.0/kg H_2 (68 yen/Nm^3), making it difficult to establish economic viability or agree off-takes, which in turn hindered private investment.

Securing off-takers for green hydrogen development

Announced Green hydrogen Projects (Jan. 2024)



Issues in securing hydrogen off-takers

Difficulty in price pass-through	High green H_2 premium vs. gray H_2 due to its infancy, technological immaturity, lack of infrastructure and cost surge due to inflation
Supply risk	Despite large-scale hydrogen projects announced, very few have been verified production scale, which may lead to significant supply disruptions
Uncertain systems/ certification	Lack of definitions and approach in green certification schemes may prevent projects from meeting requirements to obtain incentives and stall investment

Though the incentive-based policy,
the U.S. has not yet been overcome the barrier for passing-through hydrogen prices

In the U.S., there are many hydrogen projects in the pipeline but only 13% are operational or in planning, meaning private investment remains limited. The lack of large-scale projects in progress, uncertainty over incentive requirements, and challenging systems and certification procedures are also key obstacles to private investment.

Source: Global Data Hydrogen pipeline (as of January 2024)

Recent trend summary

<table>
<tr><th rowspan="2"></th><th rowspan="2">1 Policy support framework development</th><th rowspan="2">2 Private investment</th><th colspan="2">Price pass-through</th><th rowspan="2"></th><th rowspan="2"></th></tr>
<tr><th>3 The affluent (Early adopter)</th><th>4 The general public (Majority)</th></tr>
<tr><td>Industrial electrification (battery storage/EV)</td><td rowspan="3">IRA tax credit detailed guidelines to enhance domestic manufacturing</td><td rowspan="2">Progress in investments by domestic/ foreign companies in the U.S.</td><td rowspan="2">Price pass-mainly to high-income earners</td><td rowspan="2">Not yet penetrated to middle-income households</td><td rowspan="2">Investments are progressing, and costs are being passed on to the affluent</td><td rowspan="5">Neither tech-nologies has been able to pass on prices to the general public</td></tr>
<tr><td>Solar</td></tr>
<tr><td>Offshore wind</td><td>Investment cancelled/ withdrawn due to inflation</td><td colspan="2" rowspan="3">Struggle to acquire off-takers due to inability to pass on the green premium price</td><td rowspan="3">Despite policy support framework, new investment struggles / inhibited due to early stage of the market</td></tr>
<tr><td>CCUS</td><td rowspan="2">Announcement of IIJA regional hub policy support</td><td rowspan="2">Investment stagnant due to lower fossil fuel costs + higher construction material costs</td></tr>
<tr><td>H_2</td></tr>
</table>

: Progress
: Stagnate

Recent trend summary

In conclusion, in the U.S., a wide range of technologies are subject to policy support. For technologies in the market growth phase, such as storage batteries, EVs, and solar power, private investment is progressing. Still, apparently, the majority of those who accept price pass-through are affluent consumers, while the general public may be excluded. Further price reductions, price pass-through innovations, and increased information disclosure are necessary.

In offshore wind power, the risk-return adjustment process for investors is ongoing. Policy support for price fluctuations is needed.

For technologies in the market introduction phase, such as CCUS and hydrogen, we find that private investment is not progressing. Despite the introduction of both P/L support and B/S support, few players can establish economic viability. The primary causes may be inflation, the tightening of certification requirements for green hydrogen, and a lack of off-take agreements.

Given the varying progress between CN technologies, there is room for further innovation in policy and financial support frameworks. While maintaining a technology-neutral stance to ensure optionality, it is important to nurture technologies over the long term. We need to observe both the vision and the reality to determine which technologies are advancing and which are not.

Table of contents

2. Current status and challenges in decarbonization of the United States and Europe

2. Europe (EU + United Kingdom)

CN policy approach overview

CN policy approach overview

In Europe,

there are numerous regulations that aim to encourage CN in the industrial sector. The foundation of the policy is the pursuit of a "circular economy", which integrates resources, production, consumption, recycling, and reuse in a continuous loop. Circularity also enables the securing of resources, attracts production capacity (advancing industrial competitiveness), stimulates consumption, and refines recovery processes and technologies.

In the global economy, cross-border supply chains are the norm, and Europe is generally an end-user of goods sourced and manufactured elsewhere. In the future, the circular economy is intended to help Europe become more self-sufficient.

Overview of major regulations/standards in EU

Stage	Technology	Major regulations/ standards in EU	Regulations/standards outline
1 Presentation of goals through regulations	Overall clean tech	Fit for 55	Policy package to reduce GHG by 55% in 2030 compared vs 1995 levels
		Net-Zero Industrial Act	Expansion of production capability in EU for technologies contributing to net-zero (40% of consumption to be produced in EU by '30)
		Critical Raw Materials Act	Clarify critical raw materials, record their import ratios/ recycling rates to build critical raw materials value chain in EU
	CCUS	Industrial carbon management strategy	Support achievement of plan to store 50mm tons/year of CO_2 by 2030 and realization of CO_2 value chain/internal market by 2040
2 Disclosure	Industry electrification (EV/battery storage)	NCEAP	Action plan for measures to keep resources within the region as much as possible, focusing on design/production
		ESPR	Expand scope of energy-related production, tighten framework for basic requirements /conformity assessment for unified regional operations
		Due Diligence Directive	Drive battery operators for development of supply chain due diligence policies and implementation of due diligence
3 Labeling/ tracing	Overall clean tech	EU taxonomy	Establish unified criteria to gauge environmental / climate sustainability of economic activities
		CSRD2/ESRS	Mandate sustainability reporting for companies within the region. Establish requirements for reporting
	Industry electrification (EV/battery storage)	Battery passport	Mandate battery operators to record information on battery models, raw materials, carbon footprint, etc.

Ratings derived from disclosed information influence **financial institutions to optimize their capital allocation** and encourage **OEMs to request rating improvements**

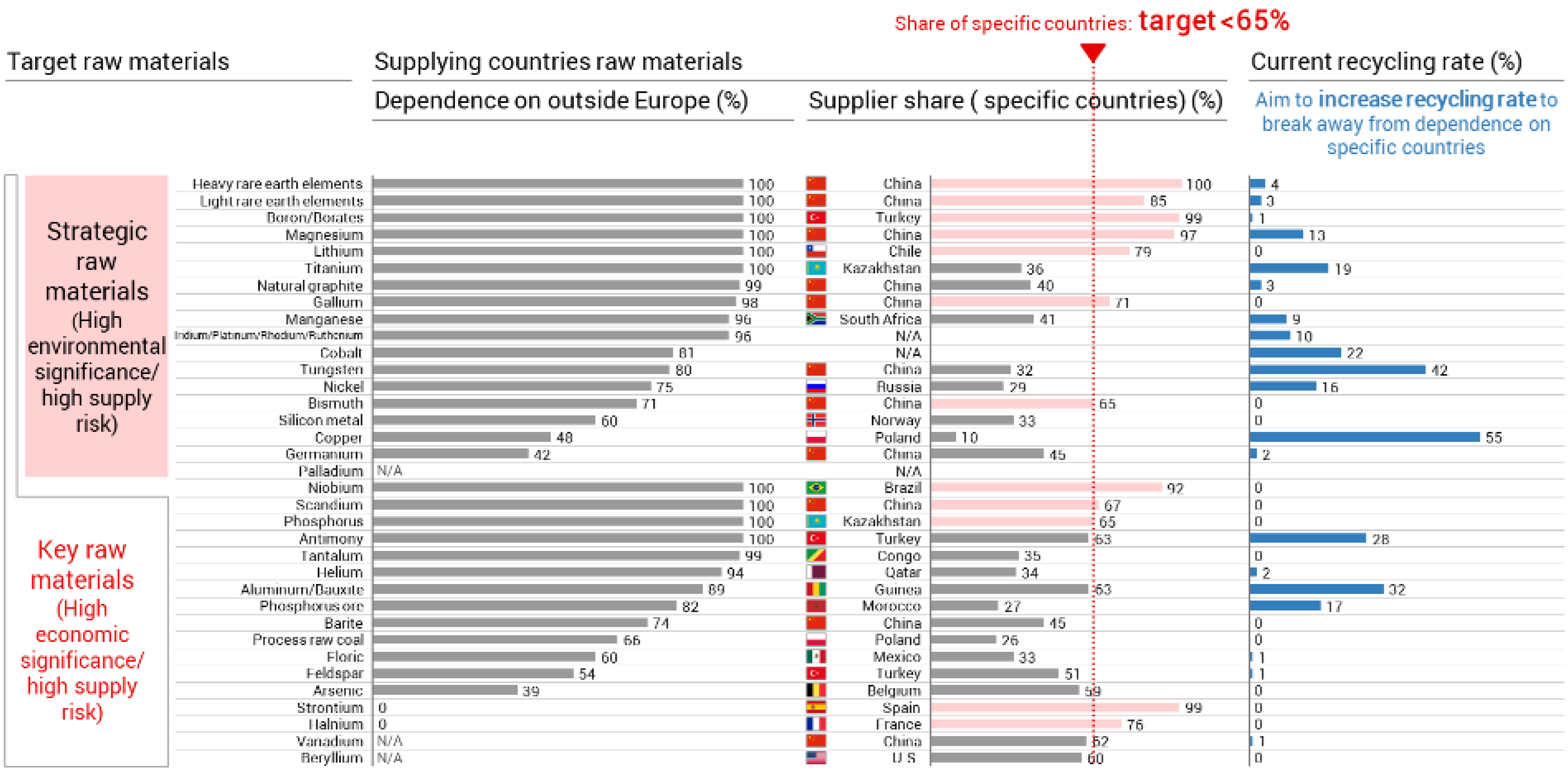
Source: European Commission (Fit for 55; Net-Zero; Raw Materials; Industrial Carbon; NCEAP; ESPR; Due Diligence; Taxonomy; CSRD; ESRS; Battery Passport)

Overview of major regulations/standards in EU

The European approach to achieving CN appears to be centered on regulation and disclosure, characterized by the following flow:

1. Goals are set through regulations.
2. Responsible parties for the goals are identified, and companies are required to disclose information.
3. The disclosed information is labeled/tracked and becomes the subject of ratings.
4. Based on the ratings, financial institutions are encouraged to reallocate funds (from low-rated to high-rated), and OEMs encourage their suppliers to improve the ratings (transactions with companies below a certain rating are suspended).

Import dependency rate/recycling rate of key raw materials



Note: Politically agreed in Nov 2023
Source: European Commission; Aggregated the monthly new car registration numbers for each month up to the data published in March 2024

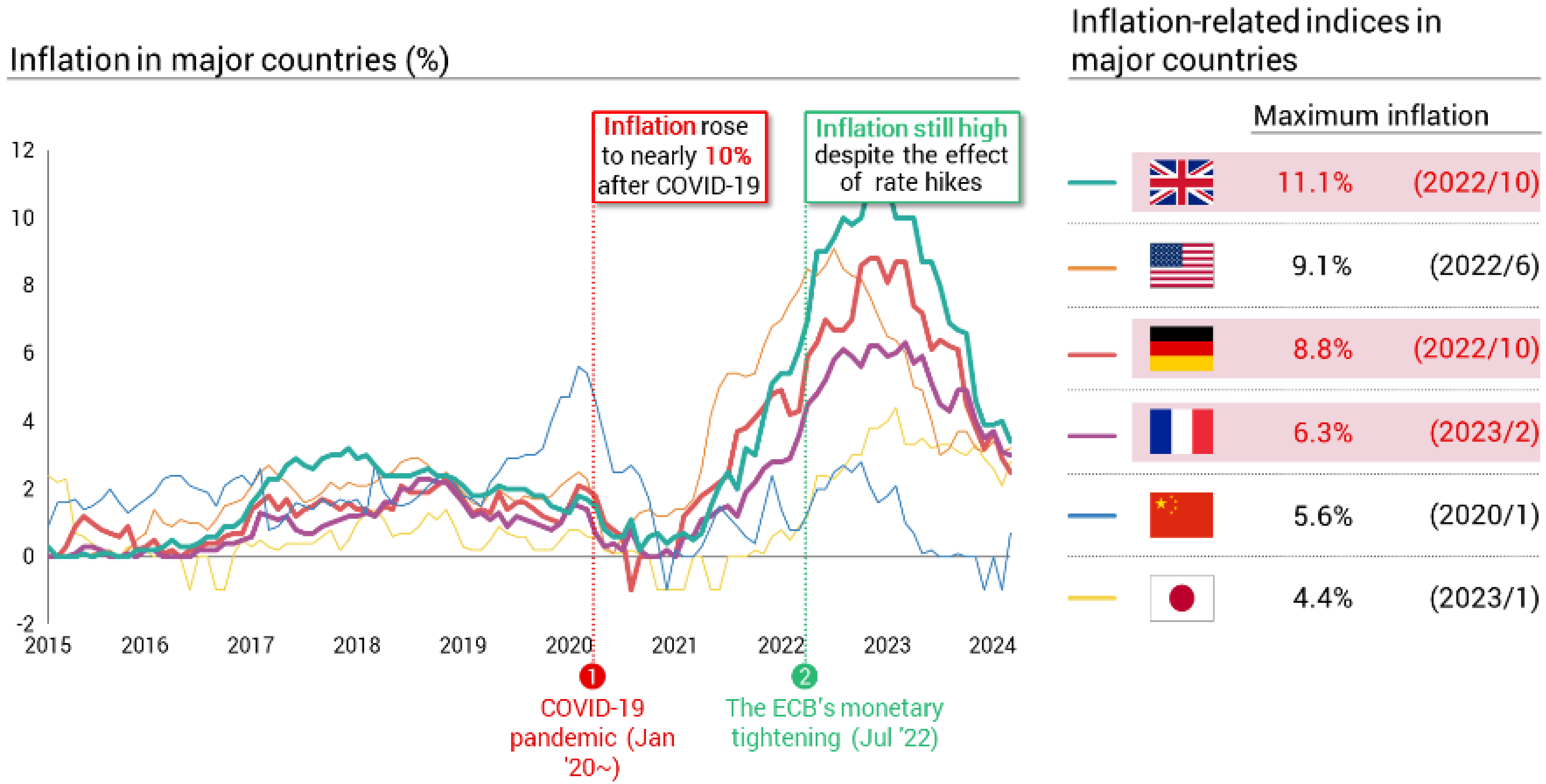
Import dependency rate/recycling rate of key raw materials

Europe has enacted a recycling law known as the EU Critical Raw Materials Act (CRMA). The law is comprehensive and strategic, setting target rates for each material. Securing materials plays an essential role in national security, domestic industrial policy, and the circular economy.

The recycling law defines two categories of materials. The first is “critical raw materials”, which have a significant impact on the EU economy and face high supply risks. The second is “strategic raw materials.” Among critical raw materials, those relating to environmental technology are designated as strategic raw materials.

Materials on this list pose a risk for the EU in terms of economy and security. If the procurement of materials is dependent on specific countries, the risk increases. Therefore, from the perspective of national security and realizing the circular economy, these materials can have a significant impact. The recycling laws include a target to reduce dependence on specific countries to less than 65% for the procurement of critical and strategic raw materials. Efforts to increase recycling rates within the EU and reduce import dependency on specific countries to less than 65% have begun.

Inflation trends over the past 10 years

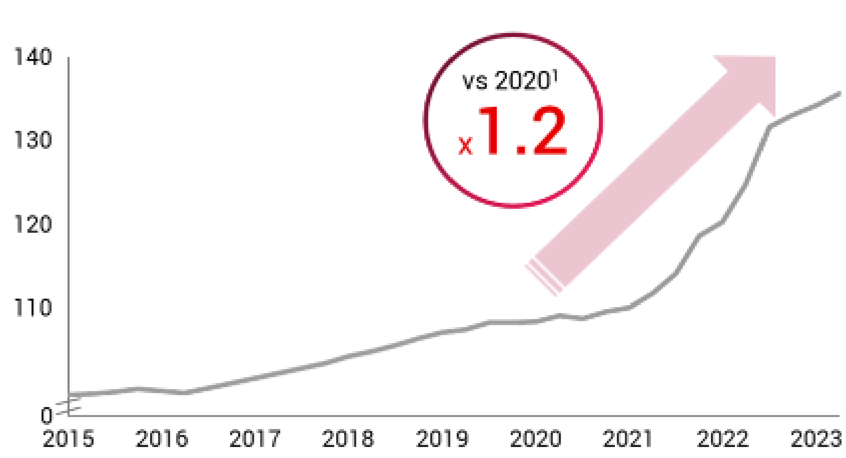


Like the U.S., Europe has also seen a sharp rise in inflation rates to as high as about 11% in the United Kingdom (the UK) and 9% in Germany. Central banks have raised interest rates, but inflation remains a persistent threat.

Source: [Consumer prices - data | BIS Data Portal]

Inflation rate of construction cost/industrial gas price

Europe: Shift in construction cost (2015=100)



Construction costs keep increasing, and are still at the high level of 1.2 times vs 2020

Europe: Shift in industrial gas price

Industrial gas prices within Europe rose sharply to 3 times vs 2020 and are still at the high level

Construction material costs are the raw costs for implementing CN technology and can be interpreted as investment costs. From 2021 to 2022, European construction material costs rose by 1.2 times. And like in the U.S., construction material costs have remained high, creating a hurdle for roll out of CN technology. After COVID-19 and the start of the Ukraine conflict, gas prices in Europe surged. Industrial gas prices jumped three-fold. But unlike in the U.S., where industrial gas prices have abated, prices in Europe continue to remain high, putting a burden on industrial production activities and the daily lives of citizens.

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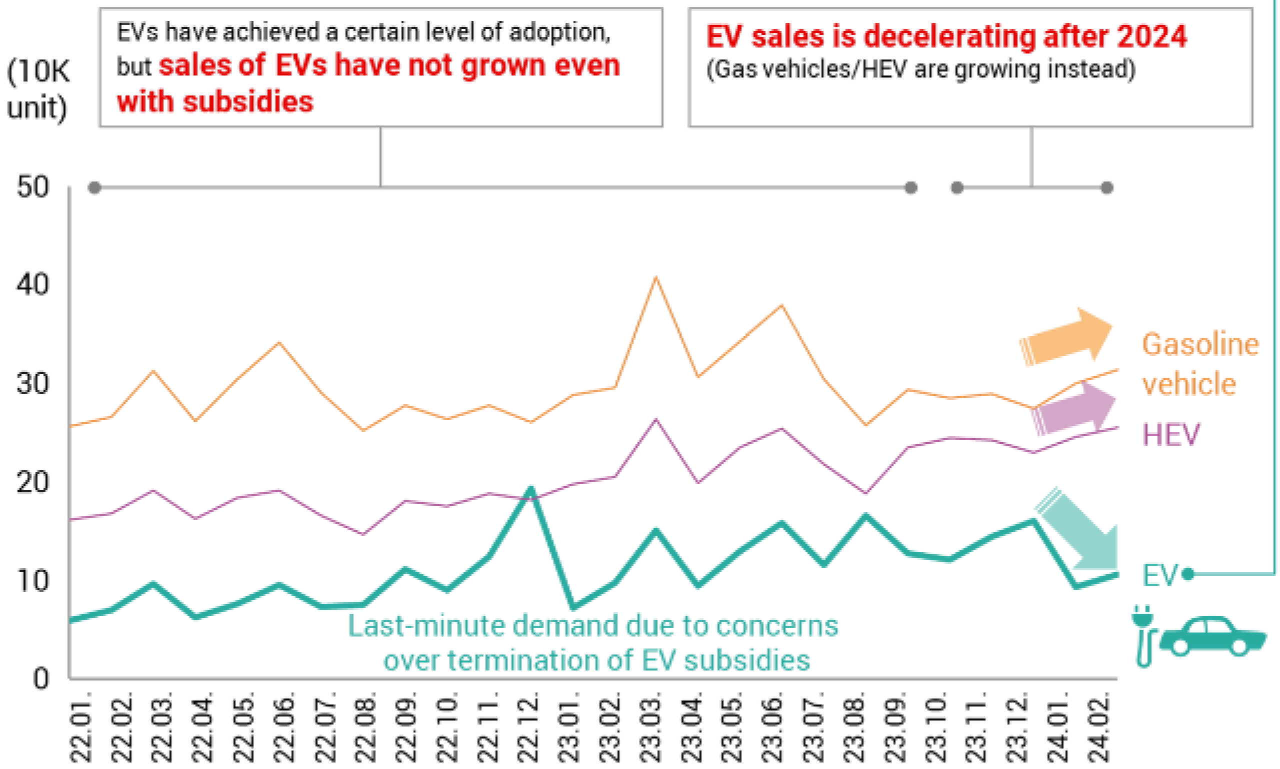
1. Comparison of 2020 Q1 and 2023 Q1, 2. Comparison of 2020 H1 and 2023 H1
Source: Eurostat (1/2); Eurostat (2/2)

EV sales volume slowdown

Europe: Shift in new vehicle sales by car type (monthly)



Europe: Factors behind EV sales volume slowdown

Termination of subsidies

Germany as the biggest EV country in Europe terminated EV purchase subsidies in Dec last year

France announced stricter conditions for EV subsidies

Demand reaching ceiling

Growth slowed down as early adopter demand has reached ceiling
- The affluent who can purchase new products quickly
- Large corporate purchase

Unlaunched low-price EV

Only limited companies in Europe announced the launch of mass-market type EVs below € 30,000 /unit accepted by the general public

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Source: ACEA; Desktop Research

EV sales volume slowdown

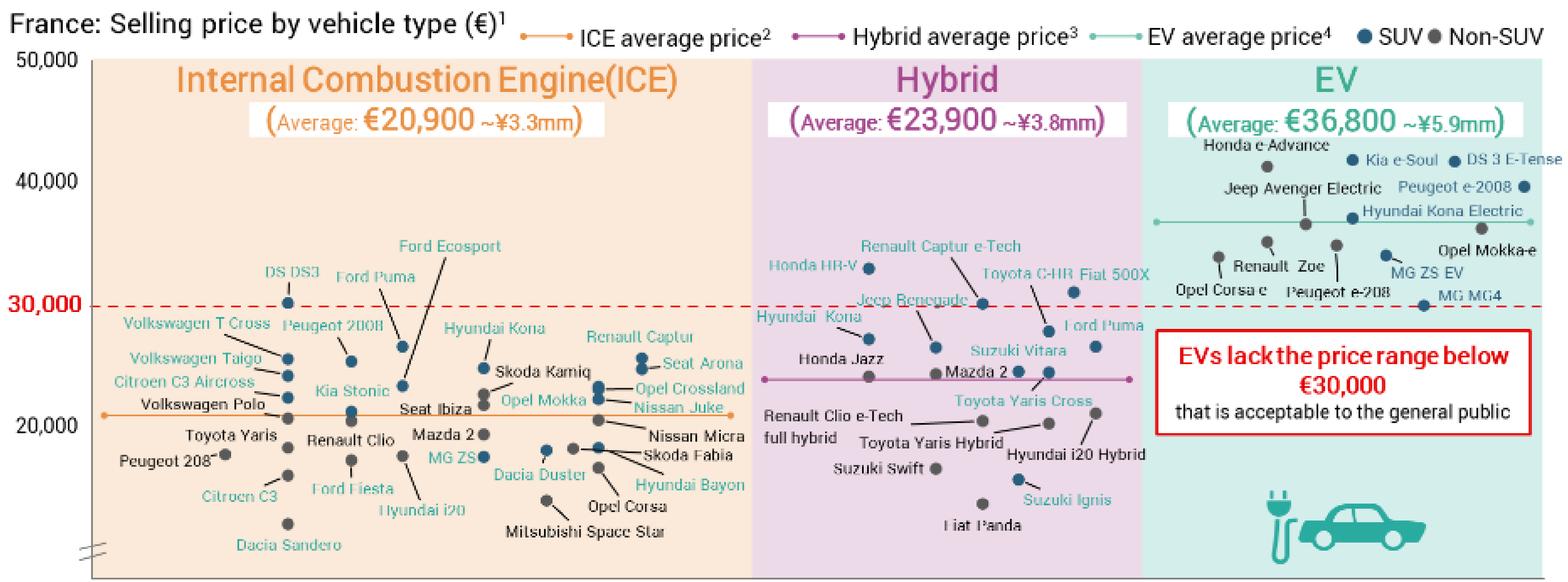
In Europe, EVs have accounted for 10% to 20% of automotive sales over the past two to three years, indicating a certain level of market penetration. However, EVs have yet to surpass the market share of hybrid and gasoline-powered vehicles. Moreover, if we take a closer look at recent trends, we see that the EV share of new car sales is actually declining, while the share of hybrid and gasoline vehicles is increasing.

Several reasons have been cited for this shift, with the most common being:

1. The end of EV subsidies, particularly in Germany, has led to a plateau in demand.
2. A lack of low-cost EVs targeting the mass market. Currently, EVs are still more expensive than gasoline and hybrid vehicles.

While the technological demonstration phase for EVs is complete and adoption has progressed to some extent, the majority of EV buyers are still concentrated in urban areas and among wealthier consumers. EVs have not yet achieved widespread adoption. To penetrate the mass market, further cost reductions will be necessary.

Difference among engine/hybrid/EV selling price



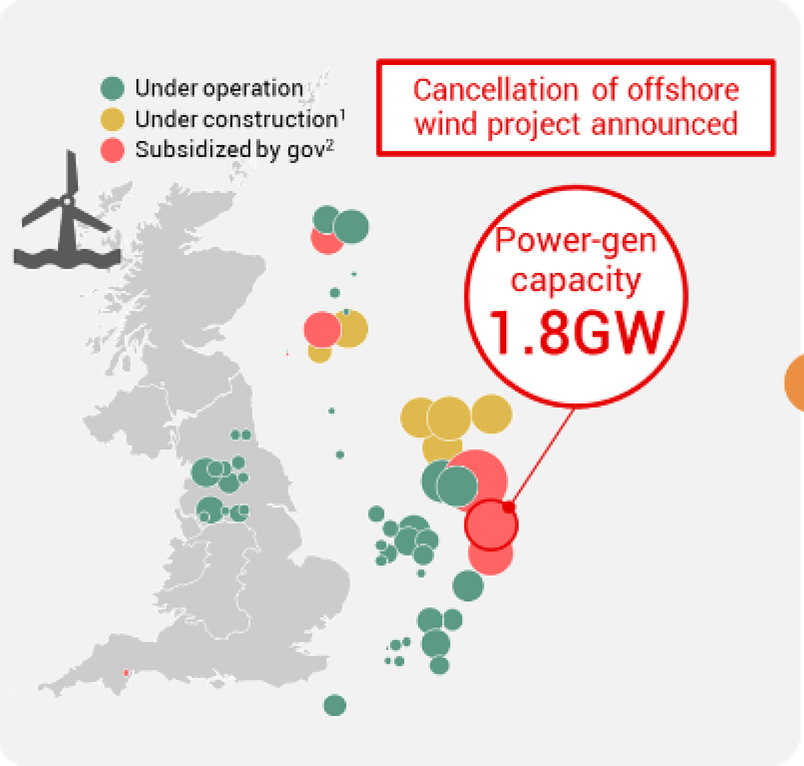
The challenge facing EV manufacturers can be exemplified by the experience in France, where the average sales price for gasoline cars is €20,000, for hybrids is €24,000, and for EVs is €37,000.

It is likely the average price of EVs will need to fall below €30,000 for mass market take up.

Note: Converted at €1=¥160
1. Entry-level selling price in France in Mar 2023 (€). Focusing on OEM's entry-range to segment B vehicle models, excluding high-range models of segment B from the analysis: Citroen, Dacia, DS, Fiat, Ford, Honda, Hyundai, Jeep, Kia, Mazda, MG, Mitsubishi, Nissan, Opel, Peugeot, Renault, Seat, Skoda, Suzuki, Toyota, Volkswagen; 2. Average price calculated based on the 33 ICE models, 3. Average price calculated based on the 17 hybrid models, 4. Average price calculated based on the 12 EV models
Source: EV Database (as of March 2023); OEM Home Page

Cancellation of large offshore wind project and the government's response

UK: Cancellation of large offshore wind project



As a result of stagnant supply chain and inflation…

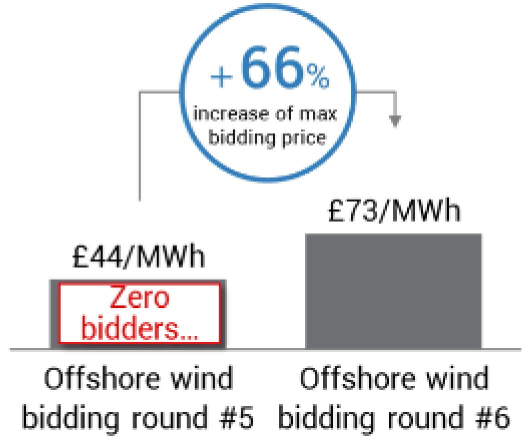
+40% increase of development costs

As a result of cancelling the project…

$530mm penalties paid

UK: government response

(Ceiling price for fixed offshore wind[3])



Following UK government's bid ceiling price increase…

Orsted decided to invest in Hornsea 3, a very large project offshore Yorkshire, UK, in Dec 2023 in anticipation of project breakeven on the UK side

* The result of #6 round is not announced yet (as of August 2024)

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1. Offshore wind farms that are under construction or for which developers have announced final investment decisions; 2. Offshore wind farms that have signed Contracts for Difference (CfD) agreements with the Government; 3. The max bidding price for offshore wind is increased to £116→176/MWh

Source: Royal HaskoningDHV; RWE in the UK; The Crown Estate; Norton Rose Fulbright; New Civil Engineer; JM Eagle

Cancellation of large offshore wind project and the government’s response

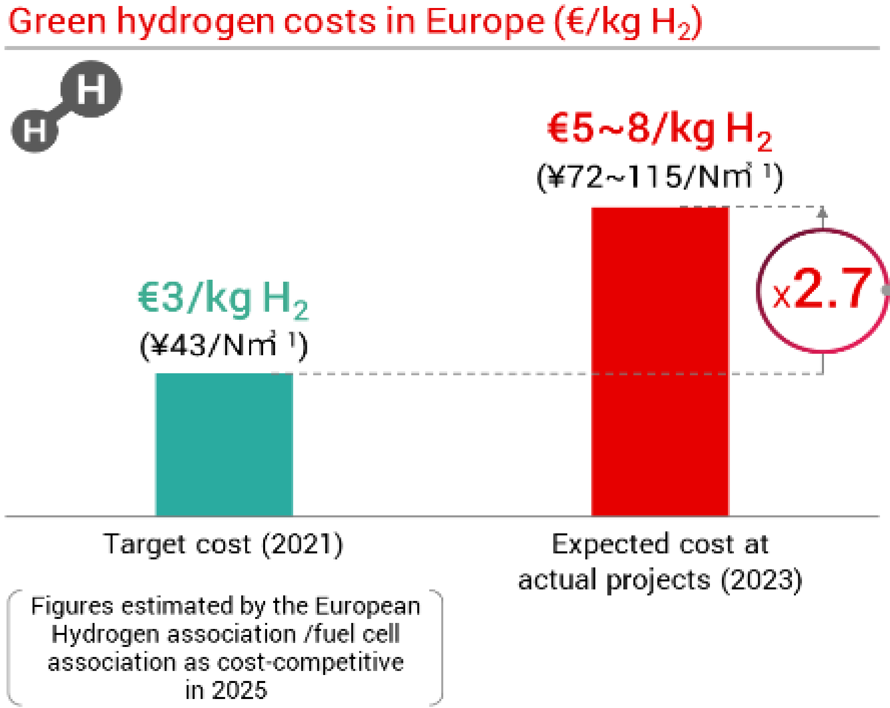
Offshore wind power in Europe is also facing challenges, due to rising construction costs caused by inflation. As a result, projects such as 1.8GW initiative in the UK have had to be cancelled, leading to a significant penalty ($530mm) after the operator won the bid through public bidding. If cost increases occur after the power purchase price (fixed price) is determined through public bidding, the project will struggle to continue to be feasible. This indicates the risk of fixing prices in the face of unpredictable costs.

In the UK’s fifth round of offshore wind power bidding, there were zero bidders, reflecting an adverse risk return equation. In response, the UK government appointed external experts to review the power purchase price necessary for appropriate cost pass-through. In the sixth round of offshore wind power bidding, the bidding price ceiling was raised by 66%. The move was effective and Denmark's leading company Orsted won the Hornsea 3 project.

The UK experience shows that while private competition based on market principles will lead to price reductions, excessive competition can erode investment appetite. Still, the UK government's response proved effective.

Japan is also advancing public bidding for offshore wind power, and the approach taken by the UK government in response to the situation in the UK market may provide a useful learning.

Green hydrogen targeted costs and actual state



Factors of increased green hydrogen costs

Impact on the cost	Factor	Description
High	**Increase in capital cost**	Inflation resulted in higher capital costs; requesting higher returns for investments on green power/ electrolyzer
	Supply chain restrictions	COVID-19/geopolitical risks caused restrictions on renewable energy (mainly wind power plants)/electrolyzer manufacturer supply chain
	Lack of infrastructure	Due to lack of infrastructure, importing green hydrogen through low-cost pipelines will be difficult for next 10 years
	Decreased electrolyzer operating hours	The price of wholesale electricity is lower than wind power, resulting in reduced hours of electrolyzer operations
Low	Complex electrolyzer systems	Increased complexity of components used in the electrolyzer system made it more difficult to reduce the cost of BOP[1] and other components[2]

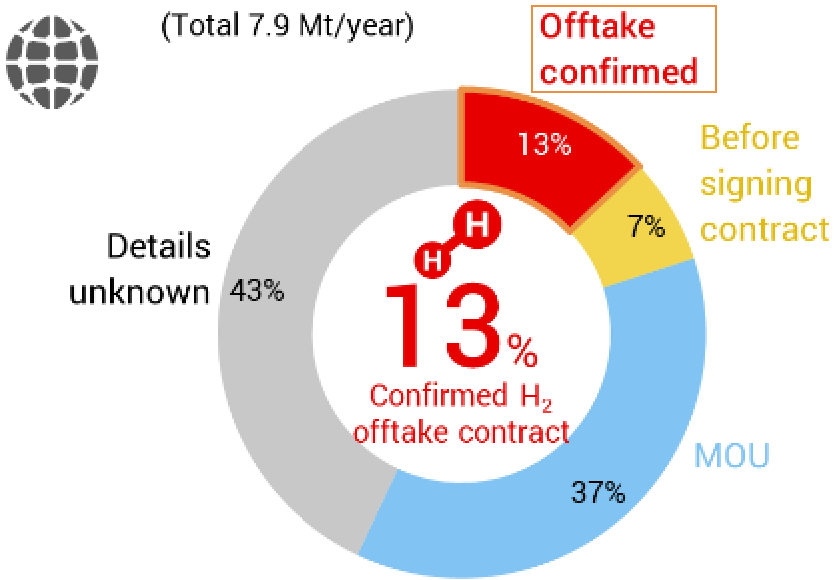
Turning to hydrogen in Europe, the introduction cost of locally produced hydrogen was previously projected at €3/kg H_2 (¥43 /Nm^3). Based on that price, hydrogen was viewed as a promising next-generation clean energy source, and many businesses began examining projects. However, as a result of inflation, capital costs rose significantly and cost projections increased to €5-8 /kg H_2 (¥72 to ¥115 /Nm^3). On that basis, it was impossible to plot a line to profitability and off-take agreements could not be reached, leading to a lack of private investment. Moreover, hydrogen faces several challenges, such as the need to establish a supply chain, improve energy efficiency, and pursue scale in complex electrolyzer systems.

1. Converted at €1=¥160, 1kg=11.14Nm^3
2. BOP = balance of plant. Refers to the equipment and facilities required around the generating unit, not the generating unit itself in hydrogen fuel cells and other energy systems, 3. Components that are already standard in utility-scale projects, such as power electronics and gas conditioners

Source: BCG「Turning the European Green Hydrogen Dream into Reality: A Call to Action」(2023/10)

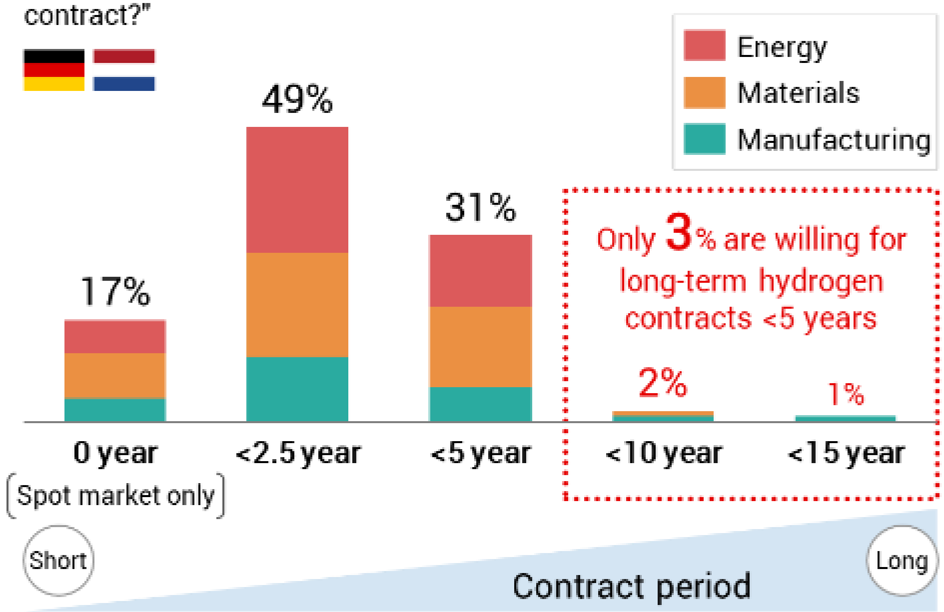
Status of hydrogen offtake

Global: Clean hydrogen offtake agreements[1]



Germany/Netherlands: H_2 consumers' willingness to commit to H_2 contract (survey of 166 respondents)[2]

Question: "How long can you commit to a green hydrogen supply contract?"



Private investment remain limited as the majority of projects are short term/pilot and it is difficult to pass on the price (off-take contracts are difficult to constrain). Bidding by the European Hydrogen Bank to compensate for the price difference with gray hrdrogen has begun

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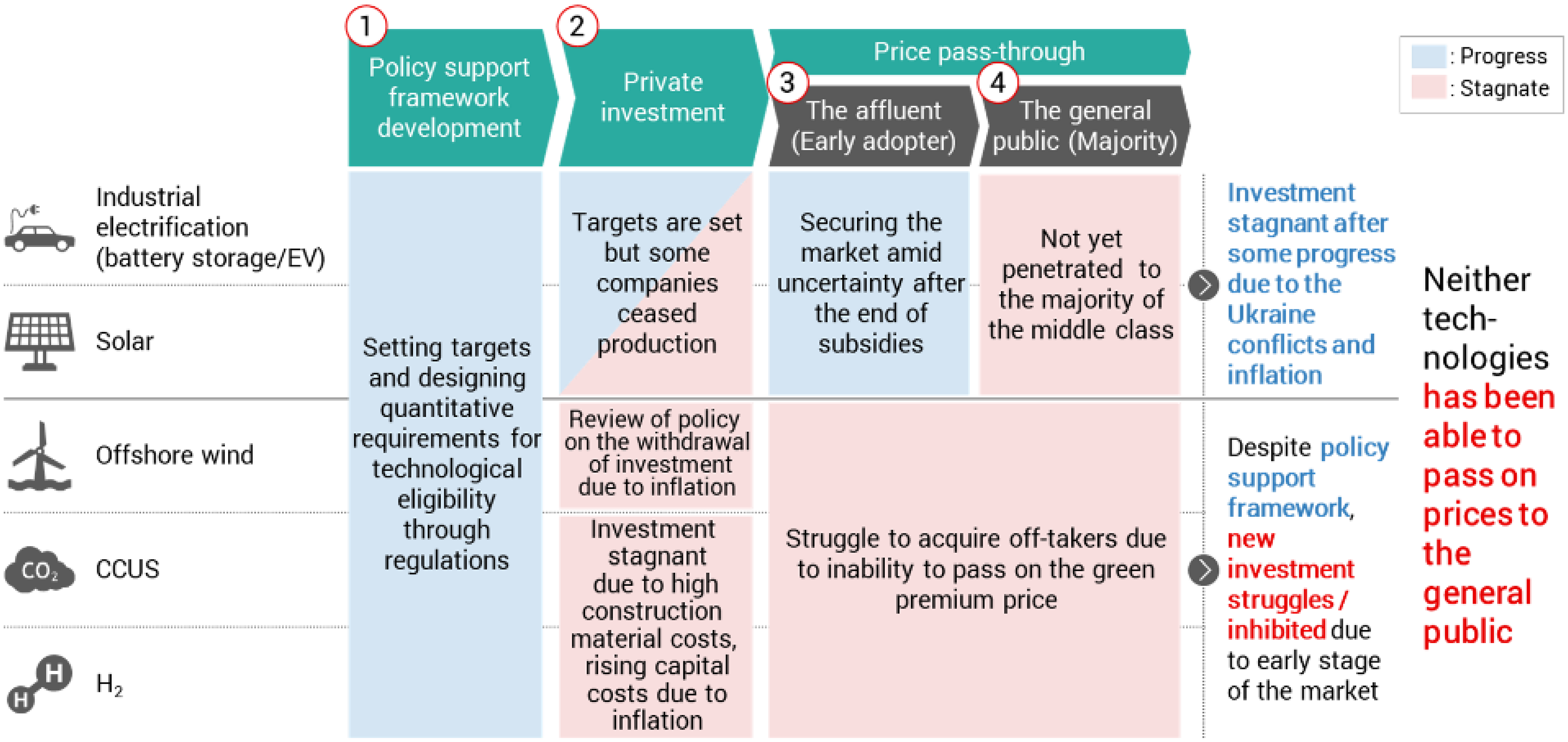
1.Includes only projects of over 20 MW or over 2,800 tons/year production. Before signing contracts includes term sheets/preliminary agreements/heads of agreement;
2.Based on a customer survey (n=166 respondents) in the relevant sectors in Germany and the Netherlands
Source: BCG; Bloomberg NEF (as of November 2023)

Status of hydrogen offtake

Globally, there are many hydrogen projects in the pipeline but only 13% have secured off-takes. And even among projects with off-takes, only 3% have contracts lasting longer than five years, with the majority being small-scale, short-term pilot projects. For hydrogen to become widespread, it will be necessary to combine measures such as inflation stabilization, energy efficiency improvement, supply chain coordination, fixed cost improvement, and policy incentives.

In response, Europe has introduced a new policy support framework through the European Hydrogen Bank, under which producers can receive a fixed premium (incentive) for each kilogram of green hydrogen produced for up to 10 years. In the first round of bidding, 132 entities from 17 countries participated, and a total of 7 projects were selected (3 in Spain, 2 in Portugal, 1 in Norway, and 1 in Finland). The bid prices for the projects ranged from 0.37 to 0.48 euros/kg green H_2, with an estimated total premium payment of between 8 million euros and 245 million euros.

Recent trend summary



Recent trend summary

In conclusion, the emphasis in Europe is on goal setting through regulation and monitoring. Regulations are being introduced for technologies including storage batteries, EVs, solar power, offshore wind power, CCUS, and hydrogen. The eligibility of technologies in terms of Europe's net-zero trajectory is quantified through the EU Taxonomy.

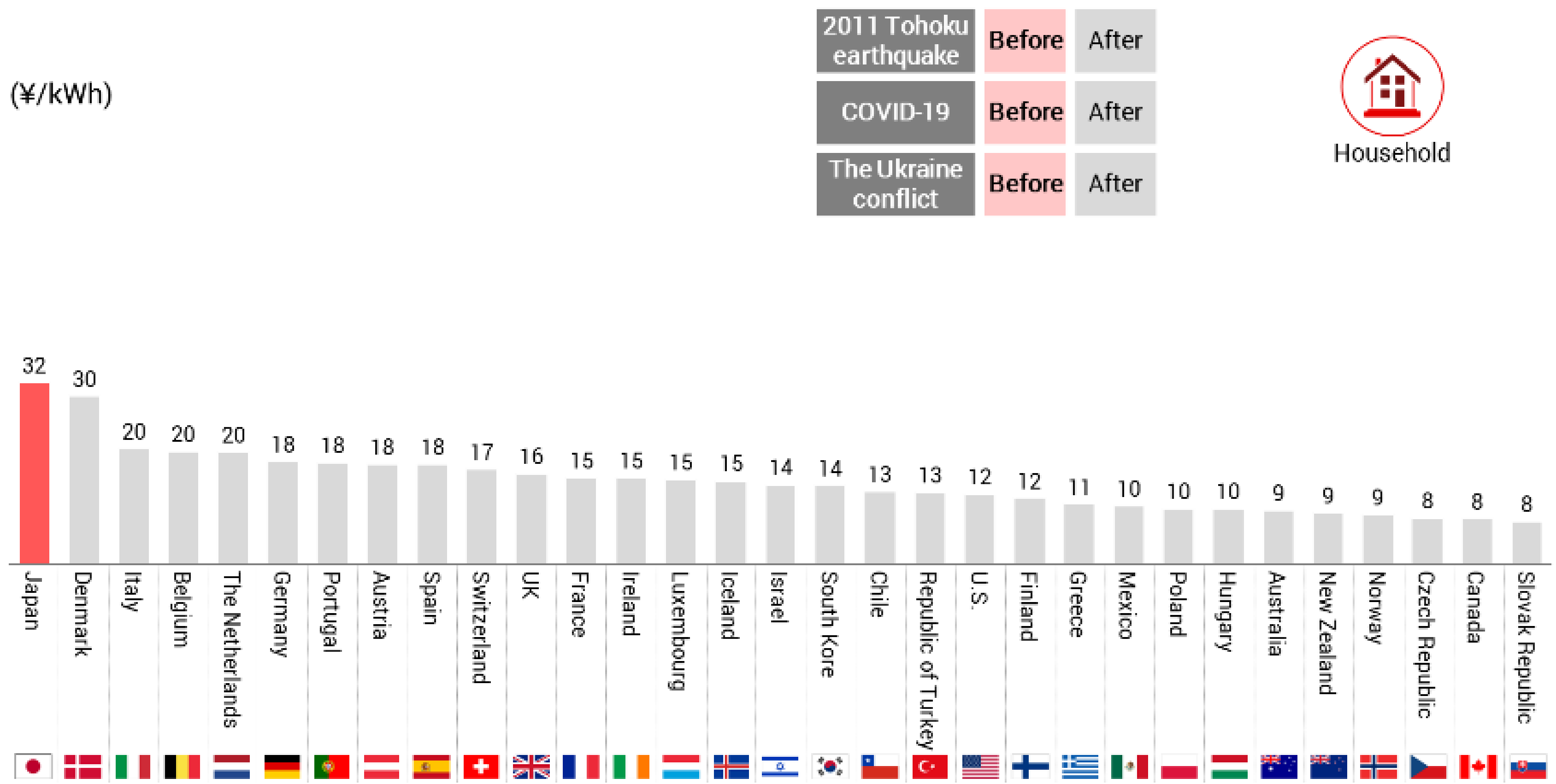
The investment landscape in Europe is patchy. Progress is evident in EVs, storage batteries, and solar power. But even in these technologies, some companies have announced production halts, indicating a reassessment of the balance between global market prices and procurement costs. In offshore wind power, inflation and excessive competitive bidding have led to a reassessment of the risk-return equation. For CCUS and hydrogen, private investment is not progressing due to a rise in capital costs caused by inflation and the inability to establish off-takes.

Looking at the price pass-through situation, even in EVs, where private investment is progressing, demand has plateaued, partly due to the end of subsidies for EVs. The lack of low-cost EVs means that mass-market adoption has not yet been achieved.

In this way, even in Europe, there are "fields where investment is progressing" and "fields where it is not." In these advancing areas, it is evident that "the target of price pass-through remains limited to the affluent (early adopters) and has not extended to the mass market."


International comparison of electricity price

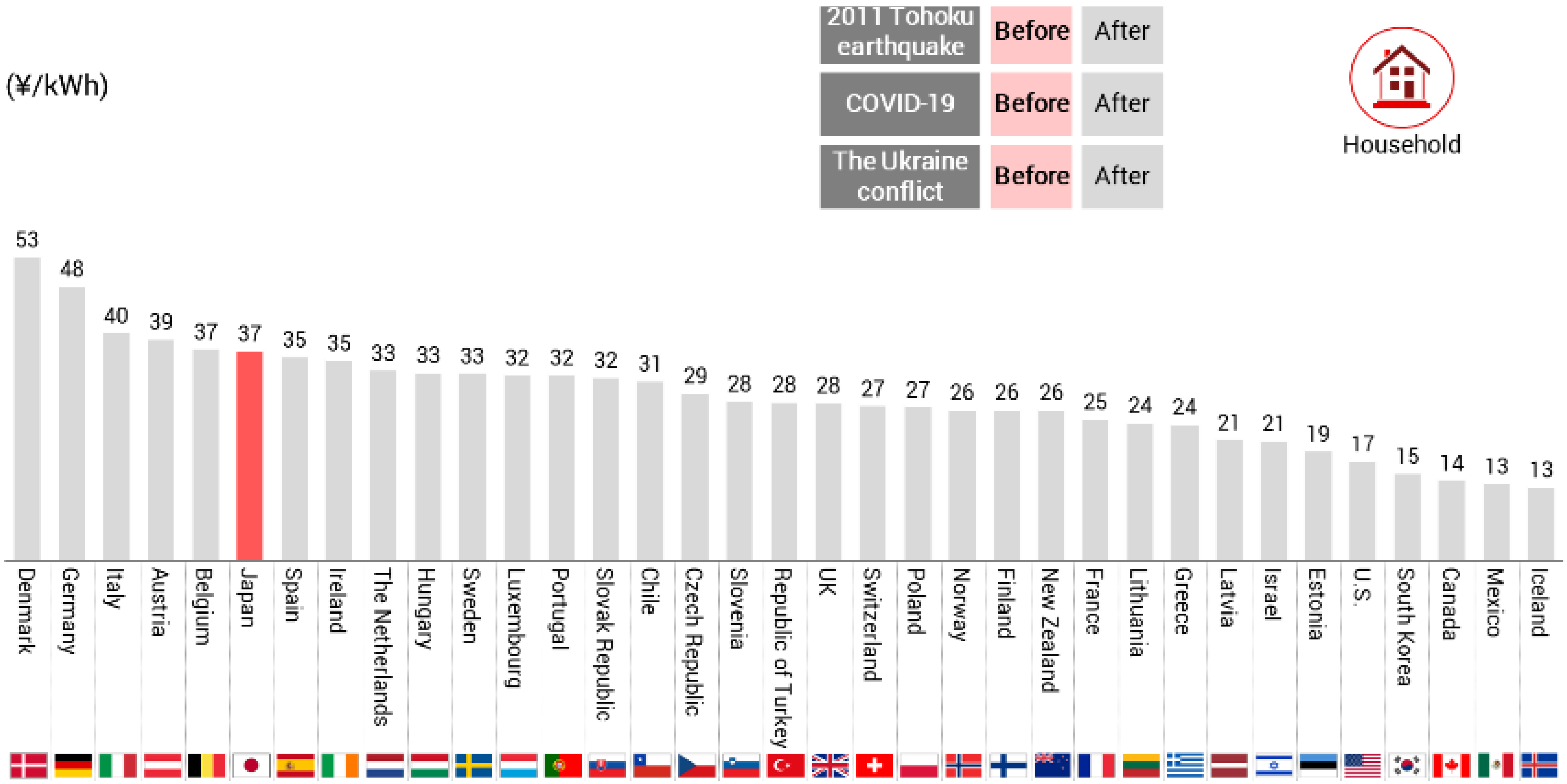
Household electricity price (2000)



A key element in the economic equation for CN progress is electricity prices in individual countries, which have varied through time. Back in 2000, Japan and Denmark had among the highest electricity prices in the world.

Note: Converted at $1=¥150
Source: IEA「Energy Prices」

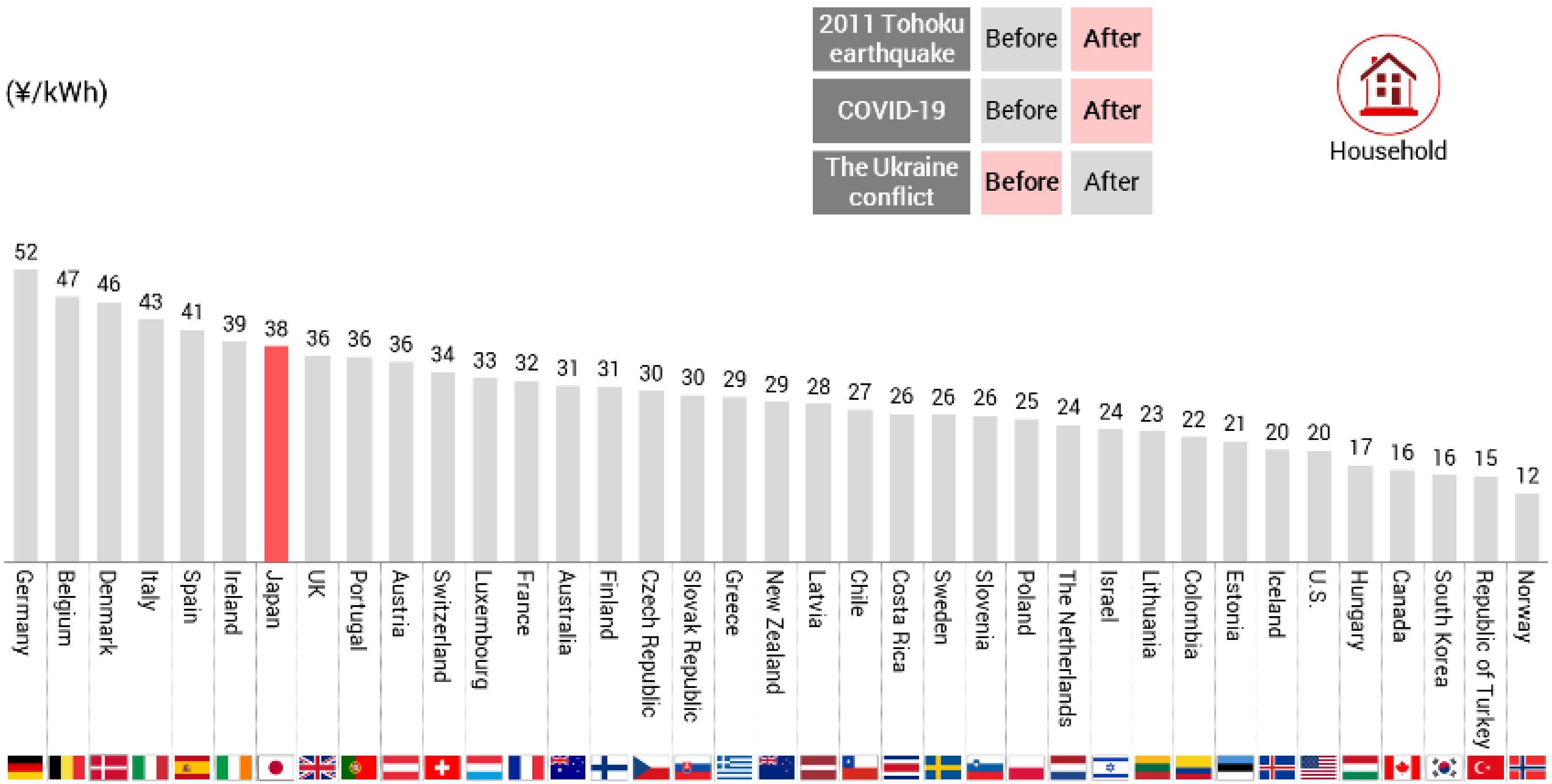
Household electricity price (2010)



By 2010, before the Fukushima disaster, the COVID-19 pandemic, and the Ukraine conflict, the gradual introduction of renewable energy began to lift electricity prices in major European countries.

Note: Converted at $1=¥150
Source: IEA「Energy Prices」

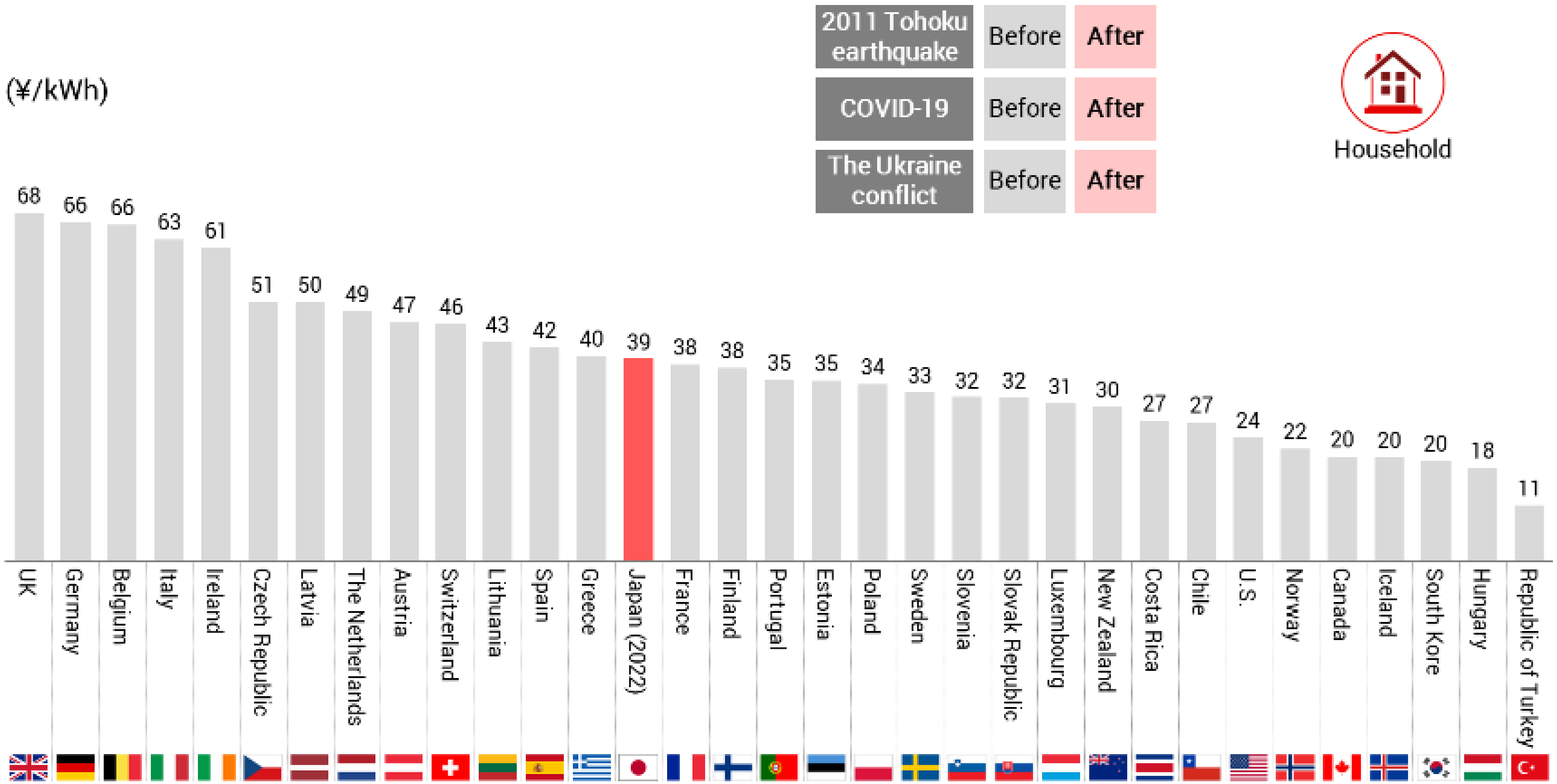
Household electricity price (2020)



In 2020, after the Fukushima disaster and the COVID-19 pandemic, but before the Ukraine conflict, electricity prices did not change significantly.

Note: Converted at $1=¥150
Source: IEA「Energy Prices」

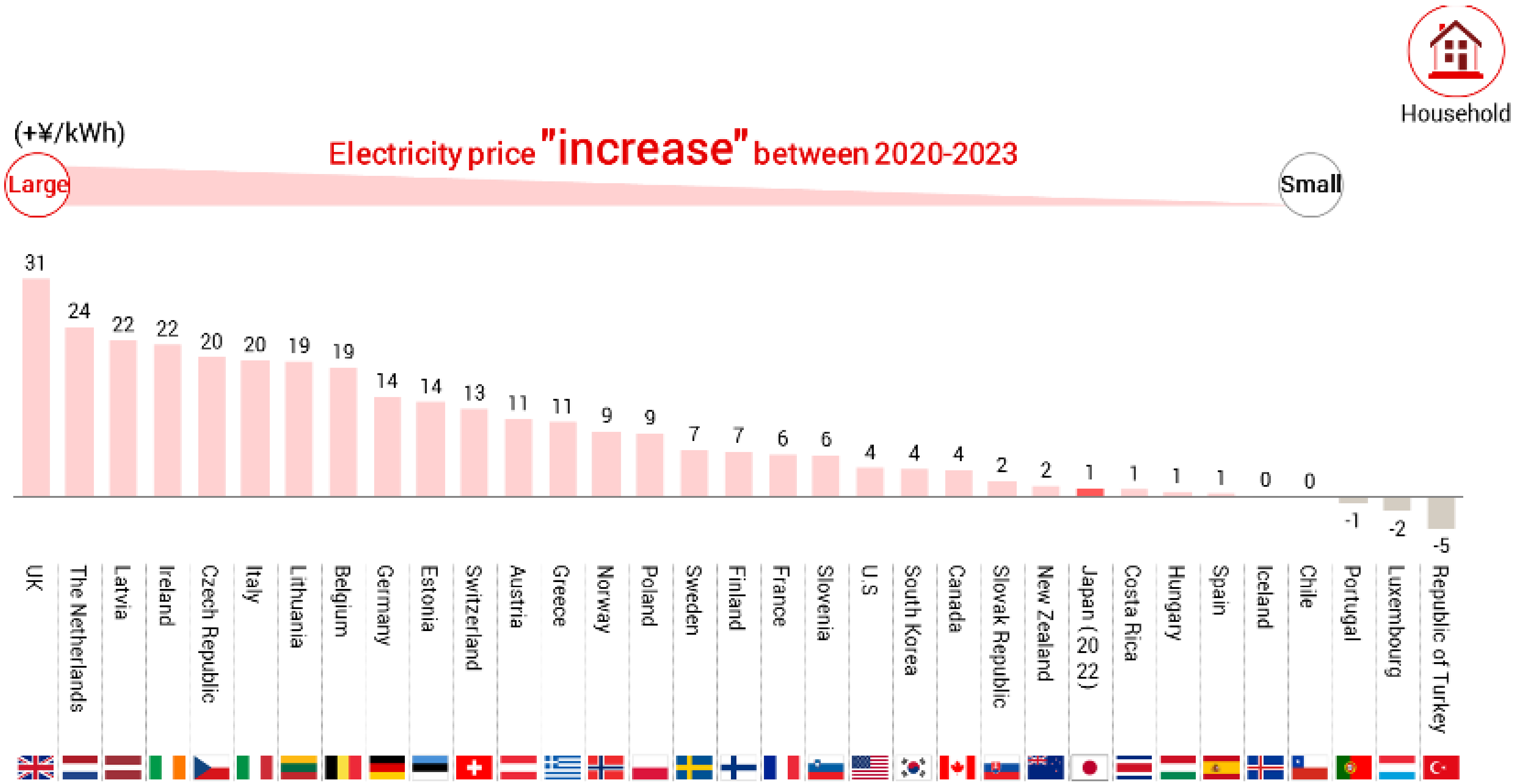
Household electricity price (2023)



In 2023, after the Fukushima disaster, the COVID-19 pandemic, and the Ukraine conflict, electricity prices rose in several major European economies.

Note: Converted at $1=¥150
Source: IEA「Energy Prices」

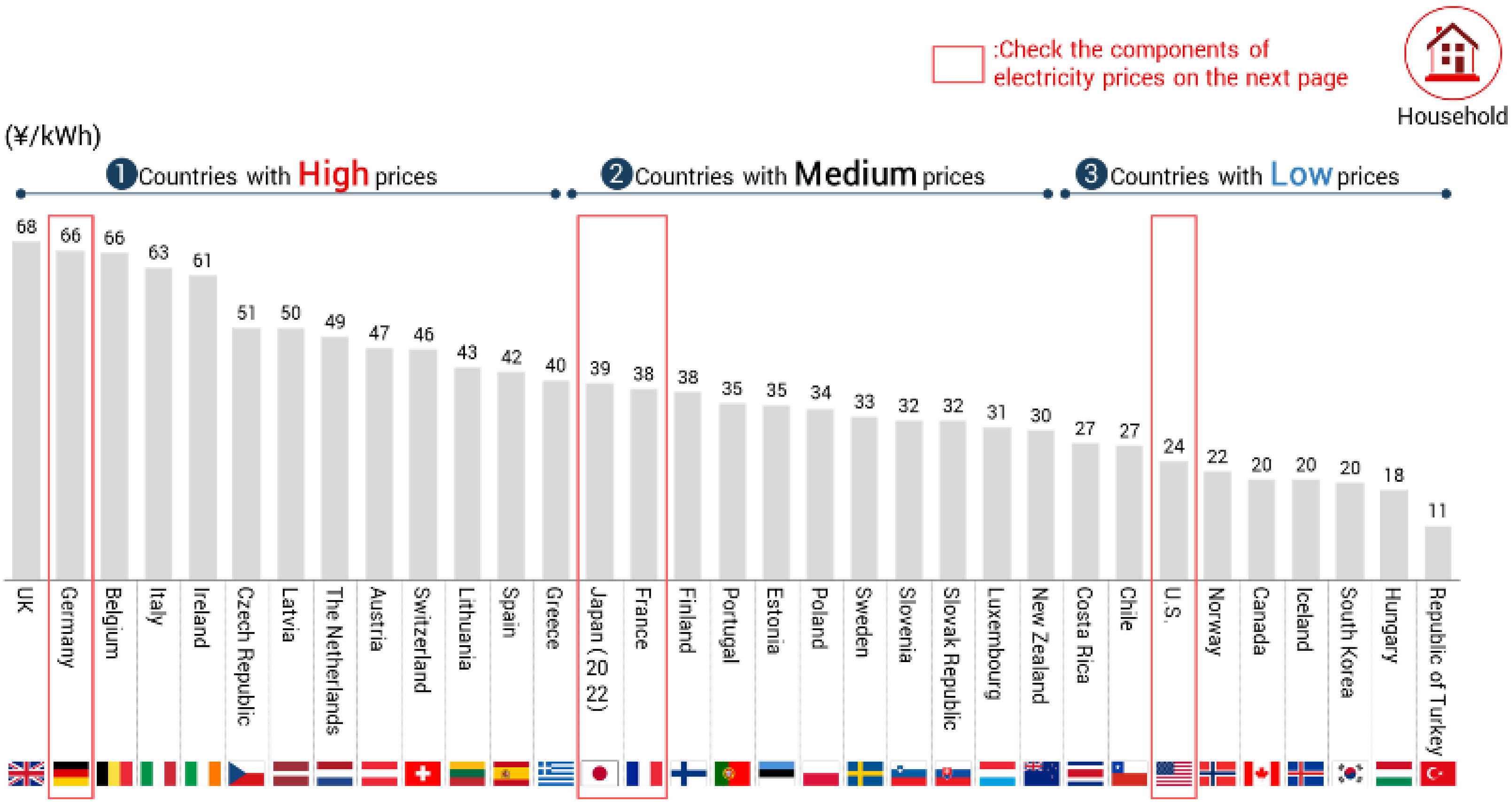
Household electricity price (2020-2023)



The comparison for the years 2020 to 2023 confirms that electricity prices have risen significantly in major European countries, while in Japan, which has scarce energy resources and has been diversifying energy sources, there were smaller fluctuations.

Note: Converted at $1=¥150
Source: IEA「Energy Prices」

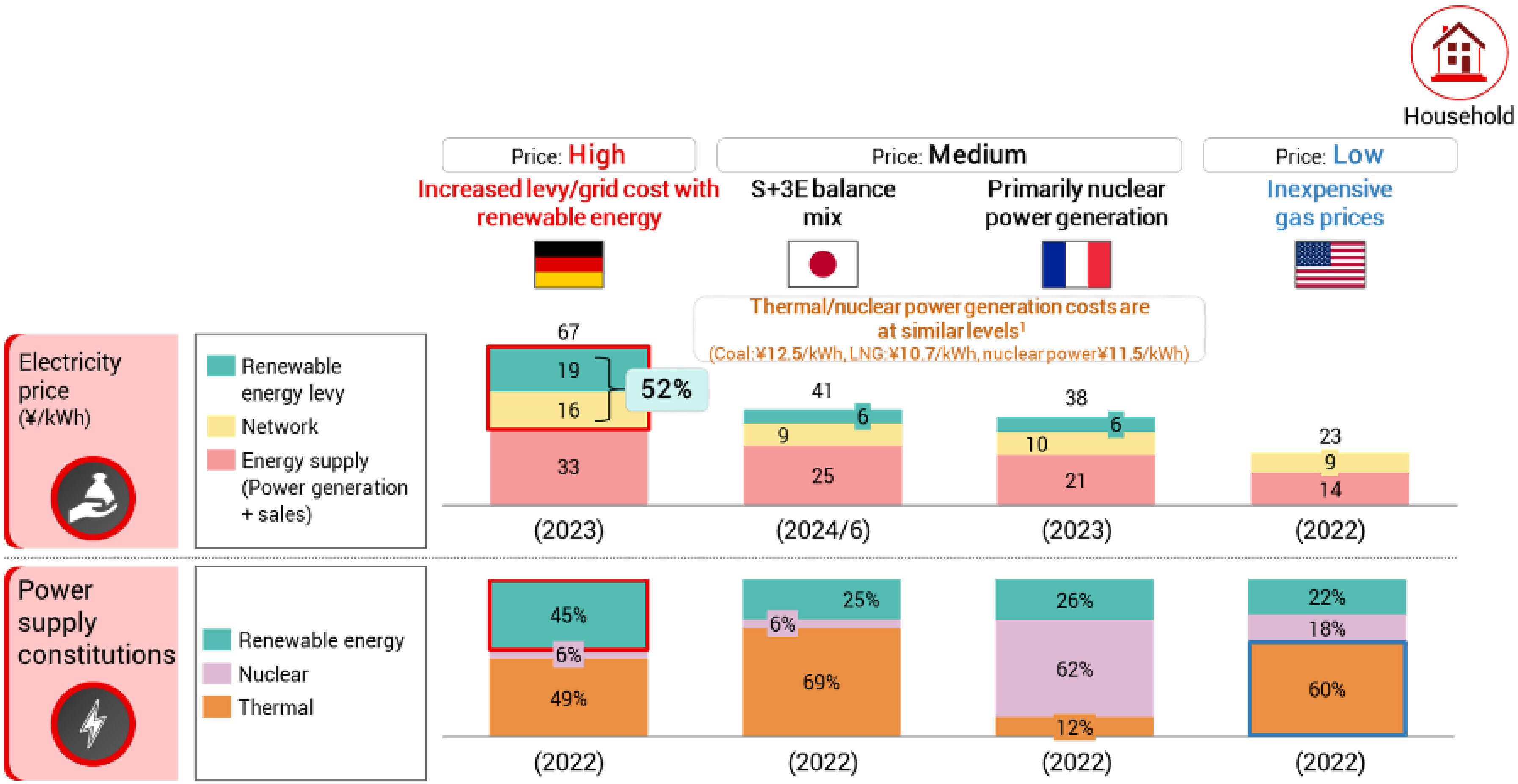
Household electricity price (2023)



In 2023, we see three broad categories: countries with high electricity prices, countries with moderate electricity prices, and countries with low electricity prices.

Note: Converted at $1=¥150
Source: IEA「Energy Prices」

Comparison of factors affecting electricity prices



1: Result of power-generation cost estimation by power source 2020
Note: Converted at $1=¥150, and €1=¥160. For U.S., "Generation" is energy supply, and "Transmission" and "Distribution" are network costs
Source: European Commission, "Electricity prices components for household consumers - annual data (from 2007 onwards)";
EIA "Electricity explained: Factors affecting electricity prices"; Estimates based on open info by TEPCO and JEPX; IEA

Comparison of factors affecting electricity prices

Breaking down our data, we categorize electricity price components into renewable energy surcharges (including other taxes), network costs, and energy supply costs. We then look at how these play out in individual countries.

Germany has aggressively promoted the introduction of renewable energy. It also addressed the variability of renewable energy by enhancing transmission and distribution networks. As a result, the renewable energy surcharge plus transmission and distribution costs account for a significant 52% of the total electricity price.

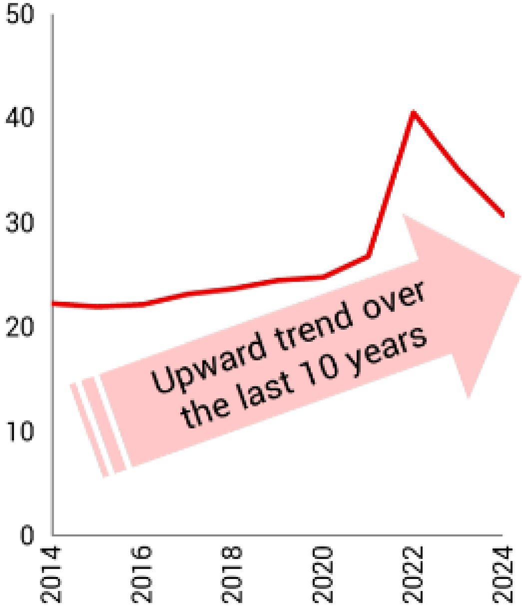
In Japan, based on the fundamental concept of S+3E[1], there has been widespread energy source diversification, alongside expansion of renewable energy (mainly solar). Japan has similar electricity prices to France despite the differences between thermal and nuclear power, and the composition of electricity prices is roughly the same.

Finally, the U.S. does not have a renewable energy surcharge burden. The network cost level is the same as in Japan and France. The energy supply cost is overwhelmingly cheaper, due to abundant fossil fuel resources in the U.S. Thermal power accounts for 60% of total power generation, similar to Japan, but the U.S. has abundant shale gas, whereas Japan needs to import LNG, creating a significant difference in energy supply costs.

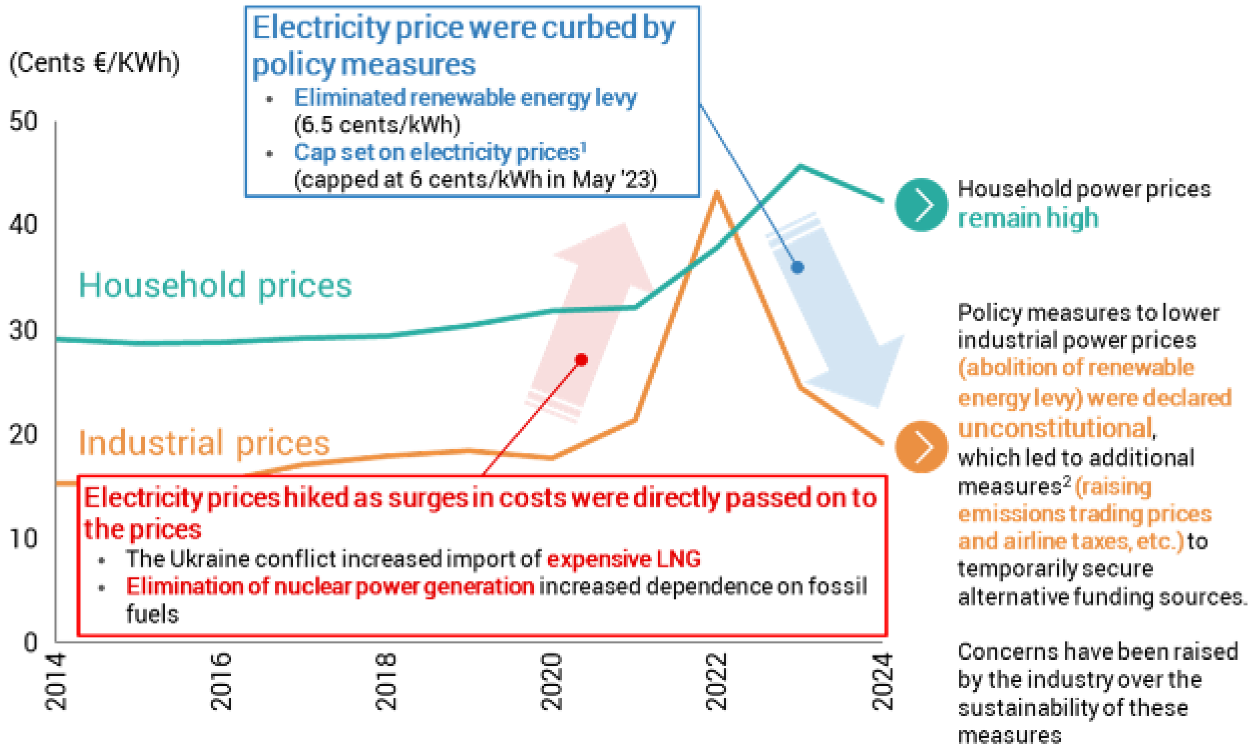
1.S+3E refers to Japan's basic energy policy, aiming to achieve safety (Safety) as a top priority, along with energy security (Energy Security), economic efficiency (Economic Efficiency), and environmental compatibility (Environment) simultaneously.

Historical trends of electricity prices

Aggregate (Industrial & Household)



Split (Industrial / Household)



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1. For industrial use, cap reduced from 13 cents (Nov. 2022) for 70% of the applicable previous year's consumption of companies consuming over 30,000 kW/year to 6 cents (May 2023) for 80% of them while cap of 40 cents is applied to 80% of the estimated consumption for household use (Nov. 2022)
2. Federal emissions trading price increased from €40/t to €45/t in 2024, aviation tax increased from May 2024, allocate part of revenues from 2023 offshore wind lease rights tender, and reduced tax incentives for agricultural diesel from 2024

Source: BDEW-Strompreisanalyse; Desktop Research

Historical trends of electricity prices

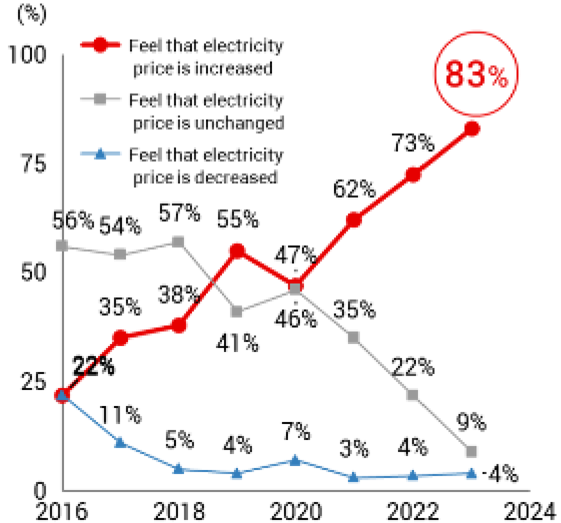
Drilling down into the electricity price evolution in Germany, we see prices have risen sharply over the past 10 years, and moved significantly before and after the Ukraine conflict. As electricity prices are directly passed on to residential consumers, the overall electricity price in Germany and residential electricity prices follow similar trajectories. On the other hand, industrial electricity prices have fallen since 2023 through policy support. Industry is exempt from the renewable energy surcharge and benefits from an electricity price cap.

However, the exemption of the renewable energy surcharge has been ruled unconstitutional, so financial resources to restrain industrial electricity prices are secured through measures such as raising carbon prices and aviation taxes. In conclusion, CN is a global issue. A coordinated response worldwide is required, so rising costs in one country do not lead to the exodus of companies or carbon leakage and hollowing out of industry.

The impact of elevated electricity prices on the industry

Corporate sensitivity on electricity prices

83% of companies are feeling the impact of rising electricity price
(German Chamber of Commerce and Industry survey)

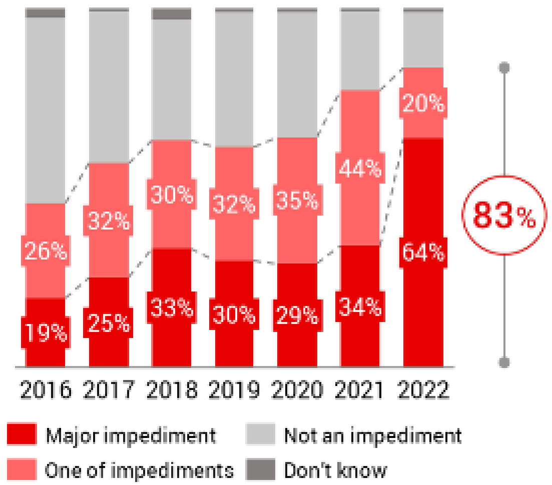


Germany: Impact of electricity price hikes on corporate investment

Impact of electricity price hikes on investment decisions

83% of companies consider elevated electricity prices as an impediment to their investment decisions

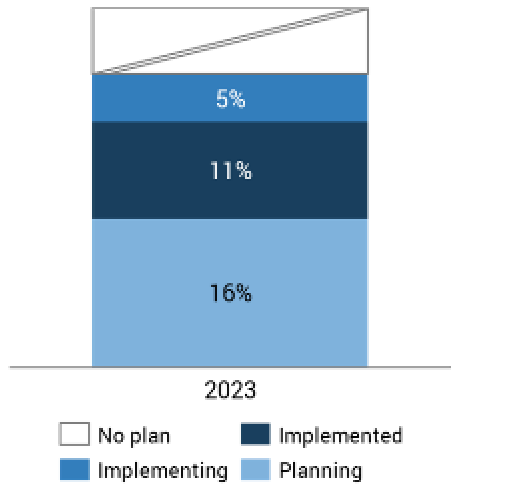
European Investment Bank survey (%)



German companies: overseas relocation/downsizing plan

32% of companies implementing or planning overseas relocation or downsizing of operations

German Chamber of Commerce and Industry survey (%)



The survey data published by the German Chamber of Commerce and Industry indicates concerns about the sustainability of financial resources for the German industrial sector. Indeed, about 83% of industrial companies feel that "electricity prices have risen in Germany" and the same proportion believes "electricity prices are a hindrance to investment decisions." Finally, 32% of industrial companies say they will "implement/plan overseas transfers/reductions if the situation in Germany continues."

Source: DIHK; EIB

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2. Current status and challenges in decarbonization of the United States and Europe
3. Common issues in the United States and Europe

Key takeaways from recent trends in the U.S. and the EU

The "Wall" of price pass-through (Private investment)

The U.S./Europe that are promoting regulation-/incentive-driven CN both face the wall of price pass-through, especially for **new technologies that have emission-reducing impact but lower energy efficiency (H_2, NH_3, CCS)**

The barrier to passing on the costs (The general public)

Even in EV/battery-related sectors where private sector investments were robust, the early adopter (the affluent) market has hit a plateau and reached a standstill; **the "Wall" of early majority (the general public)** is still high

Increased investment cost due to inflation =stagnant investment

In addition while excessive inflation is subsiding in both the U.S./Europe, project development costs remain high; forcing **various investment projects to be suspended or cancelled**

The challenge of ensuring long-term predictability in investments stands as a significant obstacle

Key takeaways from recent trends in the U.S. and the EU

Having looked closely at the policy and market environment in the U.S. and Europe, we believe that they share some common challenges. Europe promotes CN through a regulatory approach, and the U.S. through an incentive and market approach, but like in Japan and other countries, there is a price pass-through barrier, which is particularly high for technologies that may not generate significant additional value on their own beyond CO_2 emissions reductions (e.g., hydrogen, ammonia, CCUS).

Even in EVs and storage batteries, where private investment is progressing, the majority of those participating are affluent and mass-market adoption is still to come. A combination of carbon pricing, policy support, consumer awareness campaigns, and other measures will be required to support price pass-through.

Finally, there has been an increase in investment costs due to inflation, which is making price pass-through even more challenging and creates an obstacle to private investment.

What is most important is enhancing the long-term predictability of business. To achieve this, it is essential to ensure economic viability. This requires policy support and promotion of consumer awareness and understanding. If businesses can pass costs on to consumers based on this increased awareness and understanding, it will enhance their long-term predictability.

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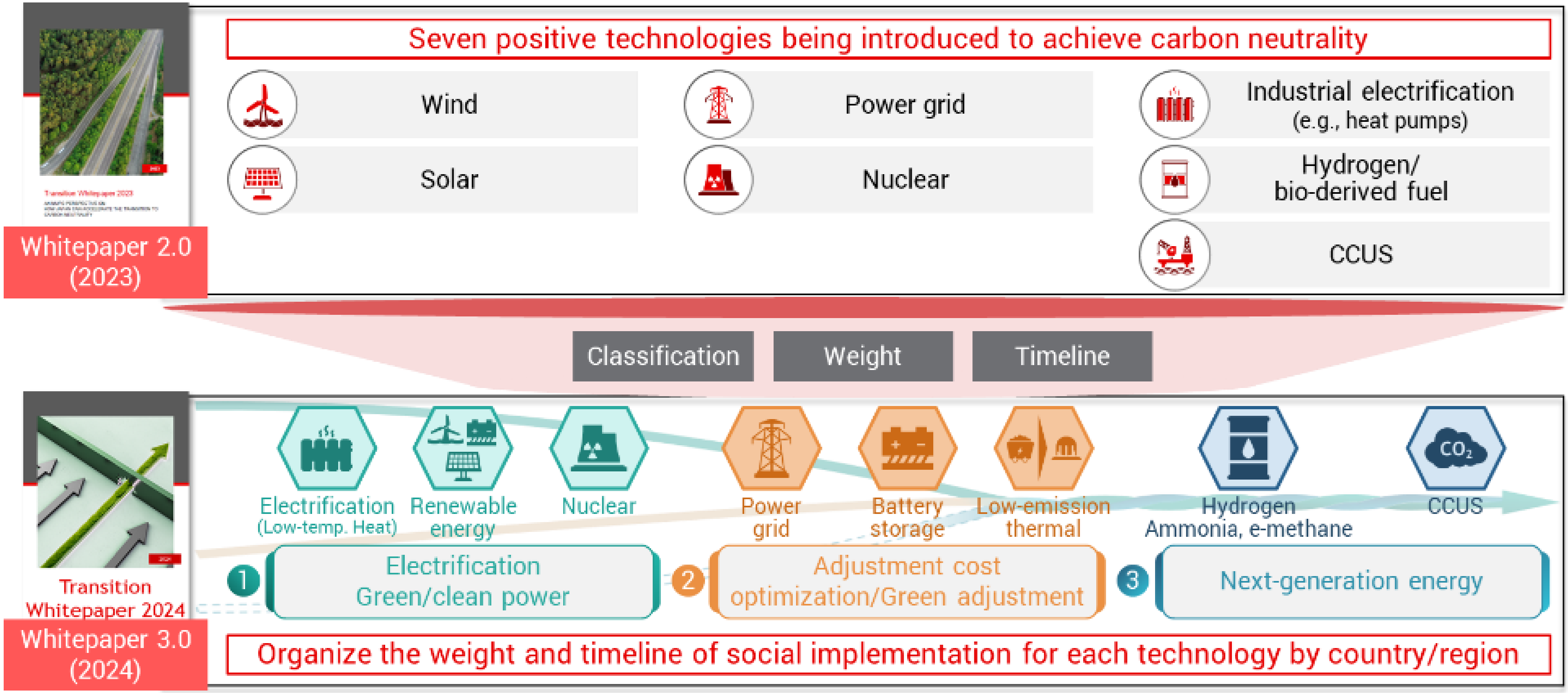
3. Current status and challenges in decarbonization of Japan
1. Reflections on the overall energy transition

Evolution from Whitepaper 2.0 (2023) to Whitepaper 3.0 (2024)

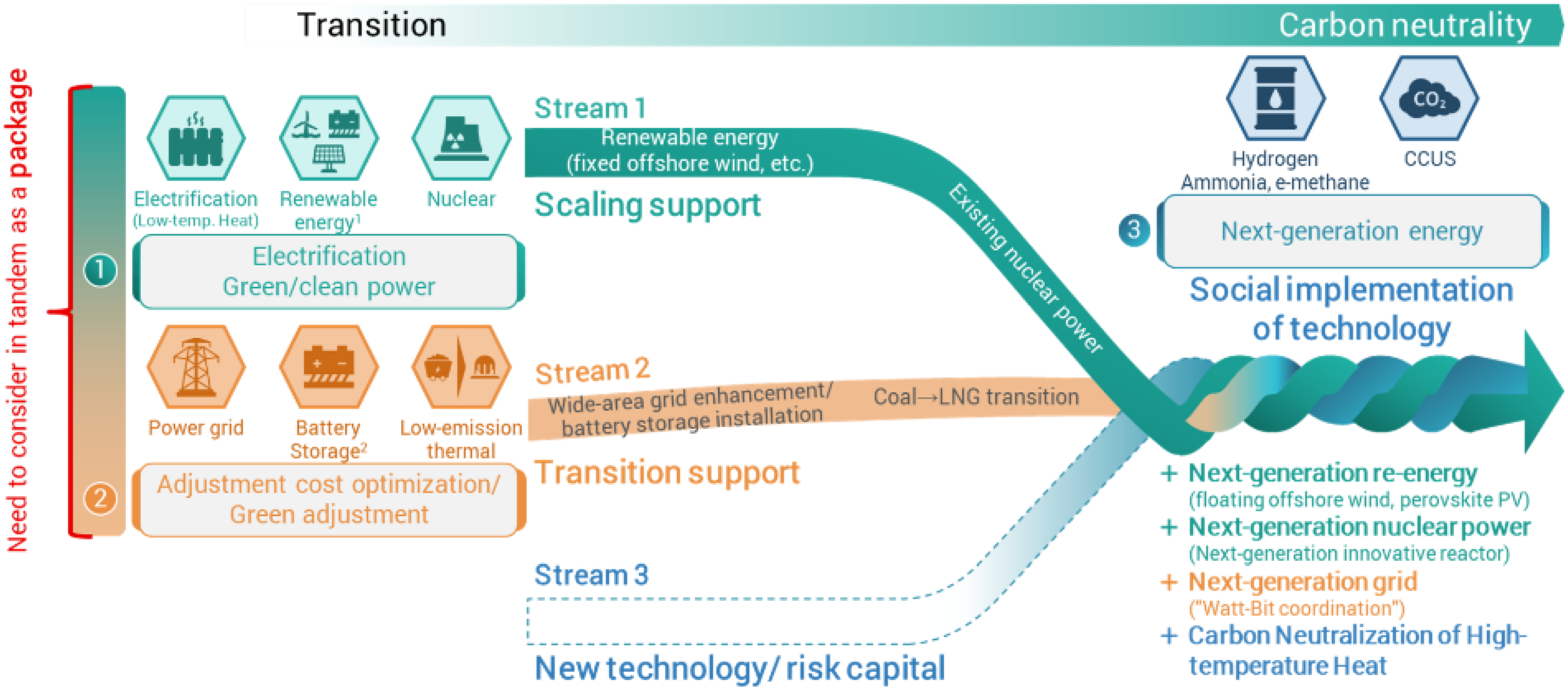


Evolution from Whitepaper 2.0 (2023) to Whitepaper 3.0 (2024)

After publishing Whitepaper 2.0, we visited Europe, the U.S., Asia, Oceania, and Japan, confirming the progress of technology implementation in different regions. Through our dialogues with customers across different businesses, we had the opportunity not just to develop a technical understanding of each technology but also to delve deeper into how they sit in a wider context.

From our discussions, we categorized seven Positive Technologies into three streams. We represented the development process graphically in the below exhibits, indicating the emphasis of each region with the thickness of arrows and adding a timeline.

Energy transition process for CN



- Energy Storage and Preservation: Hydrogen, Ammonia, e-Methane
- Carbon Removal and Utilization: CCUS (including synthetic fuels)

1: Including energy storage systems with renewable energy; 2: Grid energy storage systems

Energy transition process for CN

We categorized the technologies related to electricity and heat into three streams. The first stream is electrification, green, and clean energy. This involves switching energy sources to electricity and increasing the ratio of CO_2-free power sources such as renewable energy and nuclear power. Electrification becomes one potential solution for heat sources below 200°C, including replacing heat sources with heat pumps.

The second stream is the adjustment of renewable energy variability. It requires selecting the optimal solution for adjustment costs and optimizing adjustment measures. Electricity must match supply (power plant output) and demand (customer usage) at all times. This is known as the principle of simultaneous quantity. If the quantity is not always the same, the quality of electricity flowing through power lines cannot be maintained, leading to blackouts. In stream 1, electrification and the introduction of renewables are progressing. Renewables comes from natural sources, so it does not emit CO_2. But since it is derived from natural energy, the supply (power plant output) fluctuates significantly. There are times when the sun shines, and there are times when it does not. There are times when the wind blows, and there are times when it does not. The quantity of electricity varies at those times. To avoid blackouts, the fluctuations in renewables must be absorbed and equipment is needed to adjust for these fluctuations. The adjustment methods are diverse but include transmission and distribution, storage batteries, and low-emission thermal power. Each method has its advantages and disadvantages. An appropriate combination of equipment is needed depending on the volume, duration, and location of the fluctuations.

The third stream is the demonstration of new technologies including hydrogen, ammonia, e-methane, CCUS, next-generation renewables, next-generation nuclear, and next-generation grids. All of these are potential options, but it is difficult to see their economic viability at this point. A demonstration combining policy support and private investment is required. For high-temperature heat sources (e.g., 500°C to 600°C), it seems there are currently no prominent alternatives other than CHP (Combined Heat and Power) technology equipped with natural gas turbines and boilers.

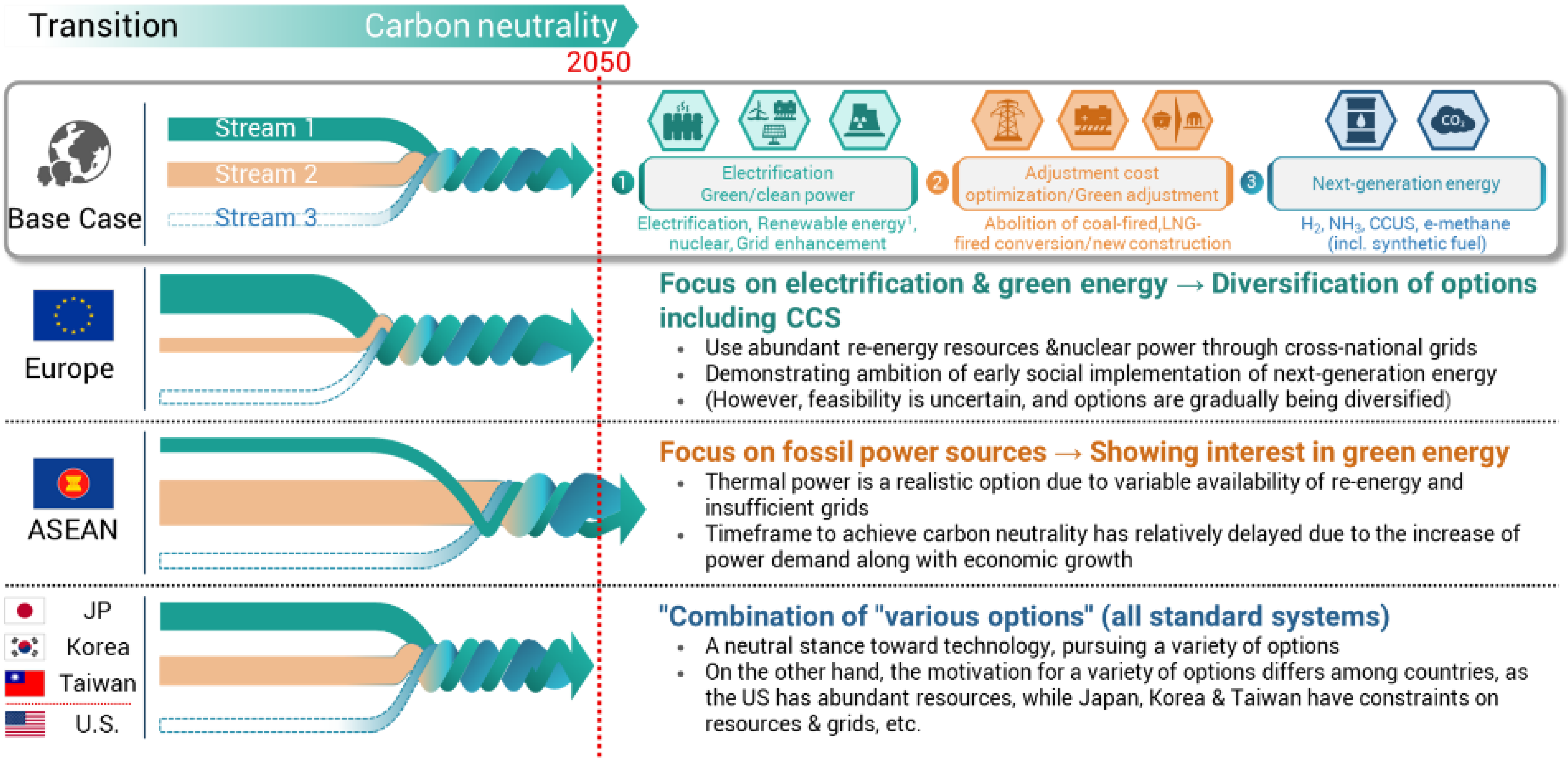
We categorize the various technologies then consider the combination of technologies with the highest quality and economic efficiency within each category and examine the future role of finance for social implementation.

Stream 1 (electrification, clean, and green energy) includes many established technologies, making it easier to unlock economic viability. In this area, private investment and financing innovation will be the drivers of scale.

Stream 2 (adjustment of renewable energy variability) faces two challenges. The first is to compare multiple investment opportunities to determine which technology is effective. Is it transmission and distribution, battery storage, or low-emission thermal power, or is it a combination of all? An integrated perspective is required to examine these options. The second challenge is to address reputational issues. To overcome with these, international financial frameworks are needed to clearly articulate why support for certain technologies is possible and necessary. This will serve as the foundation for mobilizing investment and finance. The biggest challenge in transition support is to discuss openly what everyone thinks and examine the significance and mechanisms of providing financing in financial forums.

Stream 3 requires a framework for public-private partnerships. This reflects the fact that new technologies will initially not be economically viable. However, if any technology is necessary for the country, it will need a combination of policy support and private investment.

Path to promote energy transitions based on regional characteristics (image)



1: Including energy storage systems with renewable energy; 2: Grid energy storage systems

Path to promote energy transitions based on regional characteristics (image)

We categorized the seven technologies into three streams, indicated the emphasis of each region with the thickness of the arrows and added a timeline to highlight the characteristics of each region.

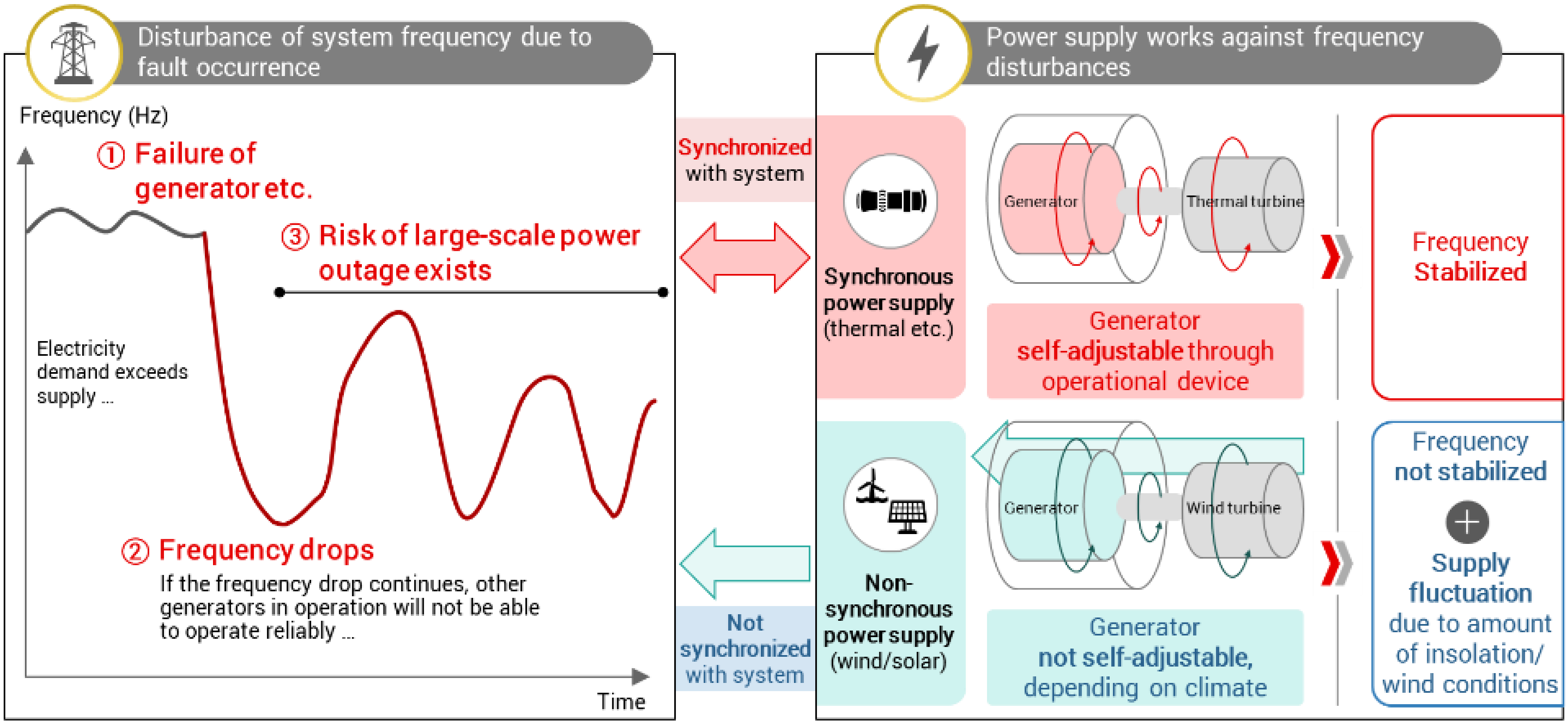
Private investment is progressing in Stream 1 (electrification, clean/green energy) and Stream 2 (adjustment of renewable energy variability), while Stream 3 (demonstration of next-generation technologies) is progressing through public-private partnerships (policy support + private investment). The vision is to achieve CN by 2050, with each stream intersecting around 2030-2040. For example, if hydrogen, ammonia, or e-methane is widely implemented, it can be used to create low-emission gas energy from surplus renewable energy or as a fuel source to reduce emissions from thermal power plants, causing the technologies to intersect and create synergies.

Europe is emphasizing Stream 1, advancing the energy transition. It is promoting investment in electrification, green, and clean energy. However, since the Ukraine conflict, there have been challenges from patchy gas supplies and rising energy prices, leading to calls for more realistic transitions. Some countries have also started considering the use of nuclear power, gas, and CCS. While the importance of Stream 1 remains unchanged, the range of technologies in Stream 2 is expanding from highly selective technologies.

ASEAN is exploring a pragmatic transition that focuses on using existing energy sources, mainly fossil fuels. The target is to achieve CN by 2060. The potential for renewable energy varies by country, some current thermal power plants are new, and the residual value (remaining investment) is high, with thermal power being the dominant energy source. As the economy grows, it will be necessary to install new power sources to meet new demand. The approach being taken is to switch existing thermal power plants from coal to gas while developing green and clean energy projects on a project-by-project basis.

Finally, focusing on Japan, South Korea, Taiwan, and the U.S., some countries are considering an approach that combines various options with a technology-neutral stance. In this context, Japan, South Korea, and Taiwan, as island nations, have higher energy costs, due to the fact that primary energy cannot be extracted domestically and must be imported. Costs in the U.S. are significantly lower, due to abundant domestic fossil fuel and renewable resources, alongside policy support. Many companies have mentioned that they rely on the U.S.'s abundant resources and IRA policy support to first develop technologies in the U.S. and then export them to their own countries.

(Ref) Electricity quality damage risk problems with increased wind/solar power



Source: FEPC; TDGC; Denki Shimbun; Chubu Electric Power Grid

(Ref) Electricity quality damage risk problems with increased wind/solar power

We have discussed electricity in terms of two factors: economic efficiency and CO_2 emissions. A power source that is economically rational and contributes to emissions reductions is a good power source. However, a third concept, which we learned from electricity company customers, is “quality of electricity”. Electricity is generated at power plants, flows through power lines, and is used in homes and offices. That flow is smooth when the frequency is constant. However, when the flow is disturbed, blackouts can occur. By way of example, assume a thermal power plant is connected to the power line. If the frequency in the power line is disturbed, the system automatically adjusts the rotation speed of the motor, and therefore its output, to correct the disturbance in the line. This is called “inertia” or “synchronous power.”

Next, let's assume renewable energy (solar and wind) is connected to the power line. What happens when the frequency is disturbed while renewable energy is connected to the power line? In short, the frequency cannot be adjusted unless the power of the wind or sunlight changes. Natural environments cannot be controlled, so renewable energy sources cannot absorb frequency fluctuations. Therefore, we need batteries, pumped storage, and perhaps thermal power plants to adjust. This is why frequency adjustment with renewable energy is called “adjustment” or “asynchronous power.” As the proportion of renewable energy in the energy mix increases, frequency adjustment becomes less effective. Thus, for renewable energy, it is necessary to understand not only the cost of generation but also the “integrated cost,” which includes adjustment power.

(Ref) Impacts of Yokkaichi momentary voltage drops incidents

About the incident

- Wednesday, 8 December 2010, 5:20 AM
- Yokkaichi Thermal Power Station

Instantaneous voltage drop of 0.07 seconds at a switchgear

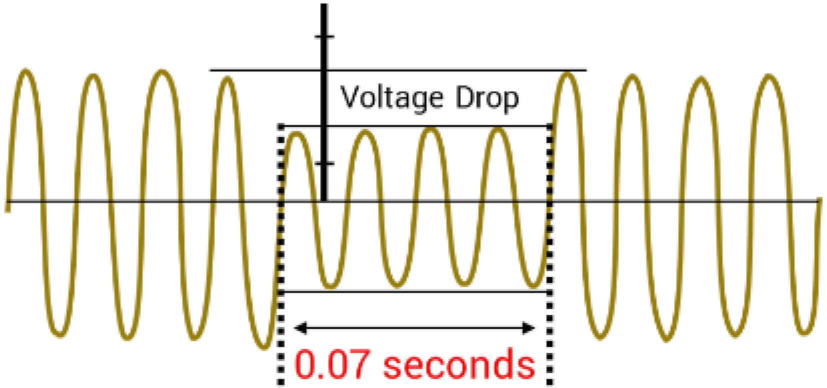
A number of business activities affected:

Mie prefecture : **109**
Gifu prefecture : **37**

At Toshiba's Yokkaichi plant **production lines were shut down**.

Estimated **¥20bn decline in revenue**[1]

Details of momentary voltage drop



- Voltage drops of 60% at the Nishi-Nagoya substation(15 km away), and 50% at the Minami-Ogaki substation(35 km away)
- Voltage drops of more than 60% in the Yokkaichi industrial complex adjacent to the power station

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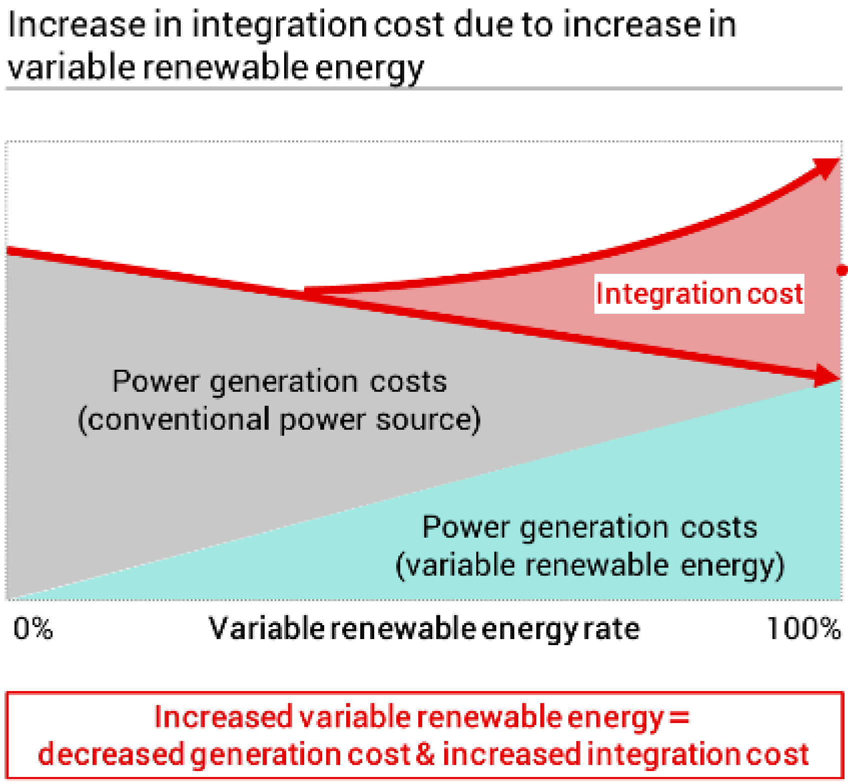
1: The company estimates sales of this product to be approximately ¥170 bn in the January-March 2011 period, and the accident could reduce shipments (equivalent to ¥100 bn in sales) for the two months from January to February 2011 by up to 20%.
Source: NKSJ Risk Management, 'Business Interruption Risks Posed by Instantaneous Voltage Drops'

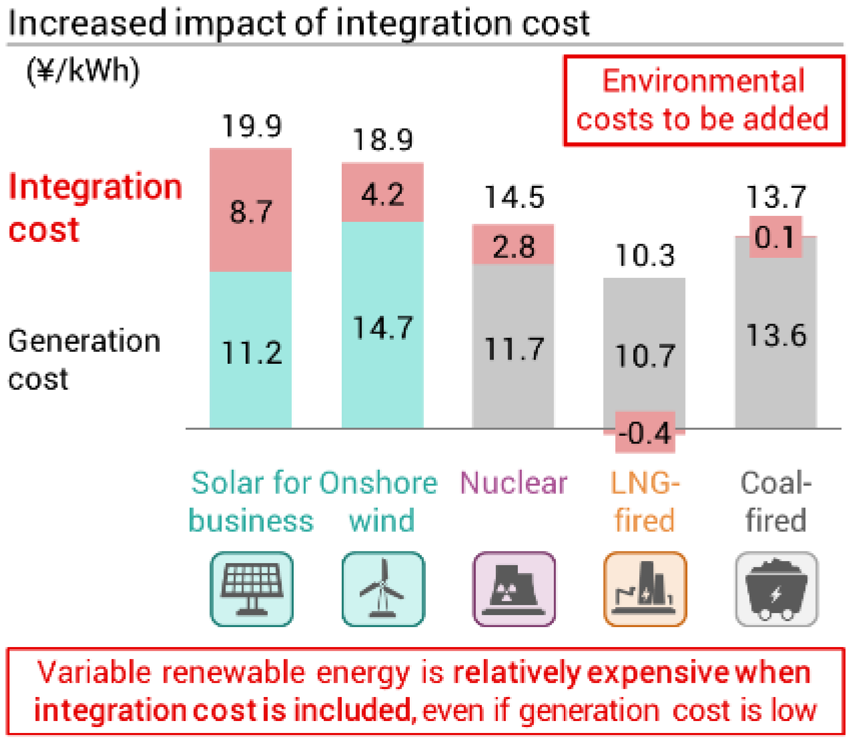
(Ref) Impacts of Yokkaichi momentary voltage drops incidents

There have been several examples of the impacts of power outages. In 2010, a momentary outage occurred in Yokkaichi, Mie Prefecture. The outage lasted only 0.07 seconds—approximately 1/100th of a second. But it caused disruptions to production and business activities for 109 companies in Mie Prefecture and 37 companies in Gifu Prefecture.

At Toshiba's Yokkaichi plant, the production line was halted, leading to a revenue loss of around ¥20bn. This shows the potentially significant impact of even a momentary outage. Our daily lives and industrial activities are reliant on electrical systems, so maintaining the quality of electricity is a lifeline for both industrial production and our daily lives.

Integration cost of renewable energy

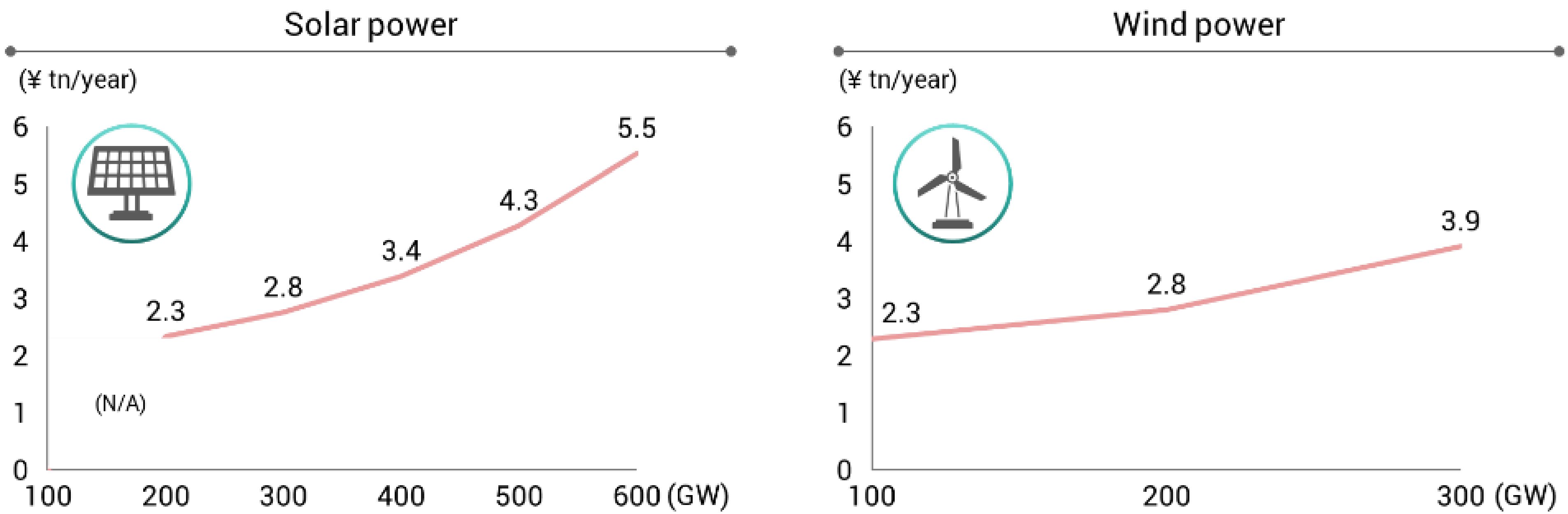




The cost of generating renewable electricity falls every year and is seen as cheaper than other energy sources. However, the concept of "integrated cost" is not widely recognized. When renewable energy fluctuates, we use thermal power plants or pumped storage to cover the shortfall. If these additional costs are taken into account, the integrated cost of renewable energy may be higher than that of nuclear power, LNG, and coal. More research is required to verify which combination of technologies is most economical.

Source: APU/IEEJ

Estimating the integration costs of variable renewable energy deployment



Integration costs will rise as variable renewable energy increases
due to the increase of battery storage costs, recharge/discharge losses, renewable energy output curtailment and transmission line reinforcement

(Integration costs can vary significantly depending on assumptions such as the cost of solar PV, wind power and battery storage.)

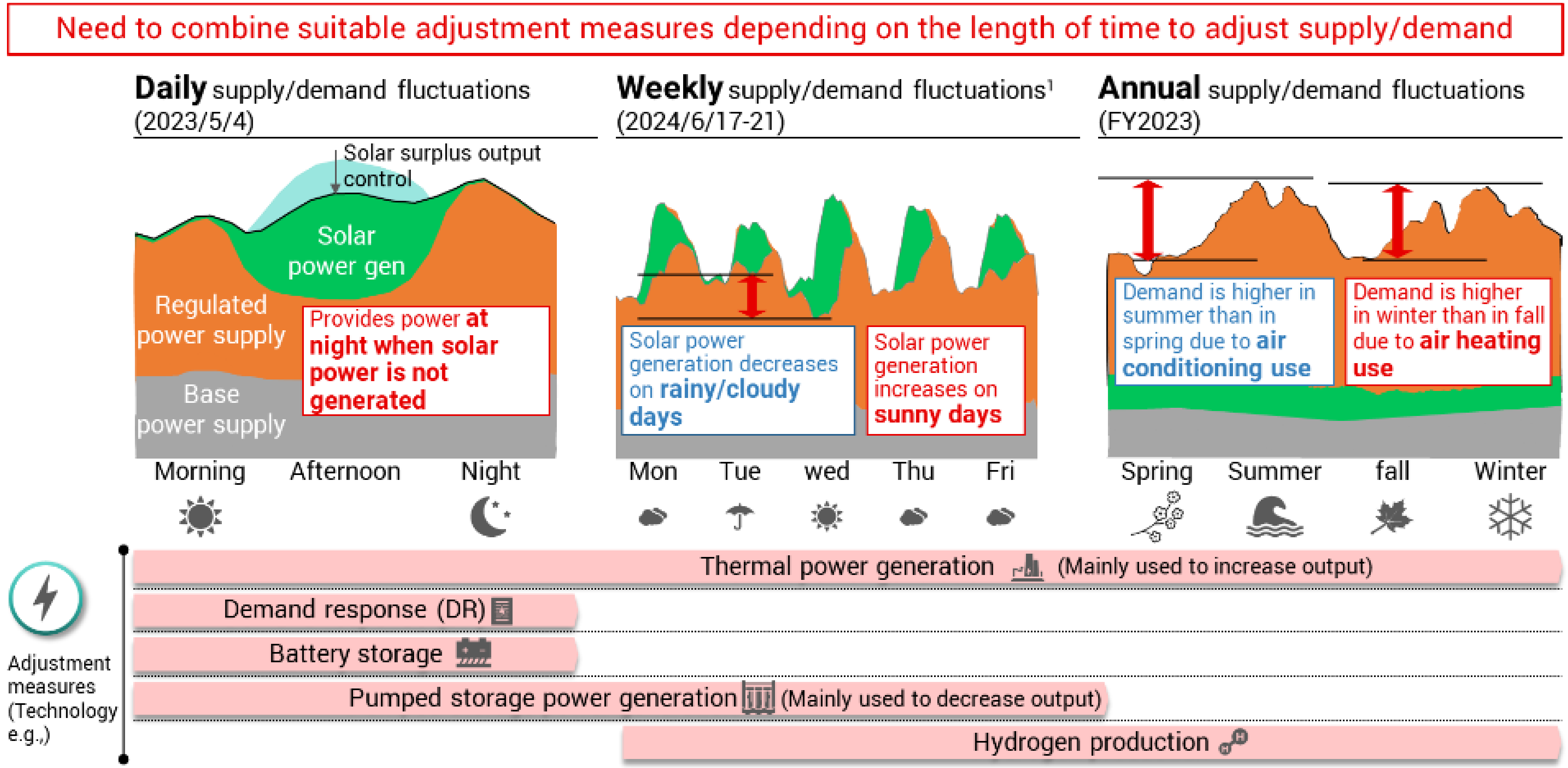
Note: Converted at $1=¥150
Source: Estimates by Associate Professor Yuji Matsuo, Ritsumeikan Asia Pacific University / Institute of Energy Economics, Japan (IEEJ)

Estimating the integration costs of variable renewable energy deployment

Associate Professor Matsuo of Ritsumeikan Asia Pacific University in 2021 conducted a study of the integration costs of renewable energy, and showed that as renewable energy increases, integration costs rise proportionally, with larger and more complex adjustment facilities needed to absorb variability in output.

These include measures relating to battery storage, charge and discharge losses, and the cost of reinforcing transmission lines. When variability cannot be absorbed by adjustment facilities, "output curtailment," which disconnects renewable energy from the power grid at a cost, is necessary. Solar power has greater output variability than wind power and incurs higher integration costs.

(Ref) Adjustment measures for short- and long-term supply-demand fluctuations



1: Indicates the weather the highest number of locations, based on the total of whether data from five locations: Sapporo, Tokyo, Nagoya, Osaka, and Fukuoka
Source: JERA; OCCTO

(Ref) Adjustment measures for short- and long-term supply-demand fluctuations

Variability in practice means that different power sources will be optimal at different times of day. Solar may be best during daylight hours but must be supported during the “lighting peak” in the early evening, when electricity usage tends to be high.

And even during daylight hours, power may vary based on weather conditions. Solar radiation and wind conditions fluctuate not only throughout the day but also vary significantly by season. Batteries can of course help, but have limited capacity at present, meaning thermal power and pumped storage are essential.

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3. Current status and challenges in decarbonization of Japan
2. Current situation: progress in Japan's policy support and corporate activities

Progress in Japan's policy support

A policy support framework combining P/L and B/S support was introduced for a wide range of techs

	Support type	Support content	Supplementary info
	Framework dev	GX economic transition bonds investment promoting measures	"Investment strategies by sector" compiled and allocation policy for ¥13tn formulated ('23/12)
	Framework dev	GX league/GX-ETS	A "carbon credit market" established, and trial emissions trading launched ('23/10)
Hydrogen ammonia e-methane	Framework dev	Basic hydrogen strategy	Based on GX policy, strategy revised with overseas markets in mind ('23/6)
	B/S,P/L support	Hydrogen society promotion act	Legislation passed incorporating support for price differentiates/ base development ('24/5)
CCUS	Framework dev	9 "advanced CCS businesses"	Businesses selected to start operations in ~'30 to establish business models ('24/6)
	B/S support	CCS business act	A bill incorporating public-private roles in CCS businesses was passed ('24/5)
Offshore Wind power	P/L support	Fixed offshore round 2	Operators for the 4 target sea areas selected ('24/3)
	Framework dev	Act on promoting the utilization of sea areas for the development of marine renewable energy power generation facilities	Cabinet approved a bill incorporating expanded EEZ use in anticipating of floating development ('24/3)
Solar power	P/L support	FIT[1]/FIP[2] systems	Electricity generated was purchased at a fixed price or a premium linked to the market price was granted
	B/S support	GI fund + GX SC construction support	Support (approx. ¥470bn) secured for mass production of perovskite solar cells ('24/3)
Nuclear	B/S support	Dev/social imple support	Support (approx. ¥450bn) quota secured for next-generation reactors ('24/3)
	P/L support	Long-term decarbonized power supply auction	Capacity revenues at the fixed cost level of decarbonized power sources are in principle compensated for 20 years ('24/1)
Power grid	B/S,P/L support	Master plan for wide-area interconnected system	Master plan for new/enhanced domestic interconnection lines published ('23/3) Currently formulating requirements for construction of Hokkaido mainland interconnection facilities (approx. ¥1.5-1.8tn)
Industrial Electrifica-tion	B/S,P/L support	Support through GX transition bonds	battery storage (¥867.4bn) + semiconductors (¥536bn) ('23/12)
	P/L support	Tax incentives for promoting domestic production in strategic sectors	Introduction of tax system of 10-year tax credit for semiconductors, EVs, green steel/ chemicals, and SAFs included in '24 tax reform ('23/12)

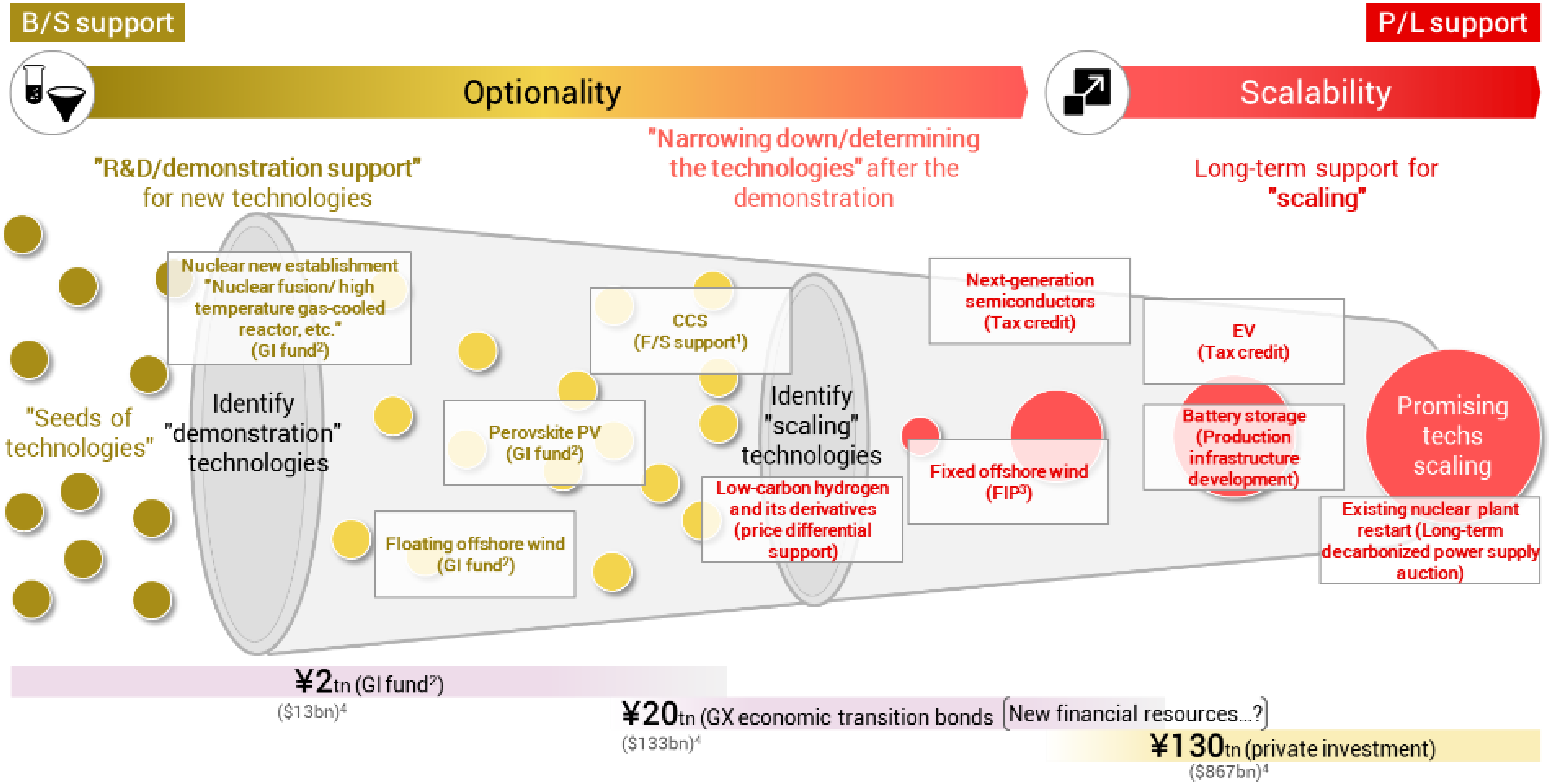
1. Feed in Tariff; 2. Feed in Premium

Progress in Japan's policy support

Japan is taking a consensus-driven approach to achieving CN through industry-government collaboration. Technology roadmaps have been discussed for 22 fields relating to CN, and on February 10, 2023, the government announced the GX Basic Policy. Japan's policies support a wide range of technology options in the spirit of technology neutrality.

The GX policy outlines the framework for P/L and B/S support in fields such as hydrogen, ammonia, e-methane, CCUS, offshore wind power, solar power, transmission and distribution, and industrial electrification. P/L support underpins business viability, and B/S support reduces the investment burden on businesses, activating investment and finance.

Policy support type for social implementation of technology



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1. Support for Feasibility Study; 2. Green Innovation fund (NEDO's program to support research, development, and demonstration projects);
3. Feed In Premium (Renewable energy feed-in tariff premium subsidy system); 4. Converted at $1 = ¥150

Policy support type for social implementation of technology

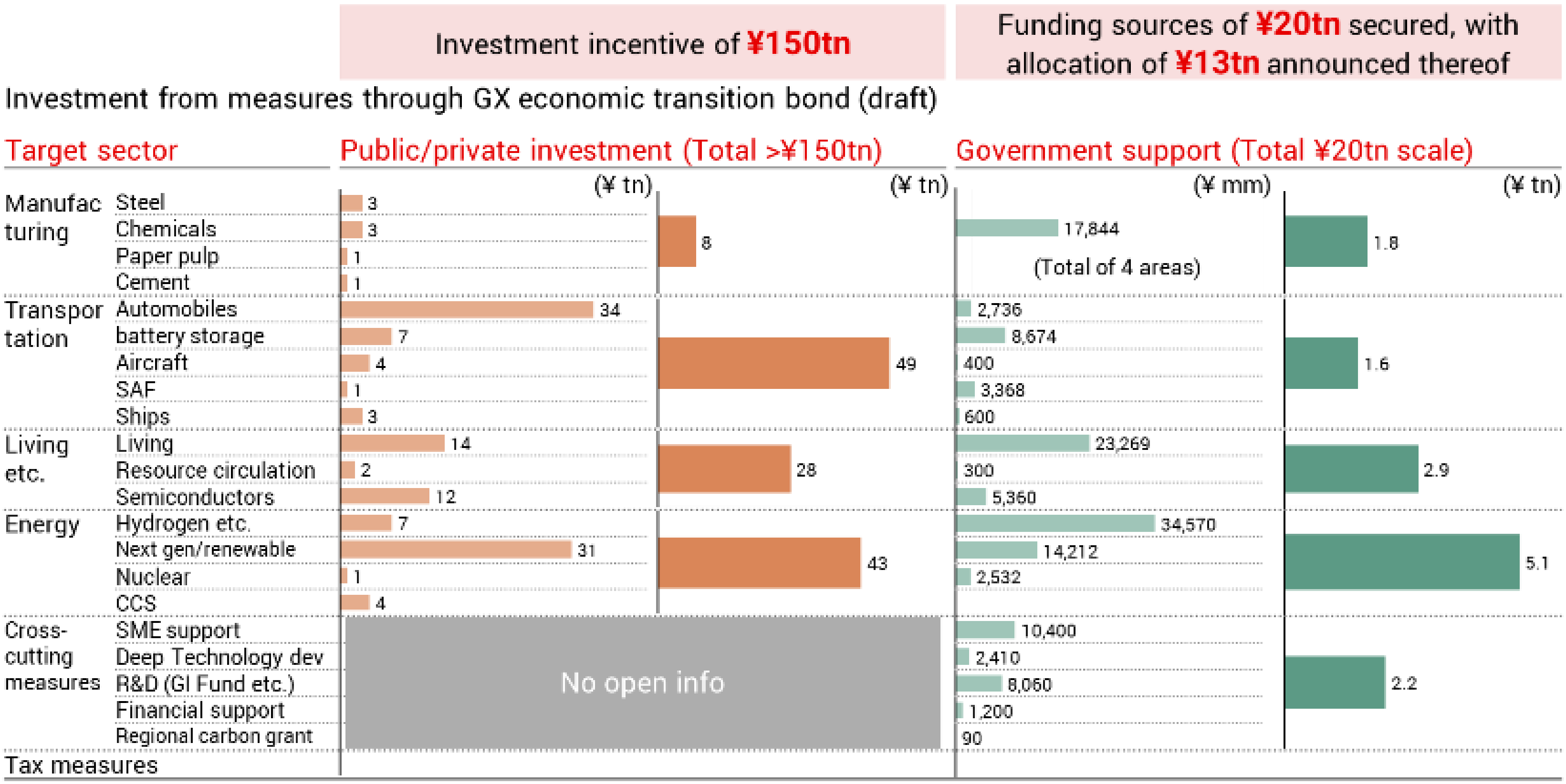
The required policy support varies depending on the maturity of the business. Through dialogues with government and industry representatives, we categorize these into three main categories:

First, R&D/Demonstration. Technologies that are not yet established but have potential are unlikely to be economically viable, so a long-term framework for nurturing development through public-private collaboration is required. Examples include new nuclear (e.g., nuclear fusion, high-temperature gas reactors), next-generation solar power (e.g., perovskite), and floating offshore wind power. These have attracted B/S support through the GI Fund.

Next is the stage where the technology is proven to be effective, and actors are determining the viability of scaling up. It involves large-scale pilots and prioritization of regions to verify scale and economic viability. This is referred to as the “technology narrowing stage”, with CCUS, hydrogen, ammonia, and e-methane among current candidates. We have seen B/S support (feasibility study support) for CCUS, as well as P/L (price gap compensation) and B/S support (infrastructure support) for hydrogen and ammonia.

Finally, the scaling stage. For technologies where the demonstration is complete, and economic viability is established, private investment and financing are activated to achieve scaling. Examples include fixed-bottom offshore wind power, next-generation semiconductors, EVs, storage batteries, and the restart of existing nuclear power plants. P/L support and B/S support are provided to act as boosters for private investment.

Investment promotion through GX economic transition bond (allocation of ¥13tn policy support)



Japan has announced that at least ¥150tn of investment and financing will be required over the next ten years to realize GX. To achieve that, ¥20tn of GX support has been announced, raised through government bonds called "GX economic transition bonds." In December 2023, ¥13tn was allocated to energy, manufacturing, transportation, and housing sectors.

Source: METI

Tax credit for promoting domestic production in strategic sectors

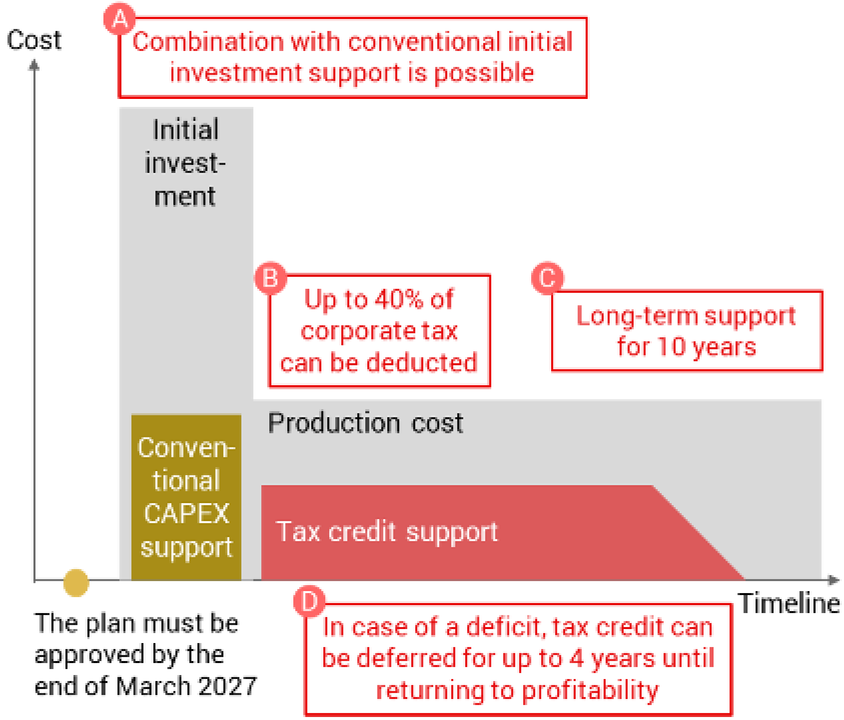
In Japan, a framework for P/L support with tax measures has been introduced

Overview of tax credit ("Production Tax Credit")

Target items

1 Semicon	MCU semiconductor	28~45nm equivalent	¥16k /sheet
		45~65nm equivalent	¥13k/sheet
		65~90nm equivalent	¥11k/sheet
		90nm or more	¥7k/sheet
	Power semiconductors	Si (current gen)	¥6k/sheet
		SiC/GaN (next gen)	¥29/sheet
	Analog semiconductors	Image censor	¥18k/sheet
		Other	¥4k/sheet
2 Electric vehicle etc.		EV/FCV	¥400k/unit
		Light EV/PHEV	¥200k/unit
3 Green steel (including blast furnace→electric furnace conversion)			¥20K/ton
4 Green chemical (including synthetic, bio-based raw materials and waste plastics)			¥50k/ton
5 SAF			¥30/liter

Key points in applying tax credit



Japan is also considering introducing a "P/L support (production tax credit)" that is similar to the IRA. Target sectors include strategic industries such as semiconductors, EVs, green steel, green chemicals, and SAF. To promote GX and strengthen industrial competitiveness, Japan is also exploring support measures beyond the conventional framework while benchmarking policies from other countries.

Source: METI

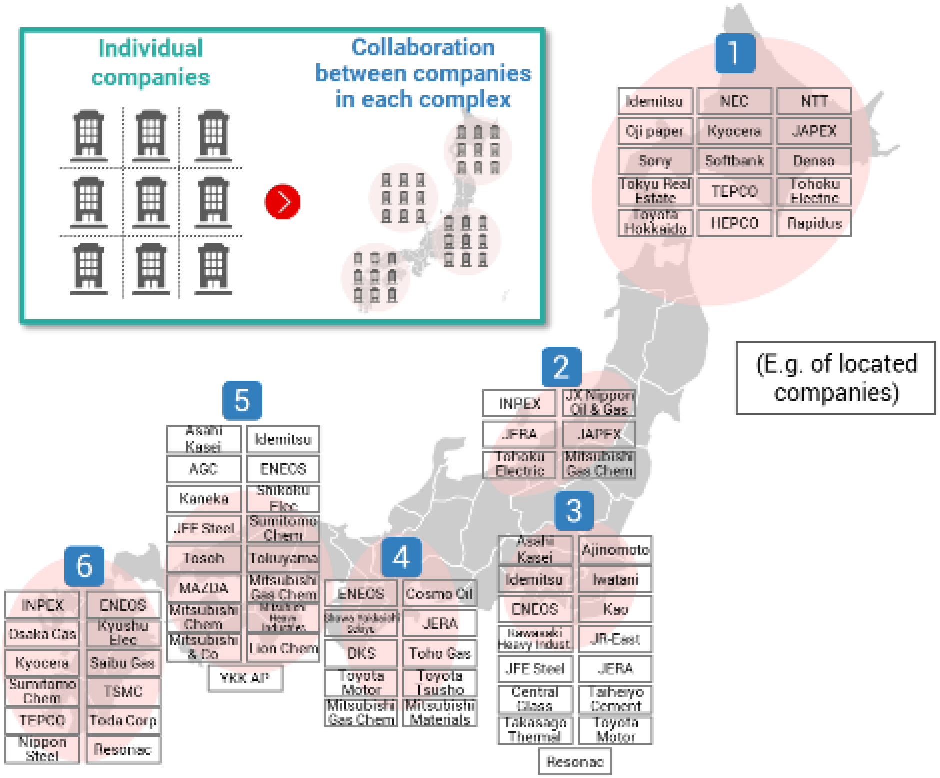
Progress in private sector dialogue and collaboration

Discussions to move jointly toward CN started from initiatives at individual companies / industrial complex units to initiatives at each regional unit

4 Chukyo (Chubu)
Energy transitions in industries / power generation clusters such as in Yokkaichi, Chita, and Hekinan

5 Setouchi
Industrial structural transformation through collaboration with terminals and complexes in Shunan, Namikata, Mizushima, etc.

6 Kyushu
Building a semiconductor supply chain with re-energy potential



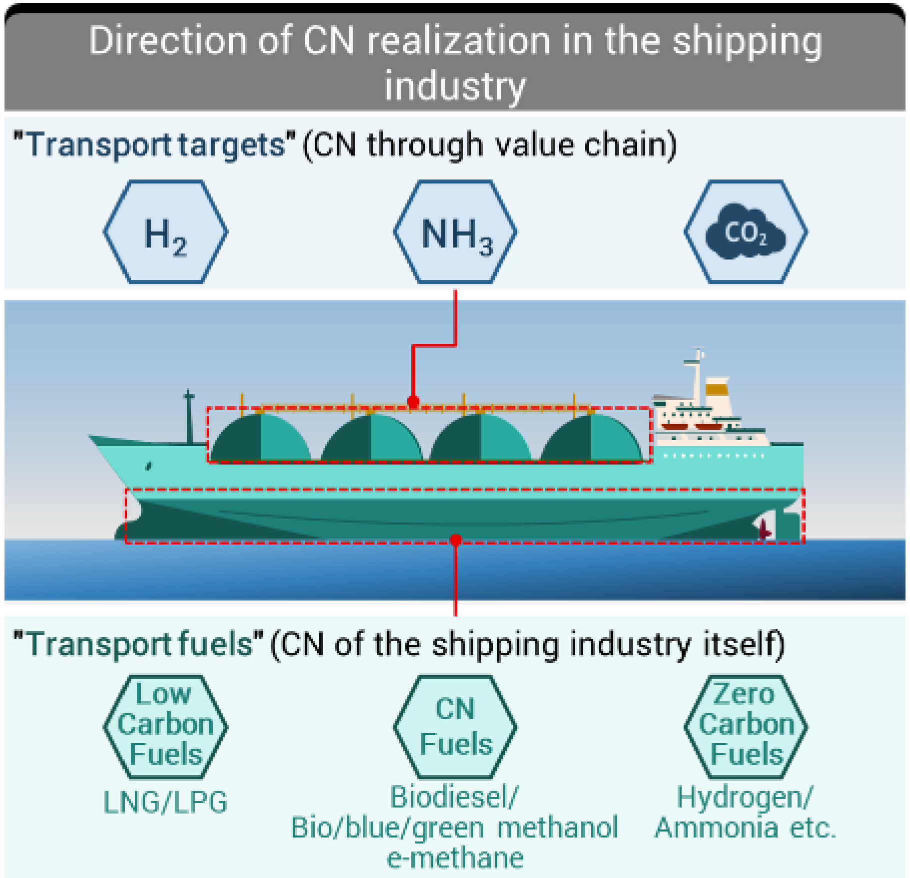
1 Hokkaido
Attracting new industries including data centers and semiconductors with re-energy potential

2 Niigata
Industrial structural transformation using existing assets in Niigata, Chuetsu, Joetsu, etc.

3 Kawasaki (Keihin)
Industrial structural transformation through collaboration with terminals and complexes concentrated

Companies are also considering action to strengthen their competitiveness, including aggregated investment at regional level. Discussions are starting in areas including Hokkaido, Niigata, Kawasaki, Chukyo, Setouchi, and Kyushu, where councils are being established to discuss optimizing regional complexes.

Start of the application of international price pass-through and direction of CN realization in the shipping industry



Price pass-through cases in the shipping industry	
Operators (Share-holding ratio)	**Ocean Network Express(ONE)** • Launched in 2017 by integrating the regular container shipping business of 3 JP shipping companies NYK Line (38%) / Mitsui OSK Lines (31%) / Kawasaki Kisen Kaisha (31%)
Method of price pass-through	Started to request for price pass-through to customers as "EU-ETS surcharge" from Jan 1, 2024, since the shipping industry became subject to EU-ETS "FuelEU Maritime" to be introduced from "Jan 1, 2025" **With regional regulations being introduced, globally unified system like IMO's is required** • Carbon taxes on the shipping need to be reinvested within the industry

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

Start of the application of international price pass-through and direction of CN realization in the shipping industry

The global shipping industry is seeing significant changes in response to global energy transitions.

First, the types of cargo are changing. As the world shifts toward cleaner energy, shipping is moving from fossil fuels to new energy sources such as hydrogen, ammonia, and CO_2. Ammonia ships are already operational, and research and development are underway for hydrogen and CO_2 carriers.

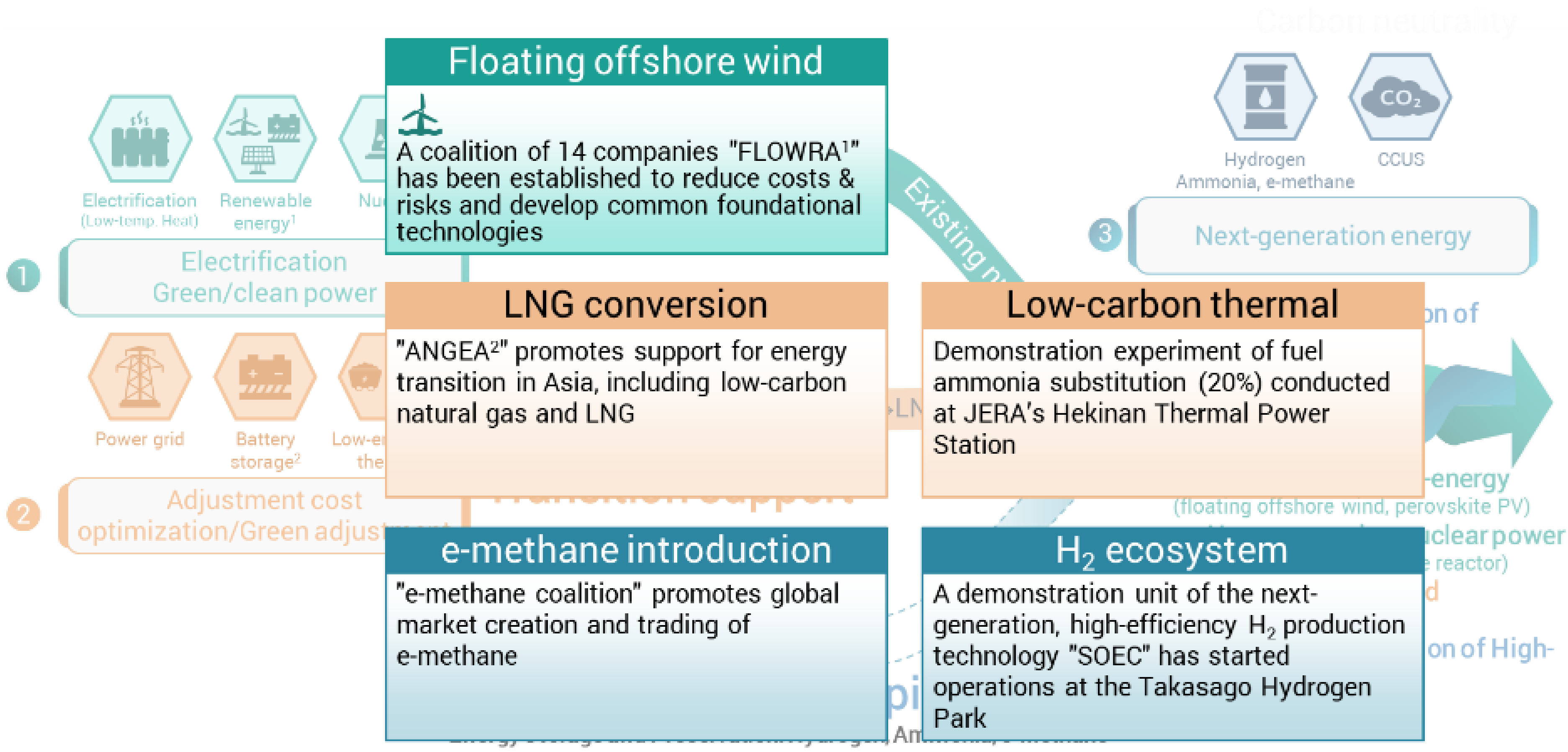
Second, the fuel powering ships are evolving. Traditional heavy fuel oil is being replaced by LNG, LPG, methanol, biofuels, and eventually ammonia and hydrogen, as efforts to develop low-emission fuels progress.

Third, shipping companies are preparing to pass on the costs of emission regulations. From January 2024, the EU began charging for emissions costs under the EU Emissions Trading System (EU-ETS). The upcoming FuelEU Maritime Regulation is also expected to further increase costs, affecting both imports to and exports from Europe. Many companies are negotiating with customers to pass on these costs, and it seems the surcharge has been relatively well accepted. However, there are significant administrative burdens, including emissions calculations and contract revisions.

As a global industry, shipping requires unified international rules. Some argue that instead of region-specific cost pass-throughs, the International Maritime Organization (IMO) should lead efforts to create global standards. There is also a call for emission surcharges to be reinvested in the decarbonization of the global shipping industry, something not currently guaranteed under the EU-ETS system.

Finally, the EU-ETS only applies to European routes, and companies that do not operate in Europe may not be fully informed. To avoid excessive administrative burdens, global collaboration between the public and private sectors may be needed to create a streamlined mechanism to cost-effectively reduce emissions.

Progress in refining technological options



1: Floating Offshore Wind Technology Research Association; 2: Asia Natural Gas & Energy Association
Source: FLOWRA; Mitsubishi Heavy Industry; JERA; Tokyo Gas; Asia Natural Gas & Energy Association

Progress in refining technological options

Leading companies in Japan have made considerable progress in the three streams discussed above. For example, in Stream 1 (electrification, green, and clean energy) 14 companies established the "FLOWRA" consortium to develop floating offshore wind power. In Stream 2, the adjustment of renewable energy variability, power utility JERA in April 2024 piloted fuel ammonia conversion at the Hekinan Thermal Power Station. Additionally, ANGEA, in which Mitsubishi Heavy Industries participates, launched a framework for discussions to support the introduction of natural gas and LNG in the Asian region, based on the premise of maximizing the introduction of renewable energy.

In Stream 3, next-generation energy, Mitsubishi Heavy Industries in April 2024 started operating a demonstration unit for high-efficiency hydrogen production technology "SOEC" at the Takasago Hydrogen Park. Osaka Gas and Tokyo Gas launched the e-NG Coalition, advancing collaboration for the utilization of e-methane to reduce gas emissions.

Recent initiatives formation trends for gas transition

Private companies are forming coalitions across borders, pooling technology and funding to aim for emissions reduction. It is necessary for governments to endorse these initiatives

e-NG Coalition ("e-methane coalition)		ANGEA (Asia Natural Gas and Energy Association)	
Name, composing companies	**e-NG Coalition** • TES (Belgium), Tokyo Gas, Osaka Gas, Toho Gas, Mitsubishi Corp., Engie, **Sempra Infrastructure Net Zero (U.S.),** Total Energies (France)	Name, composing companies	**ANGEA(Asia Natural Gas and Energy Association)** • JERA, Mitsubishi Heavy Industry, Nikki, Chevron (U.S.), ExxonMobil (U.S.), Santos (Australia), BP(UK), others
Purpose of establishment	• Formed by eight global companies in Mar 2024, aiming to realize a CN society through global expansion/adoption of e-methane	Purpose of establishment	• In Oct 2021, the establishment of ANGEA as a private initiative was announced to support the introduction of low-carbon natural gas and LNG, aimed at supporting Asia's energy transition
Activity overview	1. Efforts to increase global awareness of e-methane and promote market creation/transactions 2. Policy advocacy activities such as efforts towards global certification and greenhouse gas calculation rules, in cooperation with companies and organizations related to e-methane supply chain	Activity overview	1. Support for decarbonization efforts for Asian countries where energy demand is increasing

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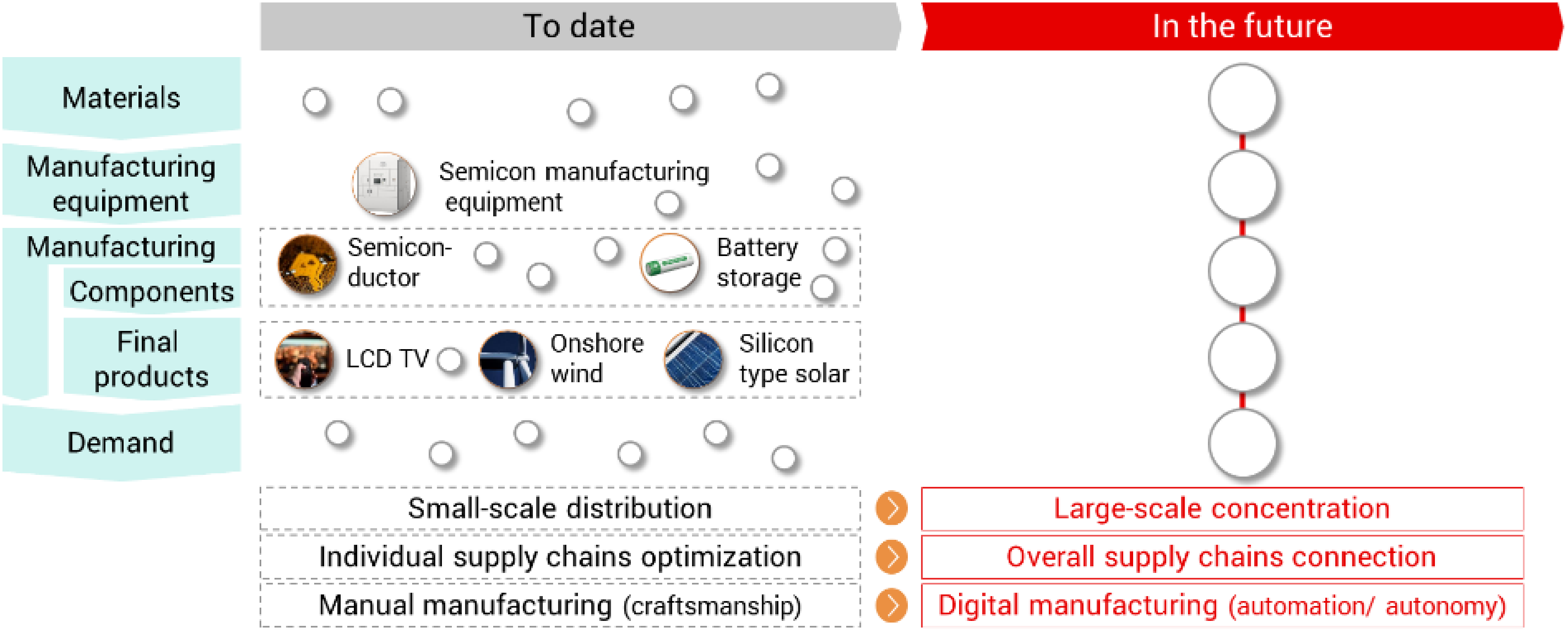
Source: Tokyo Gas; Asia Natural Gas & Energy Association

Recent initiatives formation trends for gas transition

Among private sector cross-border initiatives, the e-NG Coalition involves companies from Japan, the U.S., France, and Belgium. In Japan, Osaka Gas, Tokyo Gas, Toho Gas, and Mitsubishi Corporation are participating. ANGEA involves companies from Japan, the U.S., Australia, and U.K. Mitsubishi Heavy Industries, JERA, and JGC are participating from Japan.

These global initiatives bring together technology and capital to support pioneering technologies, verifying their effectiveness and impact and helping create international frameworks to boost recognition and expand technology utilization. This effort will provide a strong foundation for future global carbon credit trading. It is crucial that governments endorse these private-sector initiatives, linking them to larger movements.

Key players in industrial transformation for investment expansion



What is certain is that AI/digital technologies will advance, and the need for decarbonized power sources will increase. Now is the time to accelerate the creation of a collaborative systems while each companies continues to refine its own approach

Key players in industrial transformation for investment expansion

Many of the efforts toward CN will enhance Japan's industrial competitiveness. For example, as an island nation, Japan can accrue benefits from proactively establishing international initiatives and promoting international cooperation while acting domestically to achieve CN. Emissions reductions, price pass-through, and expanding technology optionality are common challenges that require global cooperation.

Japan’s industrial concentration and reinvestment is also relevant. Until now, material production, manufacturing, and demand have been handled by different companies at each stage. Segmented competition has built the supply chain. In the future, Japan must face two mega-trends: population decline and resource scarcity. With that in mind, it may make sense to consider aggregation at regional or industrial levels, investment in aggregation sites, and connecting the entire supply chain. We need more endeavor to promote efficiency through digital manufacturing, reduce personnel costs, and stimulate domestic demand. Economic prosperity will create a foundation for price pass-through for CN. Industrial clustering, large-scale investment, capturing the entire supply chain, and digital manufacturing will be key concepts for the future.

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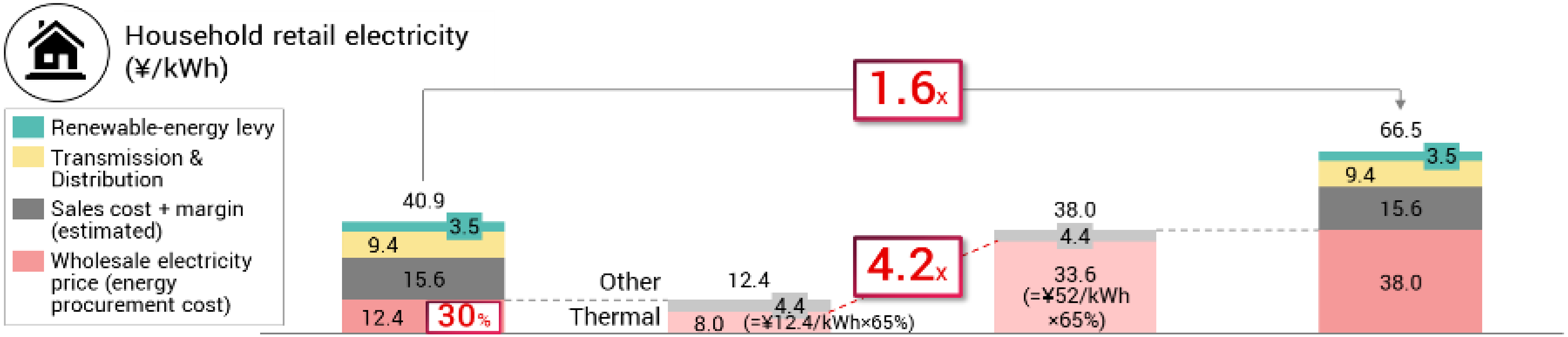
3. Current status and challenges in decarbonization of Japan
3. Challenges: impact on electricity prices with the introduction of hydrogen

Estimated changes in household retail electricity prices with H_2 power generation (Case of replacing the equivalent of current domestic thermal power generation with H_2 power generation)



	Current electricity prices (as of Jun '24)		Electricity prices after introducing H_2	
Assumption	• Contract: TEPCO, metered light B, 30A • Monthly power consumption: 350 kWh • Wholesale electricity price: JEPX spot (Avg for Jun '24, Tokyo)	Thermal power generation ratio in Japan: 65% • Coal: 30.8%(2022) • LNG: 33.8%(2022)	• Only the equivalent of thermal generation replaced by hydrogen • Hydrogen power generation unit price: ¥52/kWh (hydrogen price: ¥100/Nm³)	• No change before/after introducing hydrogen except for wholesale electricity prices (energy procurement costs)
Industrial burden	Family of 4 350 kWh/ month	**¥14,309/month** ($95)[1] (¥40.9/kWh × 350kWh/month)	**¥23,270/month (+¥8,960)** ($155)[1] ($60)[1] (¥66.5/kWh × 350kWh/month)	

Note: In calculation, figures are rounded to the first decimal place. 1: Converted at $1 = ¥150
Source: TEPCO (1/2); TEPCO (2/2); JEPX; METI

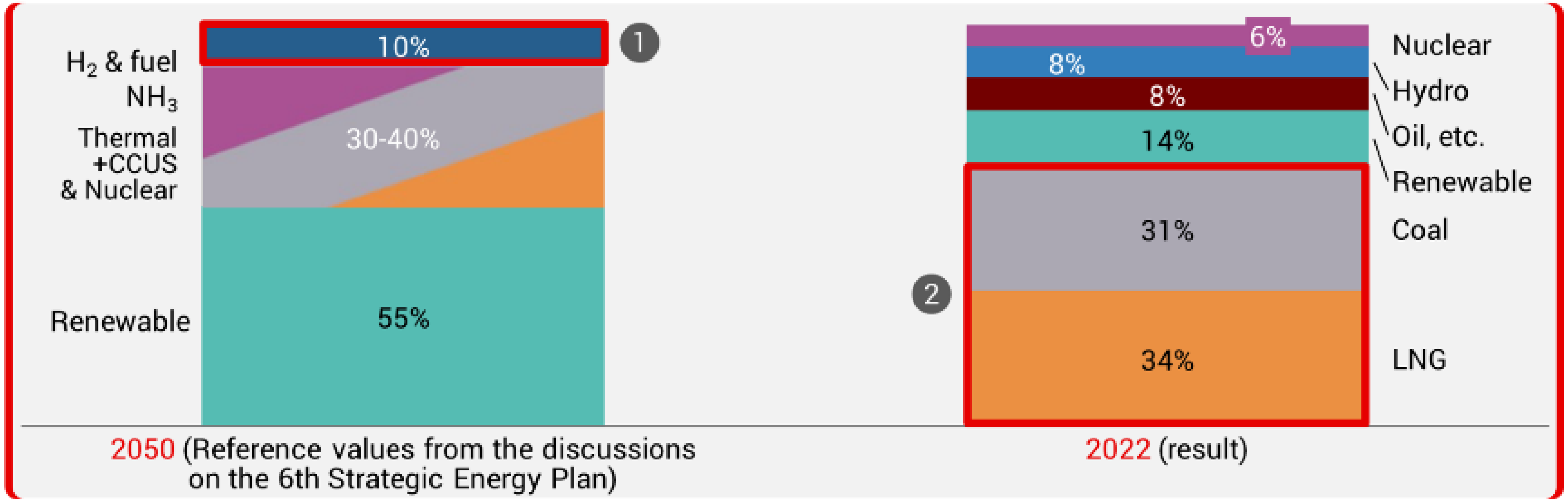
Estimated changes in household retail electricity prices with H_2 power generation (Case of replacing the equivalent of current domestic thermal power generation with H_2 power generation)

As discussed in this paper, price pass-through is a significant challenge facing industries at almost every stage of CN technology development. One way to characterize it is through the example of replacing thermal power with hydrogen. First, it is helpful to understand how electricity prices work in Japan. In 2024, the household price of electricity was ¥40.9/kWh, which we can divide into four elements: The first is the renewable energy surcharge of ¥3.5/kWh (green). The second is transmission and distribution charges (network costs) of ¥9.4/kWh. The third is regulated recovery costs of ¥15.6/kWh, and the fourth is energy procurement costs (wholesale electricity prices) of ¥12.4/kWh, accounting for 30% of the total.

Breaking down energy procurement costs, thermal power is ¥8.0/kWh, and others are ¥4.4/kWh. So, what would happen if the ¥8.0/kWh thermal power cost were replaced with hydrogen at ¥100/Nm^3 (hypothetical value)? Japan's thermal power plant capacity is 129 GW, with a generation volume of 652.8 bn kWh. If this is replaced 100% with hydrogen at ¥100/Nm^3, the cost rises from ¥8/kWh to 52 yen/kWh. This would increase energy procurement costs by 4.2 times and the retail electricity price by 1.6 times (¥40.9/kWh to ¥66.5/kWh). The burden on a typical household would rise from the current ¥14,309 per month to ¥23,270.

This calculation only considers the burden of energy procurement costs. It does not consider supply chain maintenance costs or other expenses.

Scenario for Hydrogen replacement impact estimation: current/future power supply mix



1 Base case

If the expected scale of future H_2 adoption (10%) is realized, what will happen to electricity prices?

2 Ref scenario

If all current thermal power generation (65%) is replaced with H_2 power generation, what will happen to electricity prices?

As of 2022, thermal power in Japan accounted for 65% (34%+31%) of total power generation. The Sixth Energy Basic Plan envisions reducing thermal power generation and replacing fuel with hydrogen and ammonia, assuming a total of 10% substitution. This 10% highlights the importance of securing technology optionality for fuel replacement, CCUS, and nuclear power.

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

Estimation of the impact of hydrogen replacement (additional household burden)

Assumed electricity consumption 350kWh/month
(Assumed for a household of 4)

Small — Household burden — Large

Low — High

Current: ¥14,309/month

(¥/month)

Replacement scale	Hydrogen replacement	Hydrogen price (¥/Nm³) 30 (¥16/kWh)	50 (¥26/kWh)	100 (¥52/kWh)	200 (¥104/kWh)	300 (¥156/kWh)
① Base case (10% of power supply mix) (101.1B kWh/year)	100%	+ ¥113	+ ¥477	+ ¥1,387	+ ¥3,207	+ ¥5,027
	50%	+ ¥57	+ ¥239	+ ¥694	+ ¥1,604	+ ¥2,514
	20%	+ ¥23	+ ¥95	+ ¥277	+ ¥641	+ ¥1,005
② Ref scenario (65% of power supply mix) (129GW[1] 652.8B kWh/year)	100%	+ ¥730	+ ¥3,082	+ ¥8,960	+ ¥20,718	+ ¥32,475
	50%	+ ¥365	+ ¥1,541	+ ¥4,480	+ ¥10,359	+ ¥16,237
	20%	+ ¥365	+ ¥616	+ ¥1,792	+ ¥4,144	+ ¥6,495
③ One plant (1% of power supply mix) (1GW 7B kWh/year)	100%	+ ¥8	+ ¥33	+ ¥96	+ ¥222	+ ¥349
	50%	+ ¥4	+ ¥17	+ ¥48	+ ¥111	+ ¥174
	20%	+ ¥2	+ ¥7	+ ¥19	+ ¥44	+ ¥70

(Estimated only for fuel price difference. Does not include equipment and other costs related to replacement)

Looking again at scenarios for hydrogen conversion, we see that different assumptions produce a range of household prices. For an average family of four using 350 kWh per month, the current monthly burden is ¥14,309. Assuming a range of hydrogen conversion rates, we can calculate a range of additional costs.

1: Total output of coal- and LNG-fired power generation in Japan as of April 2023
Source: TEPCO (1/2); TEPCO (2/2); JEPX; METI (1/3); METI (2/3); METI (3/3)

Example of monthly consumption expenditure

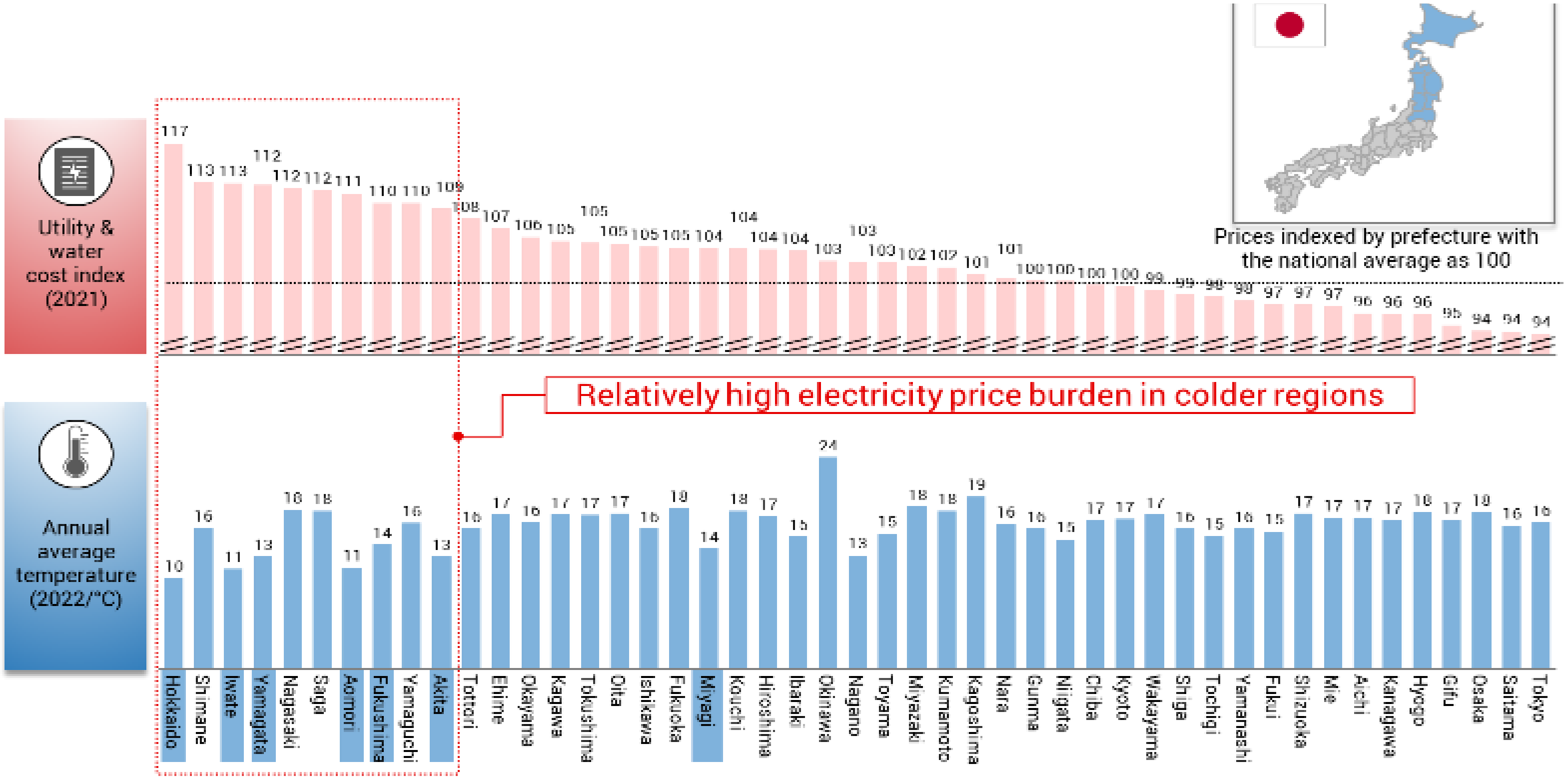
Type of consumption		Monthly consumption expenditure	
Hobbies/ beatify/ personal preference	Gym member-ship fee	¥13,000 (month)	(Lack of exercise→ positive expenditure)
	High-grade cosmetics	¥30,000(1 bottle)	(Beauty→ positive expenditure)
Food & beverages	Coffee at CVC	¥3,000(¥150/cup × 20 days)	
	Lunch	¥10,000(¥500/time × 20 days)	
Electricity price (Current + H_2 replacement impact)		¥23,270 (= ¥14,309 + ¥8,960)[1]	

People tend to be governed by habits
While electricity price increases are hard to accept, people willingly pay for these segments

Very few people would be happy to hear that electricity prices are set to increase, even if it means lower carbon emissions. However, the additional amounts payable is often not so different from normal daily expenditures such as gym memberships or cosmetics. Thus, we should expect that achieving real change will require tackling habits that have formed over a long period.

1: Assuming a hydrogen price of ¥100/Nm^3 and the replacement of all thermal power generation

(Ref) Regional differences in the fluctuation impact by electricity prices



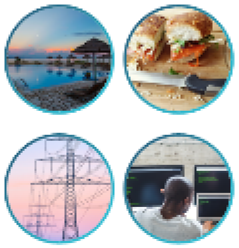
In Japan, there is no unified electricity price across the country. Instead, prices vary by region. Areas with higher electricity demand tend to have higher prices, especially in regions with extreme temperatures—either very cold or very hot—due to increased air conditioning needs. In colder regions, utilities (including electricity) make up a larger portion of household expenses, making these areas more vulnerable to electricity price fluctuations. Ensuring stable electricity supply and minimizing price volatility, especially during severe weather, is crucial to safeguarding the safety of residents in these regions.

Source: The Nikkei; Statistics Bureau, Ministry of Internal Affairs and Communications of Japan

Brands offering high added-value products / services

High brands supporting a pleasant price pass-through (high function?)

RE 100

Type of business			Examples of brands offering high added value			
Consumer goods		Fashion	BURBERRY (Fashion)	Apple (Electric appliance)	Sony (Electric appliance)	Nestle (Food & beverage)
		Beauty/cosmetics	CHANEL (Fashion/Beauty/cosmetics)	Nokia (Electric appliance)	Nikon (Electric appliance)	Unilever (Household items)
		Electric appliances	…			
		Food & beverage/household items				
		⋮				
Services		Accommodation	Google (IT/software)	Bloomberg (IT/software)		Adobe (IT/software)
		Food & beverage beverage	Microsoft (IT/software)	Meta (IT/software)	Airbnb (Accommodation)	Vodafone (Telecommunication)
		Telecommunication	…			
		IT/software				
		⋮				

We tend to spend “feel-good” money on fashion, beauty, electronics, accommodation, food, communication, and IT. However, there is no sentiment associated with electricity costs. Essential services are sometimes taken for granted and electricity price rises lead to dissatisfaction. Revisiting this habit, or closely aligning price pass-through with services from high-value-added industries where we already make feel-good expenditures may be an effective antidote.

Source: Climate Group RE100

Estimation of the impact of the hydrogen replacement in Japan (additional social cost)

(Estimated only for fuel price difference. Does not include equipment and other costs related to replacement)

Assumed annual electricity consumption 1.01 tn kWh (Total domestic power generation in FY2022)

Small Social cost Large

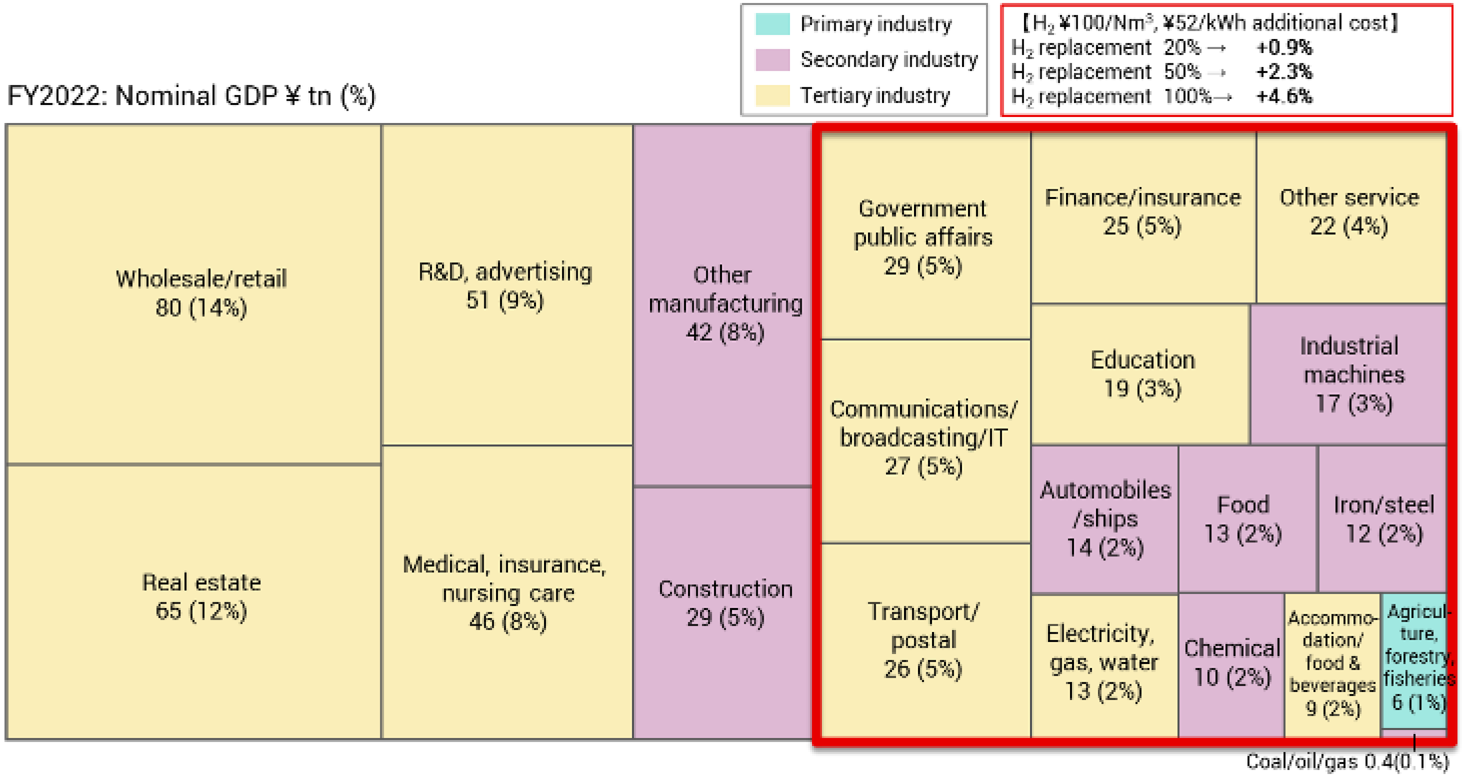
Low — High

GDP[1]: ¥558tn	(¥/month)	Hydrogen price (¥/Nm³)				
Replacement scale	Hydrogen replacement	30 (¥16/kWh)	50 (¥26/kWh)	100 (¥52/kWh)	200 (¥104/kWh)	300 (¥156/kWh)
❶ Base case (10% of power supply mix)	100%	+¥0.3tn (0.1%)	+¥1tn (0.2%)	+¥4tn (0.7%)	+¥9tn (1.7%)	+¥15tn (2.6%)
	50%	+¥0.2tn (0.03%)	+¥1tn (0.1%)	+¥2tn (0.4%)	+¥5tn (0.8%)	+¥7tn (1.3%)
(101.1B kWh/year)	20%	+¥0.1tn (0.01%)	+¥0.3tn (0.05%)	+¥1tn (0.1%)	+¥2tn (0.3%)	+¥3tn (0.5%)
❷ Ref scenario (65% of power supply mix)	100%	+¥2tn (0.4% of GDP)	+¥9tn (1.6%)	+¥26tn (4.6%)	+¥60tn (10.7%)	+¥94tn (16.8%)
	50%	+¥1tn (0.2%)	+¥4tn (0.8%)	+¥13tn (2.3%)	+¥30tn (5.3%)	+¥47tn (8.4%)
(129GW[2] 652.8B kWh/year)	20%	+¥0.4tn (0.1%)	+¥2tn (0.3%)	+¥5tn (0.9%) Refer to the later page	+¥12tn (2.1%)	+¥19tn (3.4%)
❸ One plant (1% of power supply mix)	100%	+¥20bn (0.004%)	+¥0.1tn (0.02%)	+¥0.3tn (0.05%)	+¥1tn (0.12%)	+¥1tn (0.2%)
	50%	+¥10bn (0.002%)	+¥50bn (0.01%)	+¥0.1tn (0.02%)	+¥0.3tn (0.06%)	+¥1tn (0.1%)
(1GW 7B kWh/year)	20%	+¥5bn (0.001%)	+¥20bn (0.003%)	+¥0.1tn (0.01%)	+¥0.1tn (0.02%)	+¥0.2tn (0.04%)

Of course, other scenarios are possible. For example, the government may bear some of the cost of transitioning. This would be where the government fully covers the cost of hydrogen replacement. For example, if hydrogen is priced at 100 yen/Nm^3 (52 yen/kWh) and Japan replaces 20%, 50%, or 100% of its thermal power with hydrogen, the cost increase to the Treasury would amount to 5 trillion yen, 13 trillion yen, and 26 trillion yen, respectively. This is equivalent to 1-5% of Japan's GDP of 558 trillion yen.

1: Total output of coal- and LNG-fired power generation in Japan as of April 2023
Source: TEPCO (1/2); TEPCO (2/2); JEPX; METI (1/3); METI (2/3); METI (3/3); Cabinet Office of Japan

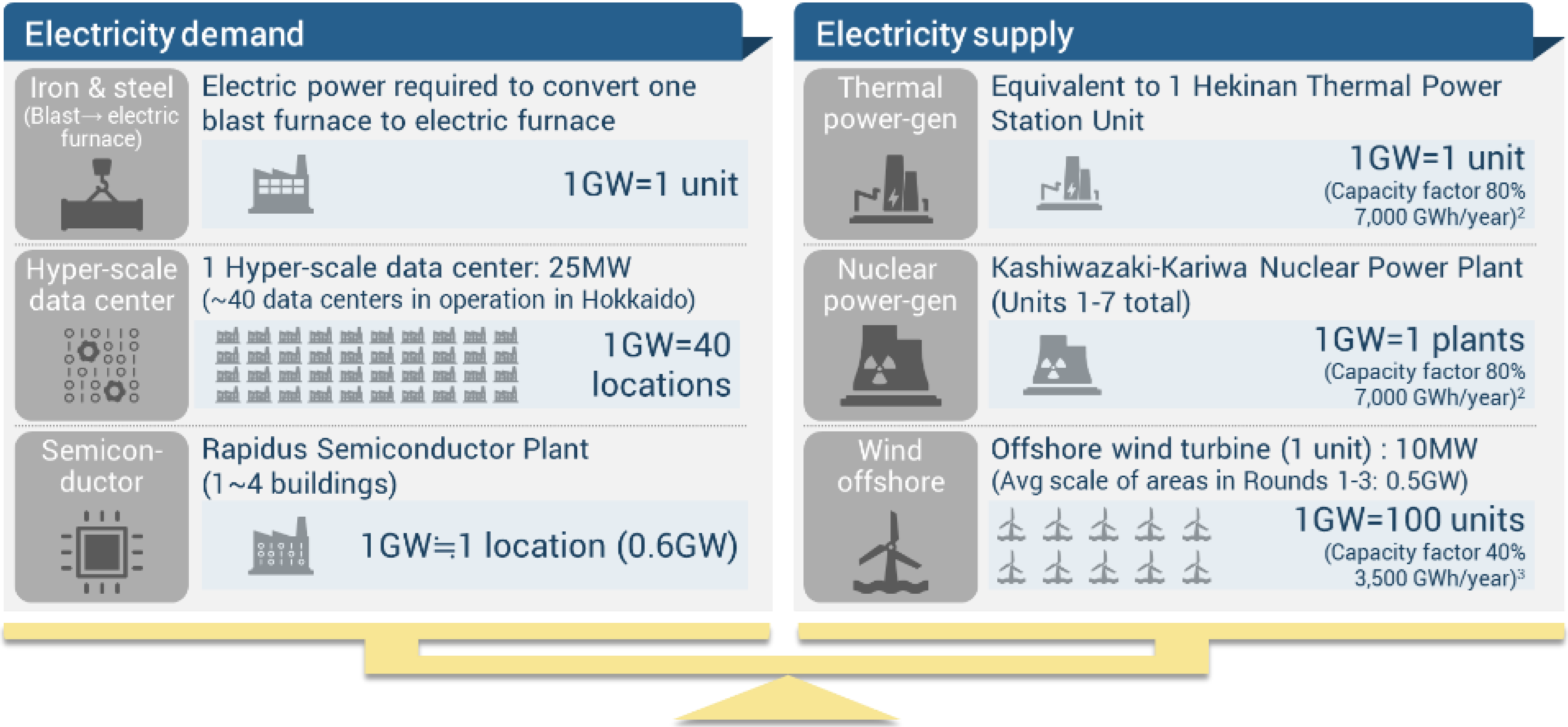
(Ref) Japan's GDP map by industry



An amount of 1-5% of GDP is equivalent to the value generated by segments such as communications, transportation, finance, education, and automobiles. Stakeholders across the Japanese economy must consider whether this is a price worth paying, given that there is an imperative to achieve CN. Options must be maintained as options, scaling must be pursued as scaling, and there must be consideration of policies and financial support that align with the maturity of the business and the development status of the technology.

Note: Names of each economic activity are based on the Cabinet Office's classification of economic activities, focusing on representative economic activities
Source: Cabinet Office

Implications of 1GW of electricity



1: The average value of 9 sea areas, excluding the offshore area of Goto City, Nagasaki Prefecture (floating offshore wind), is adopted
2: 1GW x 24h x 365days x 80% ≒ 7,000GWh; 3: 1GW x 24h x 365days x 40% ≒ 3,500GWh
Source: JERA; TEPCO; The Denki Shimbun; Nippon steep; Softbank; The Hokkaido Shimbun; METI (as of May 2024)

Implications of 1GW of electricity

Below, we gather some examples of demand and supply to understand what 1GW means in practical terms:

On demand:

1. When a blast furnace in the steel industry is converted to an electric arc furnace, the electric arc furnace requires 1GW of power, equivalent to one furnace.

2. Forty hyperscale data centers collectively require 1GW of power.

3. A major semiconductor factory has a demand of approximately 1GW.

On supply:

4. A large thermal power plant, which currently has a 20% ammonia replacement, generates 1GW per unit.

5. A nuclear power plant also generates 1GW per plant. Offshore wind power (1GW) is equivalent to 100 turbines.

Japan's initiatives and progress (progress and stagnation)

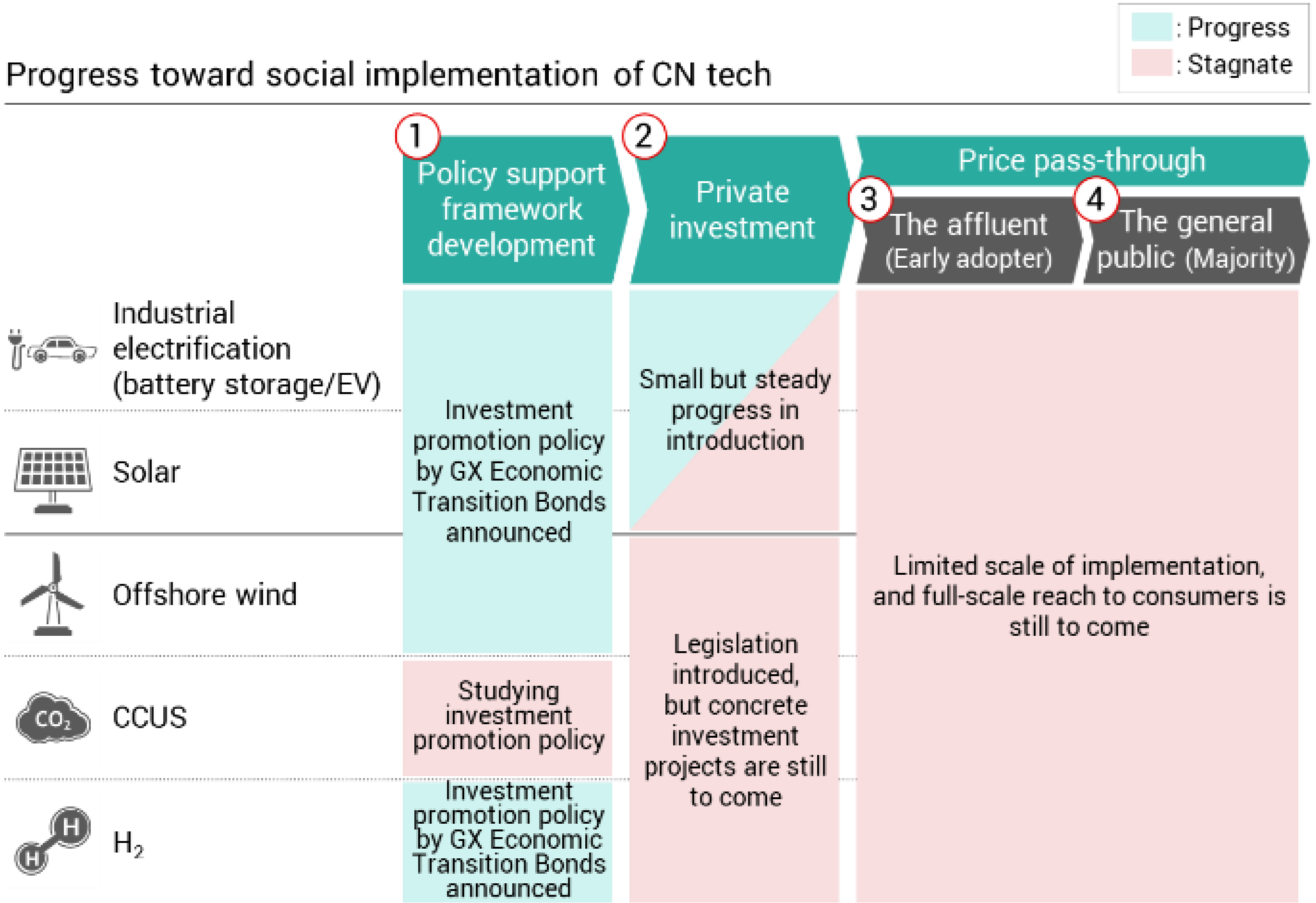
CN policy approach overview

【Approach】
Consensus-driven x public-private collaboration (multi-industry collaboration)

【Purpose】
Achieve GX (Green Transformation)

- The goal is to address climate change, improve energy self-sufficiency/ industrial competitiveness and boost economic growth

Progress toward social implementation of CN tech



Japan's initiatives and progress (progress and stagnation)

In summary, Japan is taking a consensus-driven approach to CN through industry-government collaboration. The policy support framework is secured through GX economic transition bonds, and support frameworks are being developed in areas such as electrification, solar power, offshore wind power, and hydrogen. Japan’s policy also incorporates P/L support, B/S support, and their combination.

Policy implementation is about one year behind the U.S. and Europe and the effects are still being measured, but the development of support frameworks is progressing smoothly. Private investment is also beginning to progress in storage batteries, solar power, and EVs.

CN requires both the CN goal (vision) and business viability (reality). To achieve the vision for CN, it is essential to (1) expand technological options (optionality). Within these options, pursuing business scale requires (2) ensuring long-term business predictability and economic viability. To enhance long-term business predictability, it is crucial to provide consumers with the right information and promote (3) end-user awareness and understanding regarding cost pass-through.

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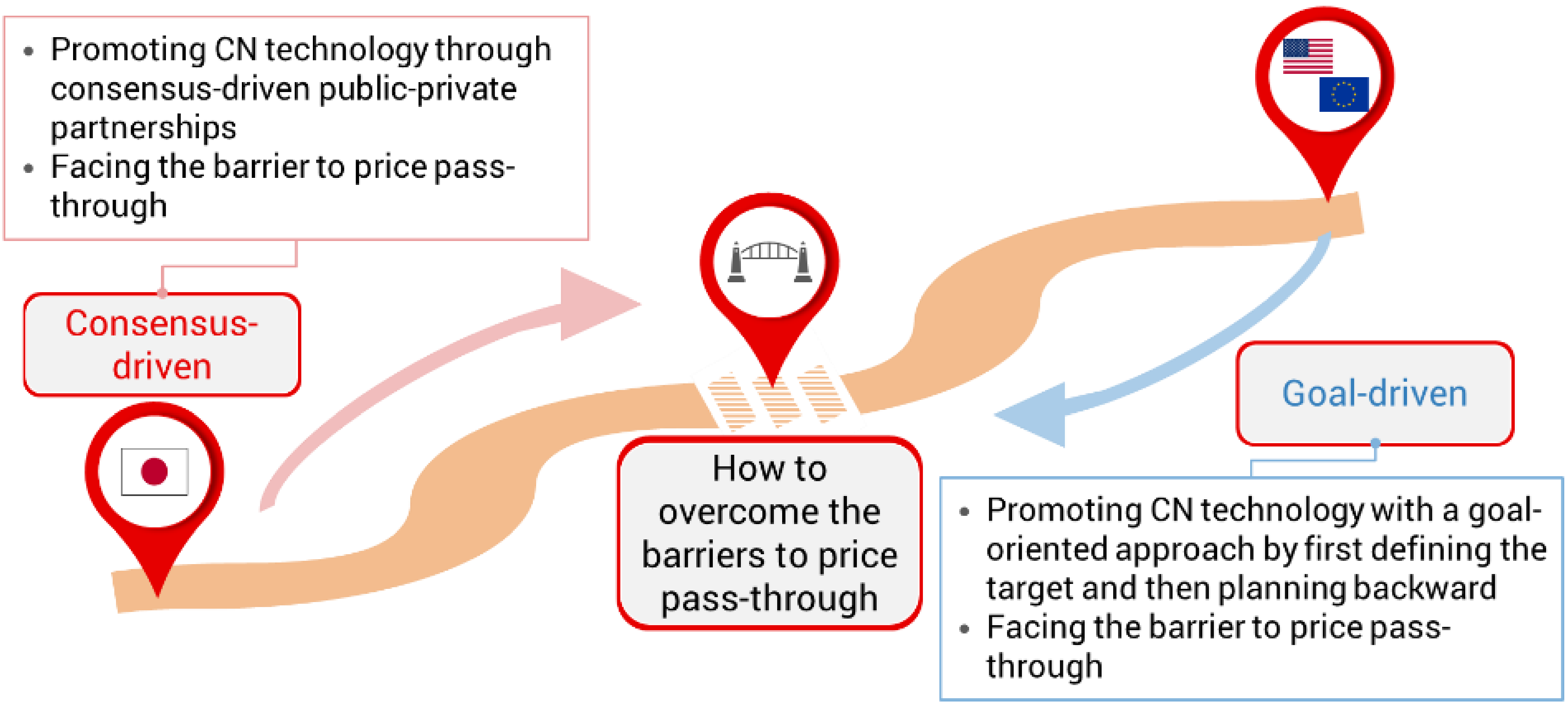
4. Points for further discussion

■ **Challenges in approach for CN faced by each country/region**

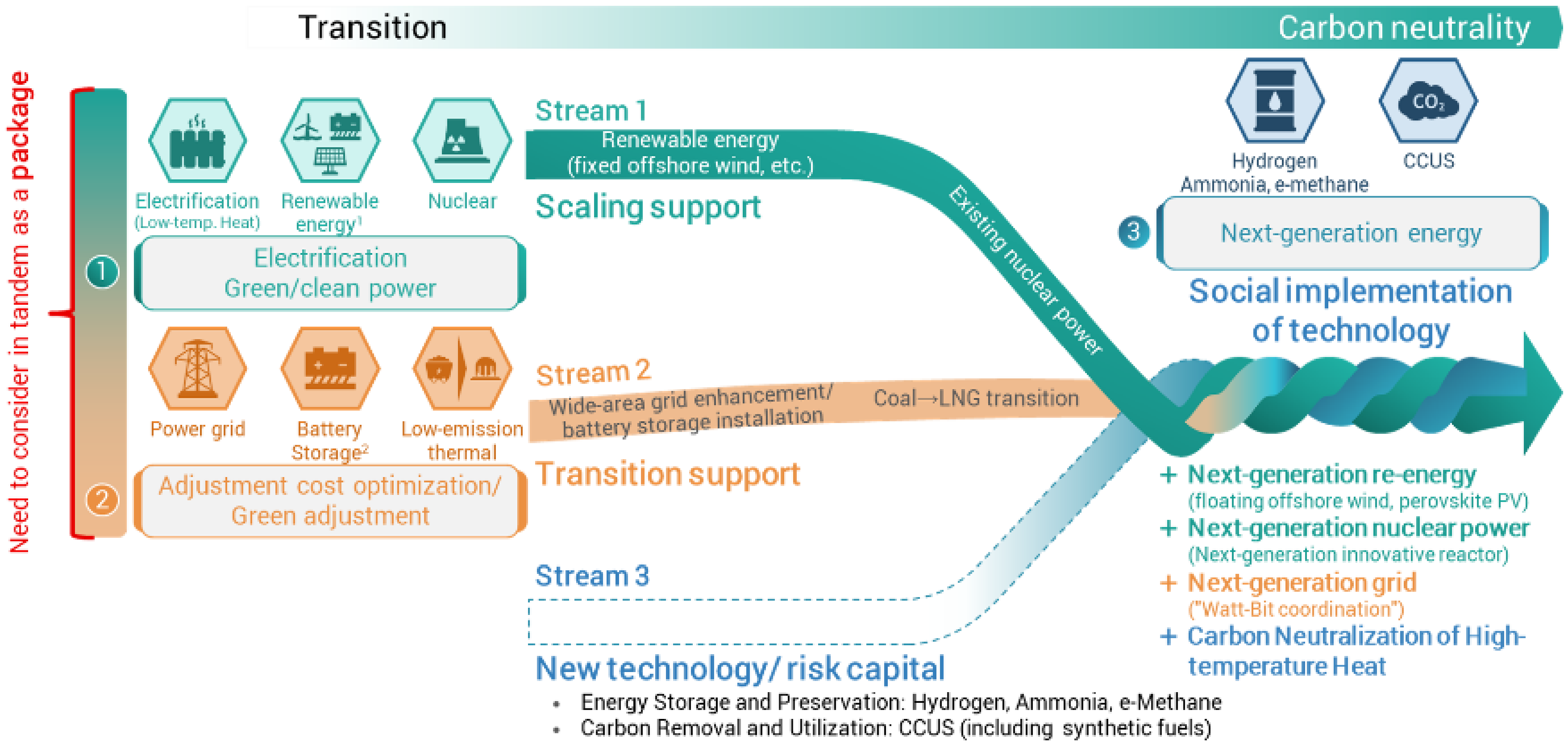


Challenges in approach for CN faced by each country/region

Globally, countries are facing the same challenges in pursuing their CN goals, despite slightly different approaches in each region. Europe tends to focus on regulations and targets, the U.S. on incentives and markets, and Japan on industry-government collaboration (consensus-driven), and these variations play out in the specific ways countries are proceeding. Differences in language and legal frameworks also have an impact. Still, the common goal remains unchanged. Looking ahead, we believe the world will require mutual respect for each other’s approaches, careful peer analysis of other countries’ use cases, and the willingness to apply lessons learned to domestic policies, as well as share domestic successes with the world.

Whether goal-driven or consensus-driven, the implementation of new CN technologies comes with a high cost burden and a price pass-through barrier. The ultimate question is how to overcome this barrier through international cooperation.

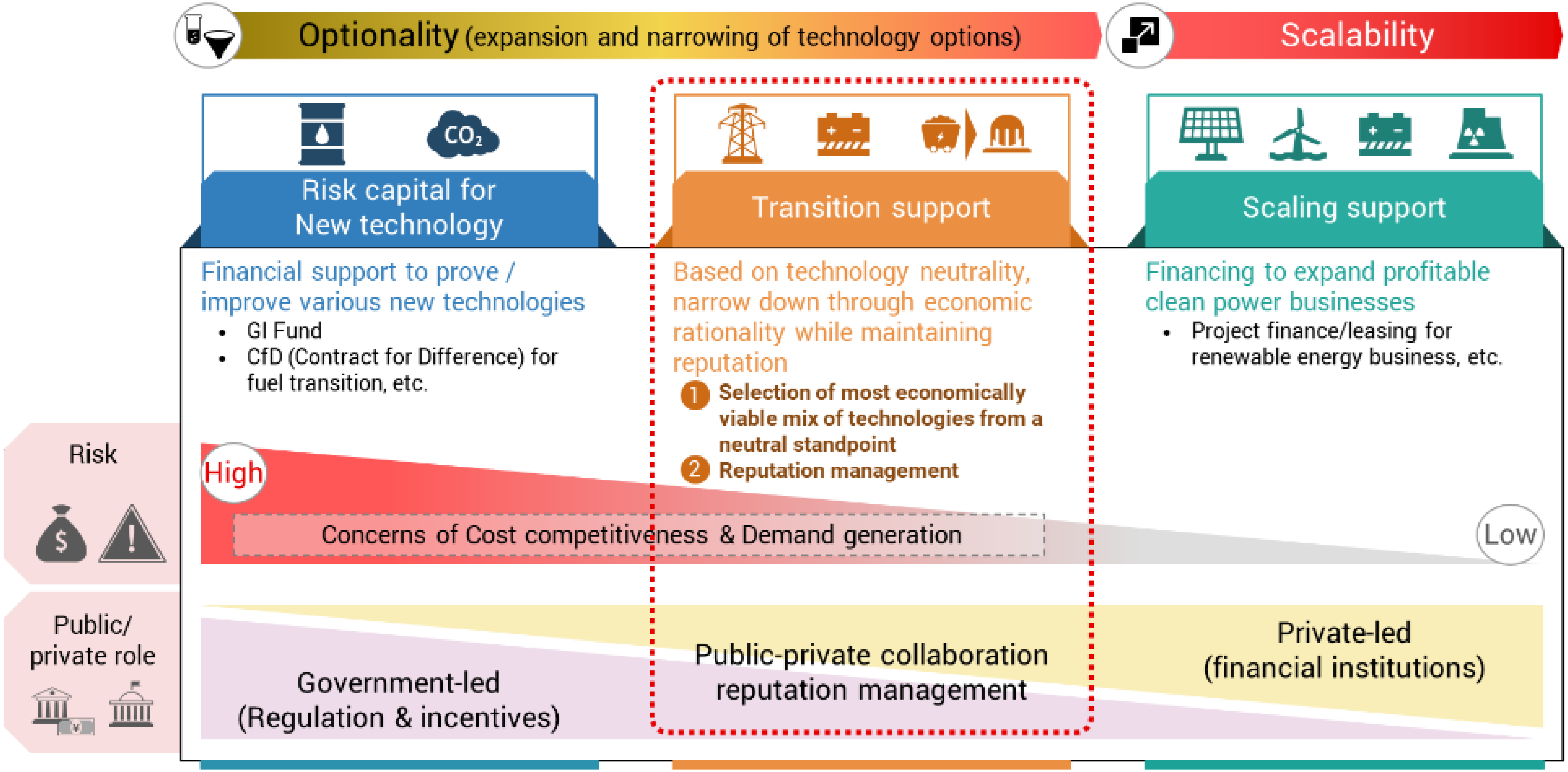
Energy transition process for CN



CN technologies relating to electricity and heat are categorized into Stream 1 for electrification/clean and green energy, Stream 2 for absorption and adjustment to achieve renewable energy variability and Stream 3 for the social implementation of next-generation technologies.

1: Including energy storage systems with renewable energy; 2: Grid energy storage systems

Types of financing to achieve the transition

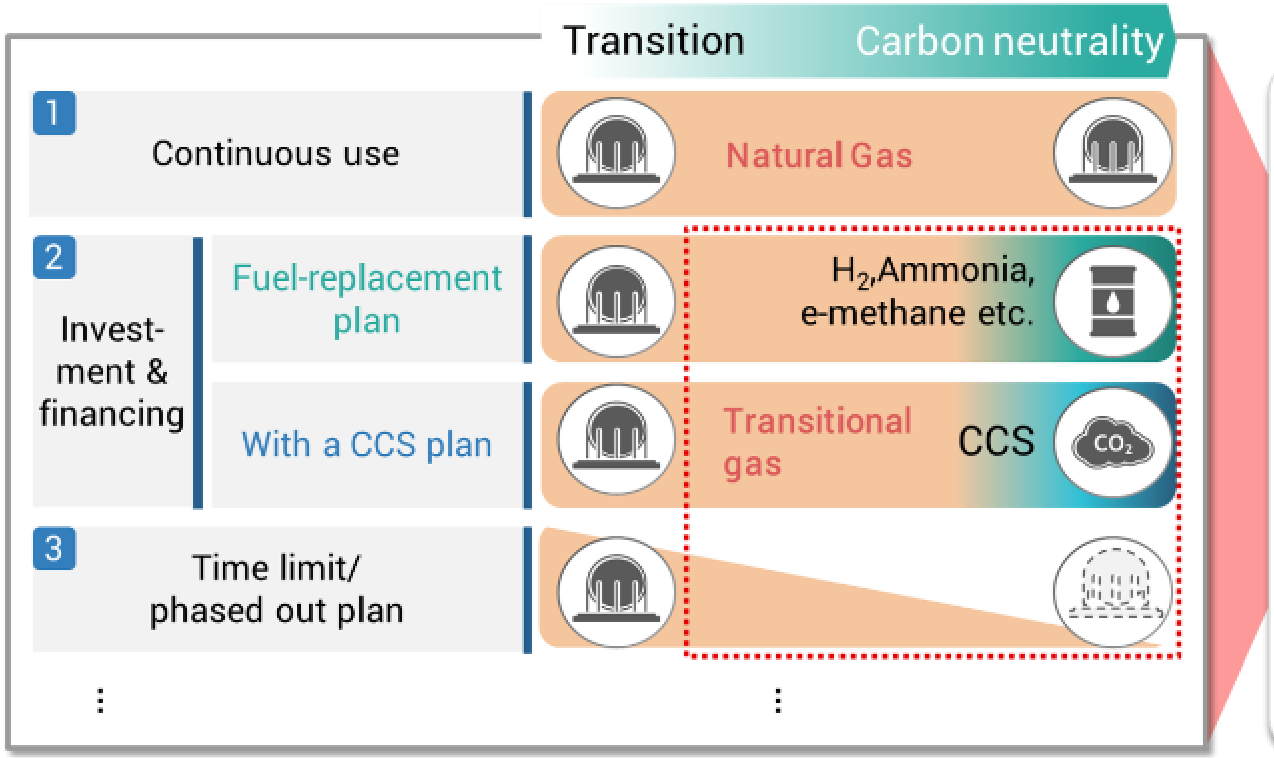


Types of financing to achieve the transition

Based on the classification of Streams 1 to 3, we can consider the nature of policy support and finance. In the first stream, government-led policy support frameworks (B/S support and P/L support) are effective. In Japan, the GI Fund (B/S support), price gap compensation for hydrogen and ammonia (P/L support), and infrastructure support (B/S support) are driving technology development. In the next stream, private finance is supporting scaling. Various financial products such as project finance and leasing are available. This is where private financial institutions can ramp up their involvement.

There is also a need for transition support. Stream 1 and Stream 2 technologies complement one another, enabling emissions reduction and the maintenance of electricity grid quality. In Stream 2, there can be benefits in seeing different technologies as a single integrated proposition in terms of financial support, as they are all adjustment measures and are thus comparable. In this scenario, efficiency and price determine optimal capital allocation. This may be best achieved through industry-government collaboration.

Types of finance for gas transition



- What would it take for **gas to be internationally recognized as a transitional gas?** (need further concretization of the word "no lock-in gas")
- **What needs to be discussed in the international financial arena to maintain our reputation?**

Need to jointly tackle through public-private partnerships

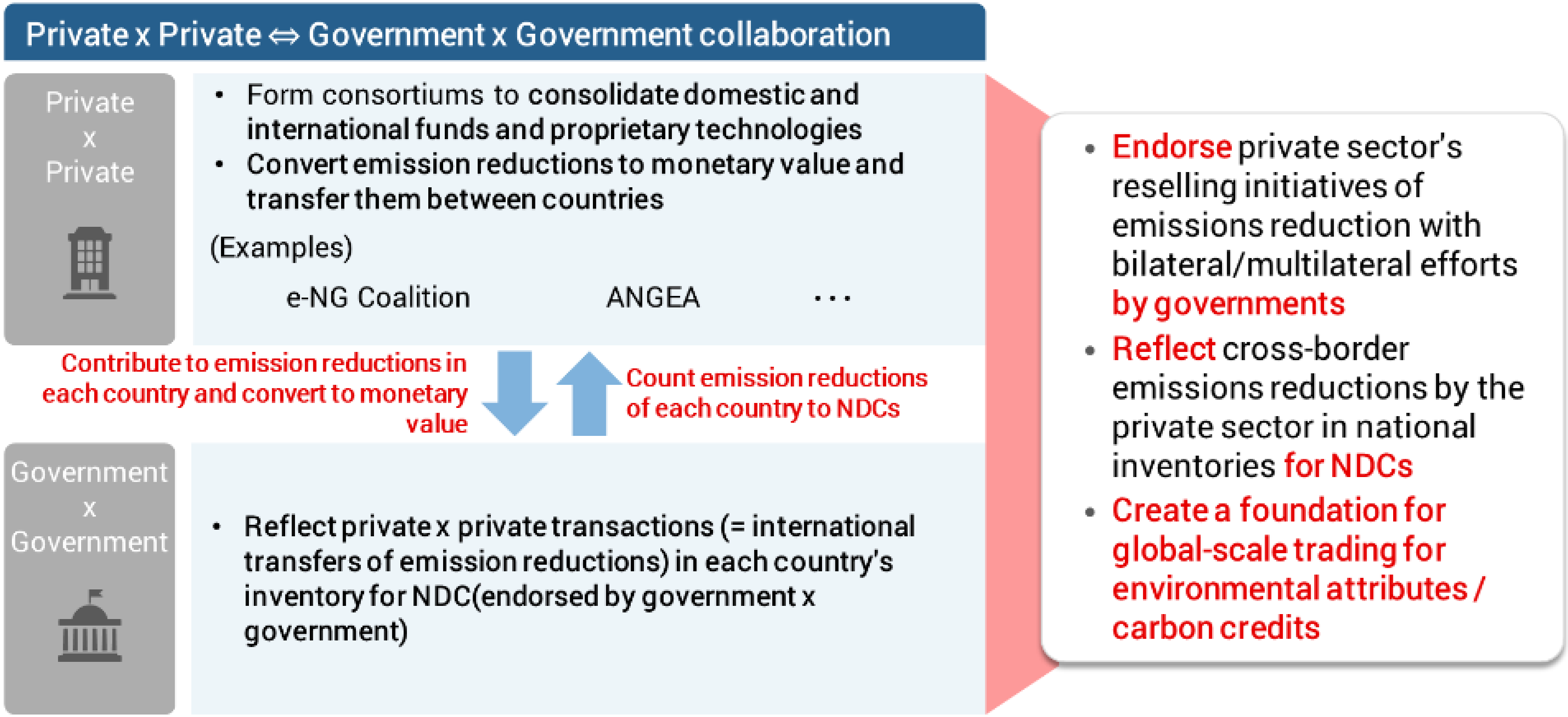
Need to discuss within the international financial community:
"Can you finance a gas project?"

Types of finance for gas transition

Another point is reputational issue. The shift from coal to gas and low-emission thermal power is seen by some as a realistic transition, while others see it as a lock-in. It is crucial to discuss at international financial initiatives to ensure that financing can be provided for necessary transitions in a country or region without facing reputational impact.

Taking the specific example of the judgements required, switching from coal to gas reduces CO_2 emissions by 65% but does not achieve zero emissions. Perhaps hydrogen can replace it or CCS could be added. It may be possible to limit its use in some way. By considering these and other options regularly, we might find a path to financing. Judgements will probably be best made collectively and internationally, so that the overall approach is refined.

Significance of forming consortiums for natural gas transition



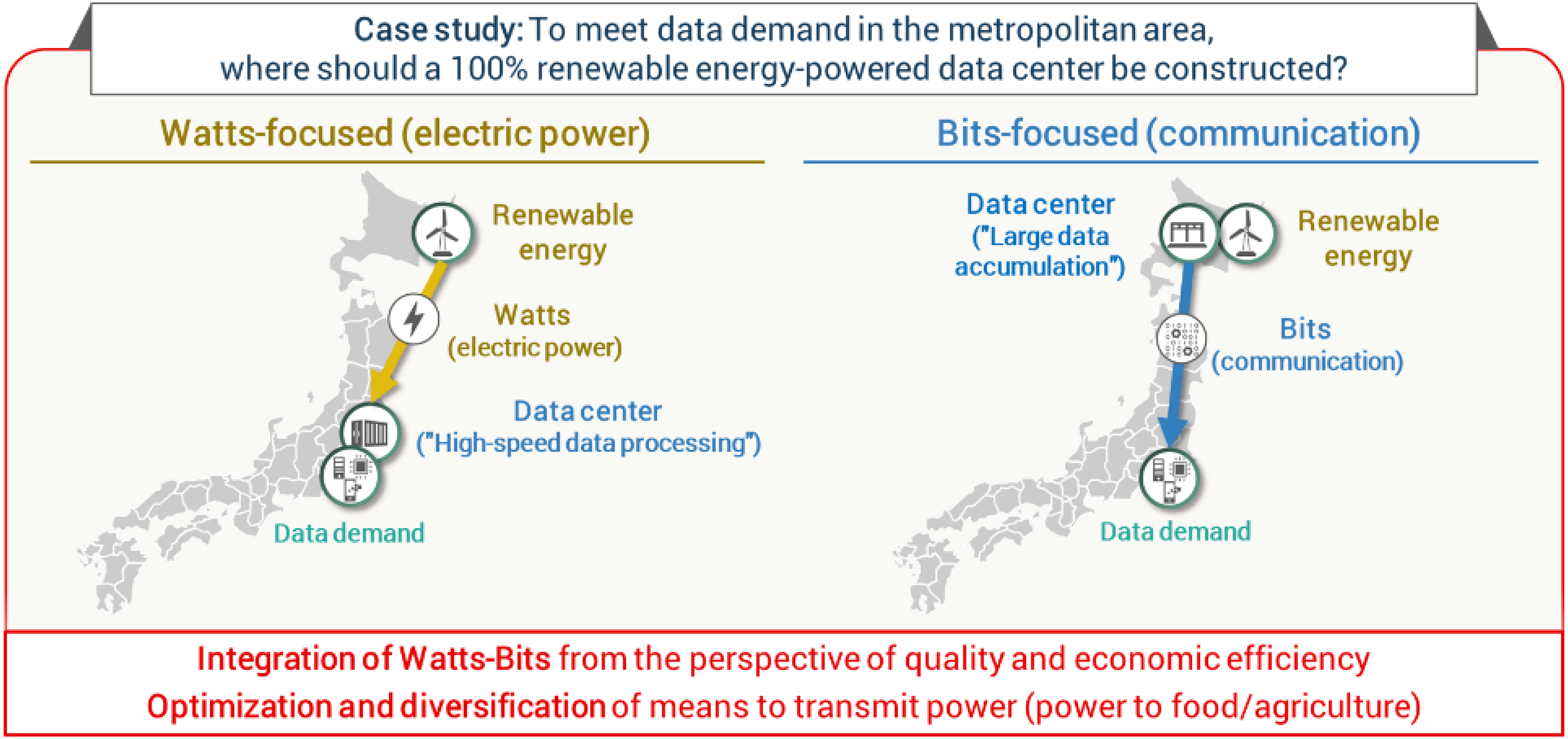
Source: Tokyo Gas; Asia Natural Gas & Energy Association

Significance of forming consortiums for natural gas transition

It will be important for governments to endorse private-sector initiatives such as the e-NG Coalition and ANGEA through collaboration among industry players, government, academia, and finance. Suppose companies from countries A and B successfully implement low-emission technology in country A with combined technology and capital, and the emission reduction effect in the form of environmental attributes is purchased by a company from country B in a private transaction.

Could the emission reduction effect be reflected in country B's GHG inventory for NDC instead of country A's? Or vice versa? By advancing private sector initiatives, governments can lay foundations for the global trading of carbon credits in future.

Matching power supply and demand using integrated Watts-Bits

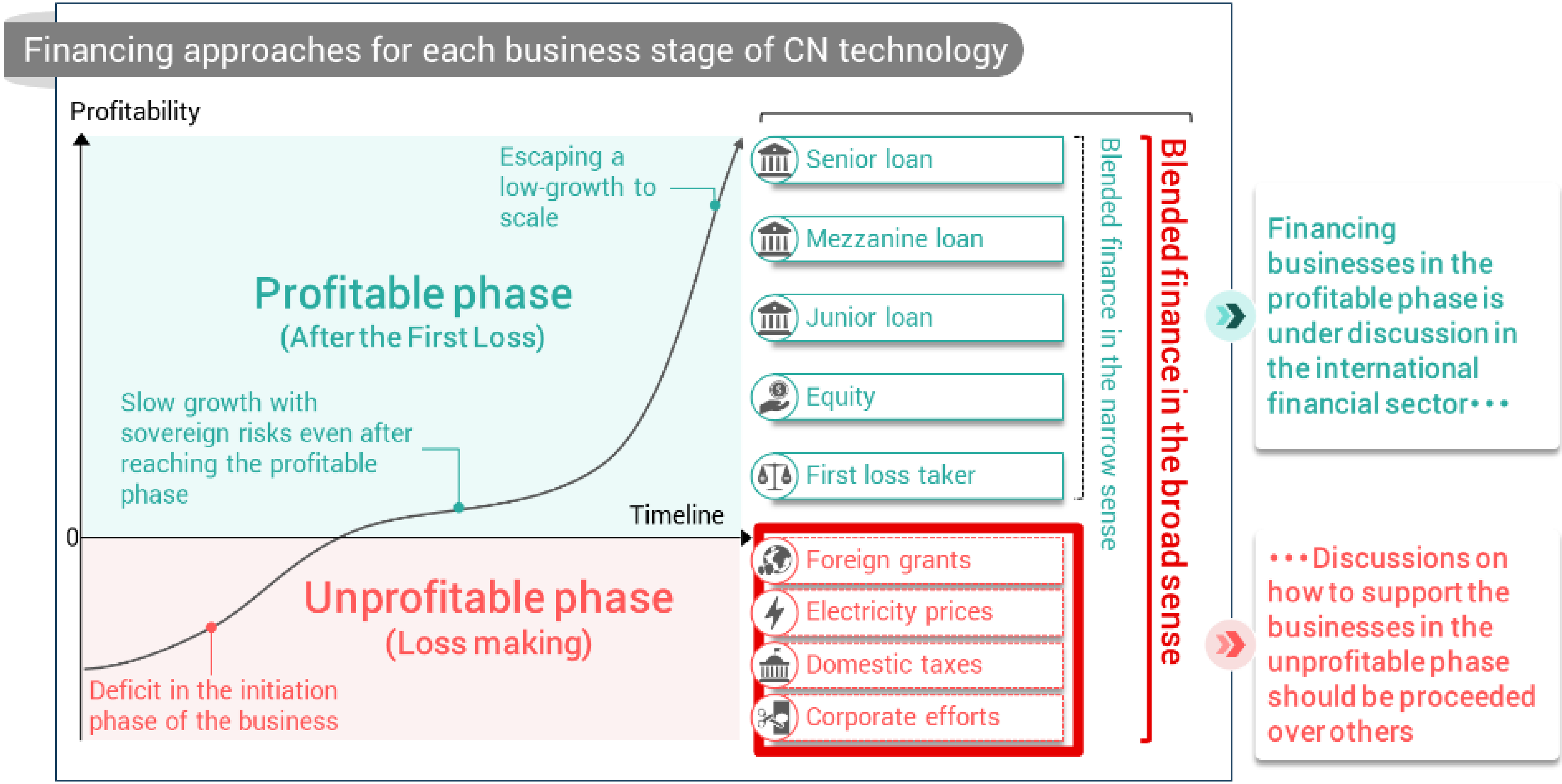


Source: [TEPCO PG]() (2024/7)

Matching power supply and demand using integrated Watts-Bits

An electricity company customer told us a story about the merits of integration based on Watts and Bits, or Watts-Bits. With demand for data centers expected to rise in the future, we expect to see a rise in demand for renewable energy. Therefore, the question is how to connect the data center's demand location and the renewable energy generation. One approach is to connect the renewable energy power plant and the data center's demand location through electricity transmission lines. This is the idea of transporting electricity. Another approach is to install the data center next to the renewable energy power plant and transport data through communication networks from the data center. This is the idea of transporting data by communication. Whether to transport electricity or data, effectively advancing GX requires an integrated perspective to determine the optimal choice between watts and bits.

Global discussion on blended finance

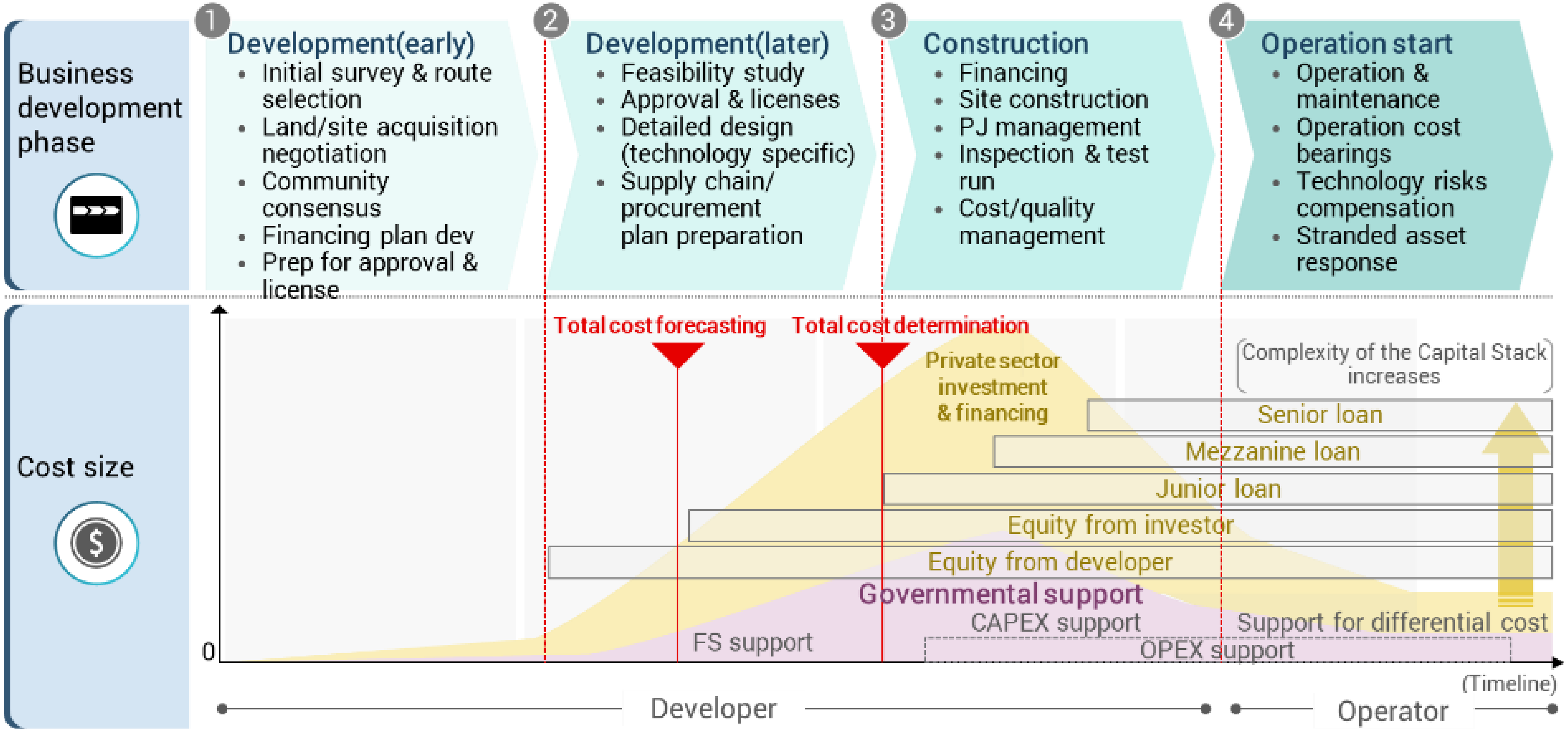


Global discussion on blended finance

To achieve multilateral financial cooperation globally, it will be essential for governments, financial institutions, and private investors to collaborate in creating a mechanism for capital intermediaries to access difficult-to-reach countries and projects. In this way, projects in higher-risk countries can access investment. The key is to combine government financial institutions as first-loss takers with equity from investors, and junior, mezzanine, and senior financing in a multilateral collaboration. In short, we believe that blended finance can play a critical role.

However, it is also important to focus on the fundamentals. Financing a red-ink project will only increase the red ink. First, there must be a mechanism to turn red ink into black ink, then apply financial leverage. It is important to separate these two. Turning red ink into black ink may involve considering subsidy frameworks (non-repayable funding) at home and abroad, implementing price pass-through through of electricity prices and taxes in the project country, or introducing mechanisms in addition to corporate technological innovation and cost reduction efforts. It is essential to consider these mechanisms in conjunction with the broad concept of blended finance.

Finance types by business development phase



Finance types by business development phase

In blended finance, the capital stack determines the blend allocation. This requires participants to categorize projects by stage—early development, late development, construction, and operation start—with the capital stack growing as the stages progress. Initially, governmental organizations take the capital risk, for example through subsidies. Afterwards, the investor pool expands, with new levels of the capital structure added. Finally, when operations begin, the baton is passed to pension funds, life insurance companies, and other long-term stable investors with low capital costs.

The skill of financial institutions lies in the art of blend allocation, but in the early development stage, developers usually start the project by conducting investigations, securing routes, obtaining permits, and determining what business to implement. As the work progresses and the burden of assessment costs increases, the investor pool expands. The capital stack gradually grows over time.

(Conclusion) Recap on the purpose of this Whitepaper

The purpose of this Whitepaper is to **start the discussions on some of the important agenda for the international financial community with some space for consideration** (rather than reaching to conclusions)

1. **How can the transition technologies be financially supported? (with wide options)**
2. **How can the business without economic viability be supported? (role of financial institutions for scaling)**
3. **Are the individual roles of policy support and private investment well understood by technology stages?**

In advancing these discussions, it is essential to objectively measure direct impact of decarbonization and to identify **new values**

(Conclusion) Recap on the purpose of this Whitepaper

To summarize, regardless of the policy approach in each region, we find that the price pass-through barrier is a global issue. Some technologies appear to be attracting private investment while others are not. Inflation stands as a barrier to investment and this is a common challenge in all countries.

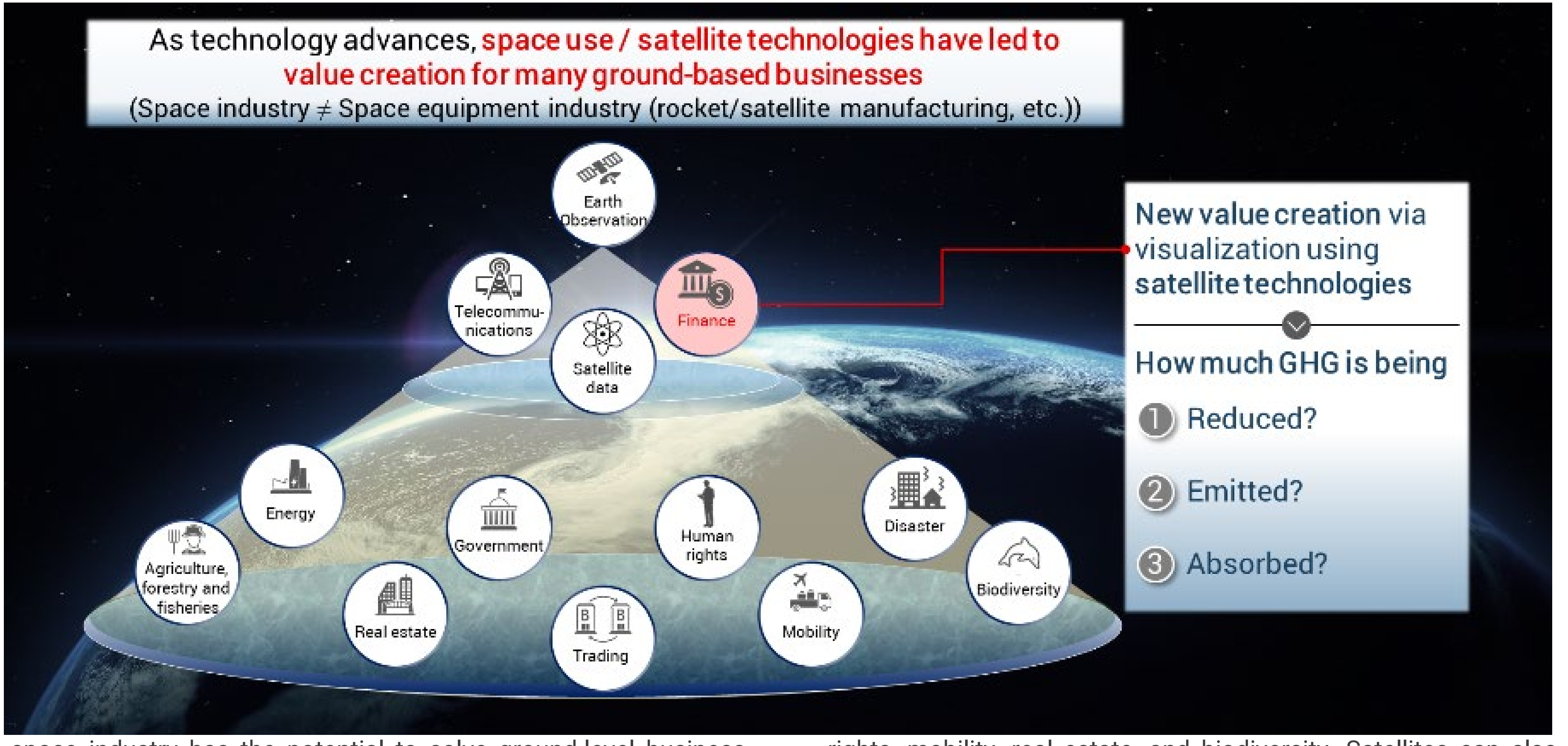
Next, financial support is required depending on the project stage, with the role of financial institutions varying depending on the stage. Most importantly, we find that to advance transition support, frameworks that lack clear language should be thoroughly discussed through international cooperation. Key questions for market participants:

1. Based on local/regional characteristics and from a technology-neutral perspective, what kind of transition support is required to achieve CN? Specifically, under what conditions can financial support be provided for the transition from coal to gas and low-emission fuels?
2. How do we support projects that lack economic viability? How do we combine policy support, subsidies, private efforts, domestic price pass-through, and consumer awareness to support projects through international cooperation?
3. Are the appropriate choices being made by comparing the technologies across and within different categories rather than looking at each technology individually? In adjusting renewable energy variability, what combination of storage batteries, transmission lines, and low-emission thermal power is most effective and economical? Should we send electricity through transmission lines or send data through communication cables?
4. Most importantly, it is crucial to know how much CO_2 we are emitting, how much CO_2 we are absorbing, and whether emission reductions are being achieved. To support these endeavors, the space industry may provide technology that is helpful (see next chapter).

These challenges must be recognized by everyone involved and addressed step by step so that collaborative solutions can be found.

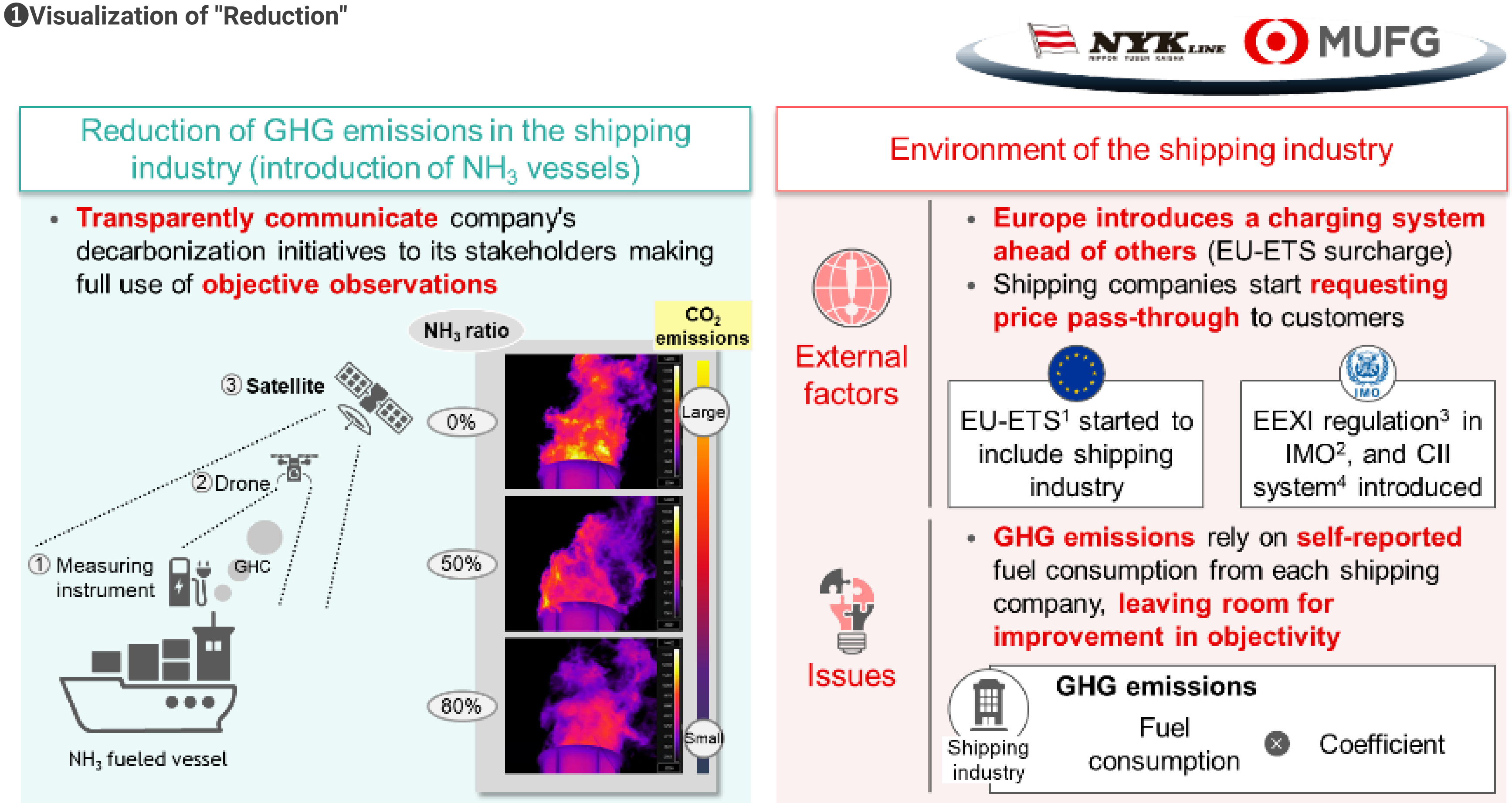

Objective and neutral data
with traceability

Objective and neutral traceable data



The space industry has the potential to solve ground-level business challenges. Indeed, satellite data and data communication environments are already providing solutions in energy, agriculture, forestry and fisheries, construction, administration, trading, human rights, mobility, real estate, and biodiversity. Satellites can also help companies gauge greenhouse gas reductions, emissions, and absorption.

❶Visualization of "Reduction"



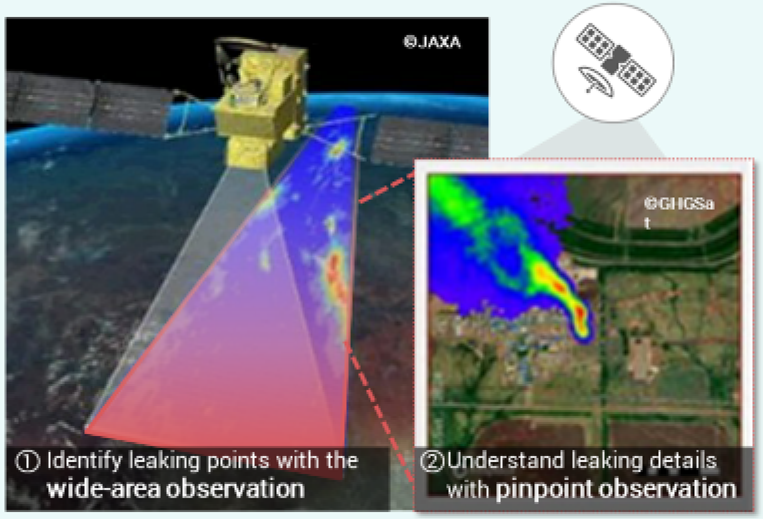
Among examples of space use cases, NYK and MUFG are piloting a system to monitor the correlation between ammonia substitution ratios and CO_2 emissions when ship fuel is replaced with ammonia. With EU ETS taxation on the horizon, satellite data has the potential to reduce the time and effort required for shipping companies to calculate emissions but also support objectivity.

1.European Union Emission Trading Scheme; 2. International Maritime Organization; 3. Energy Efficiency Existing Ship Index; 4. Carbon Intensity Indicator;
Source: Collaborative demonstration of Nippon Yusen, Nagoya Electric Works, Shimizu Corp., ArkEdge Space, Sunflame, and MUFG

❷Visualization of "Emission"

GHG emission monitoring of LNG plants/pipelines

- Linking Japan's core large satellites with small commercial satellites from overseas to ① wide-area observation and ② pinpoint observation



Trends in methane emissions management

External factors

- International discussions/initiatives underway to manage methane emissions in LNG value chain

UN environment programme MMRV[1] framework in OGMP[2] 2.0 etc.	JP-Korea collaboration in LNG value chain

Issues

- Earth Observation is attracting global attention including COP28 as one of the objective observation methods
- Need for Japan to actively participate in building a mechanism based on international collaboration

In an example of utilizing satellite data to measure how much greenhouse gas is being emitted. SDS, Mitsubishi Electric, GHGSat, and MUFG are currently conducting a project to monitor methane leakage from LNG plants and pipelines, potentially allowing for early identification and fixing of leaks. Moreover, utilization of satellite data has been highlighted at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP), with Japan asked to contribute to global framework development by presenting international use cases for satellite data.

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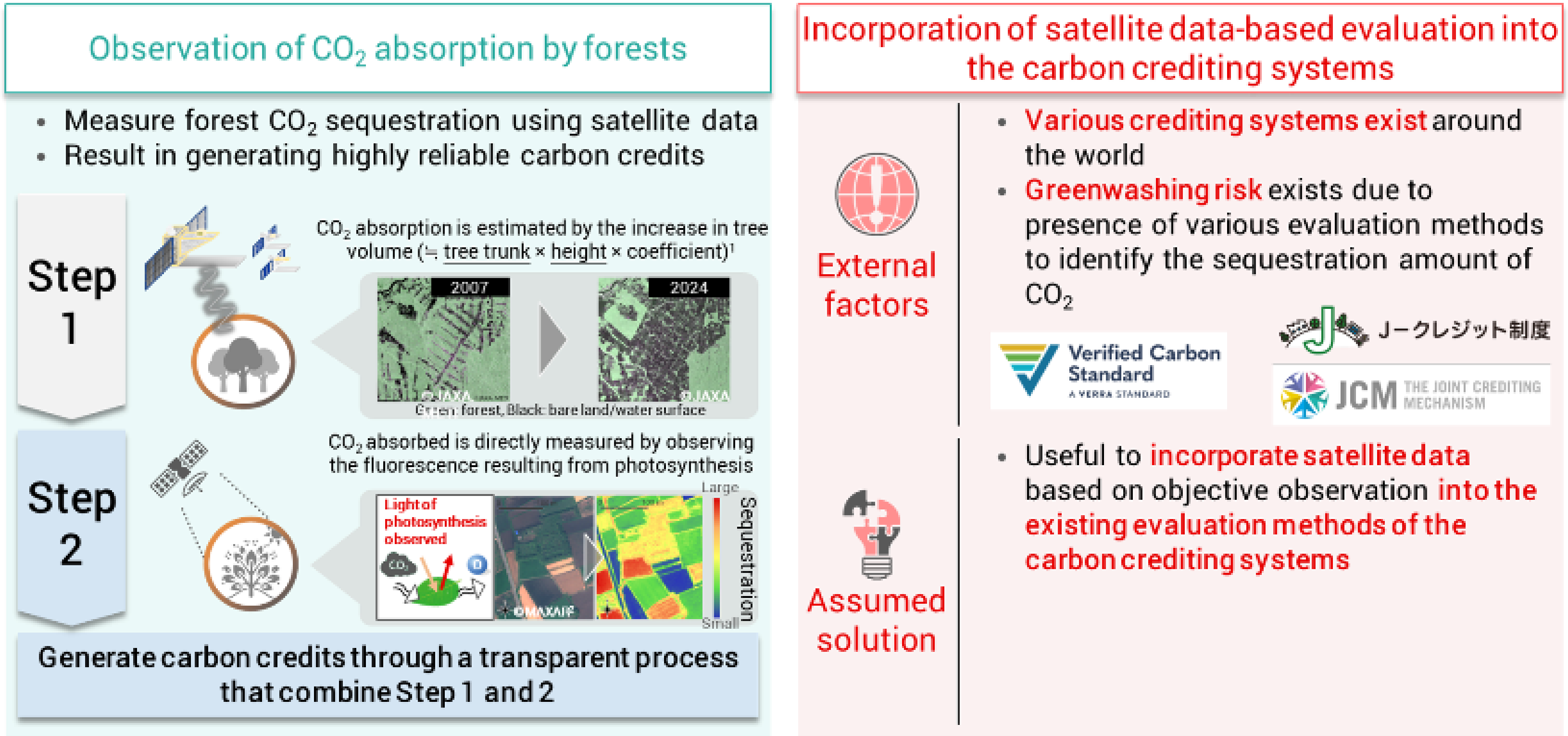
1. Measurement, Monitoring, Reporting and Verification; 2. Oil Gas Methane Partnership
Source: Collaborative demonstration of Mitsubishi Electric Corp., SDS, GHGSat, MOE, JAXA, and MUFG

❸Visualization of "Absorption"



There are also examples of satellite data being used to study absorption. JAXA and MUFG are working together to measure the amount of CO_2 absorbed by forests. Step 1 measures how much CO_2 tree trunks absorb by monitoring the volume of trees. Step 2 measures how much CO_2 tree leaves absorb by monitoring photosynthesis.

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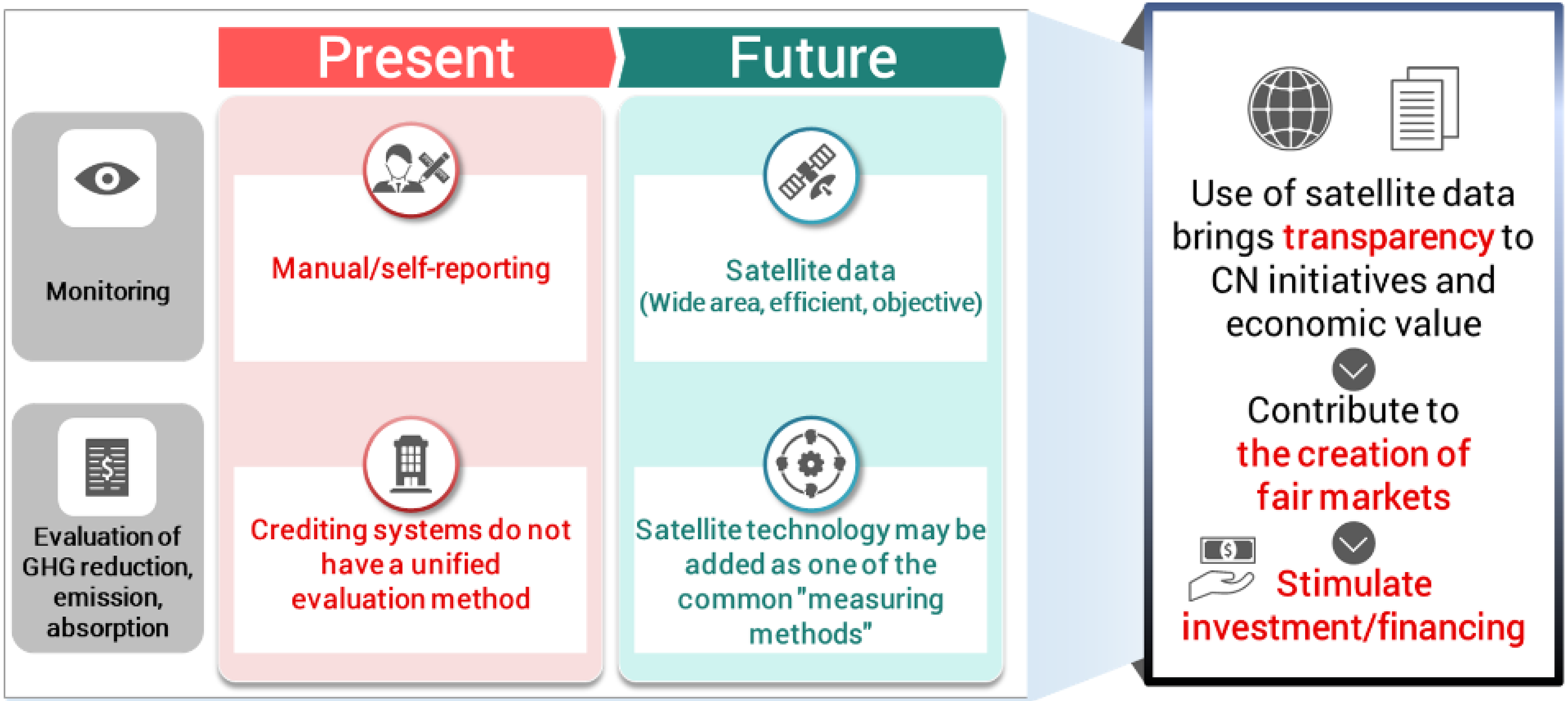
1. The underlined items were observed using satellite data. MUFG was commissioned by JAXA to conduct 「Demonstration project on forest carbon credit calculation using satellite data (FY2024-2025) (Collaborative demonstration by SDS, Mitsubishi Electric, Archeda, Forest Value, and MUFG) 2. Prepared in cooperation with Mitsubishi Electric and SDS based on Maxar's satellite data

Outcomes from satellite use



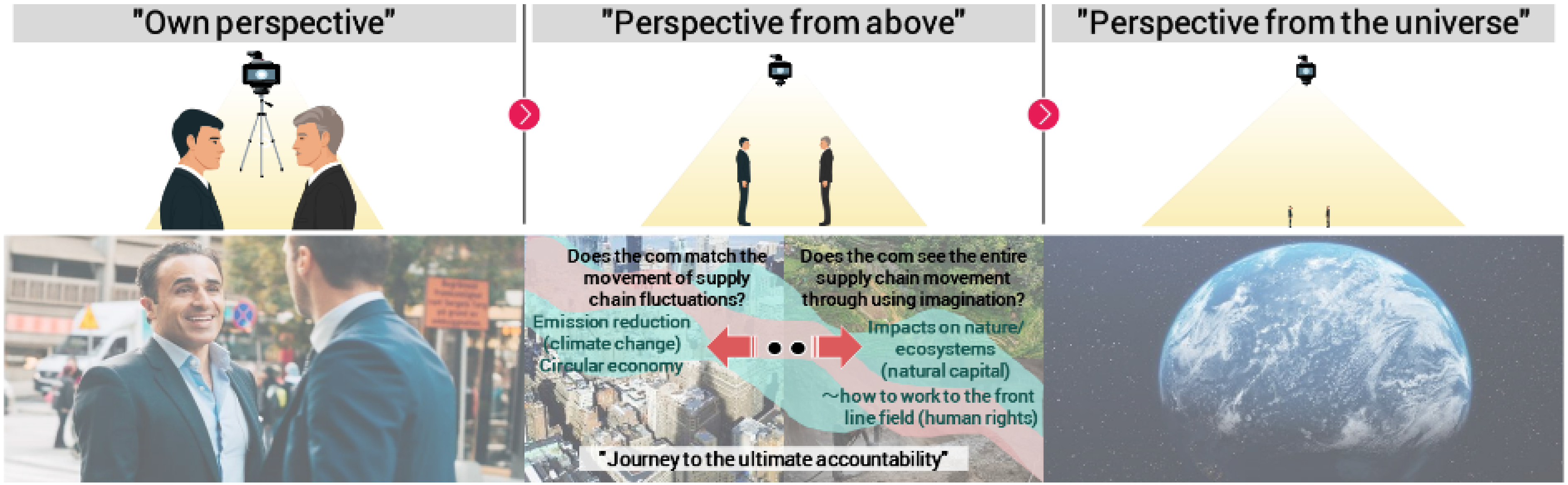
Outcomes from satellite use

In addition, various initiatives for carbon credits are emerging globally. And companies face potential risks, such as greenwashing. Objective monitoring of CO_2 absorption by satellite data may be one way to minimize those risks.

The benefits of satellite data can also be seen in more objective, broader, and less labor-intensive monitoring—presenting the potential to become the global “standard”. By objectively “visualizing” how much CO_2 is being emitted, reduced and absorbed, it can boost the transparency of CN initiatives, potentially leading to the creation of a fairer market. From the perspective of cross-industry collaboration, ground industries can work with the space industry to comprehensively address ground challenges and devise new solutions.


Sustainability is the ultimate accountability

Sustainability is the ultimate accountability



[Conventional perspectives]
It was enough to **satisfy the customer in front** by considering price, quality, and service only for the company and the direct business partners

[Perspectives now required]
Required to position the com as part of a large supply chain and take an **integrated view of the environment**

[Perspectives to hold in the med-to long-term]
Required to stimulate a healthy discussion on all issues such as population, economy, resources, environment, and gap between rich & poor, etc. by overlooking on a **global scale**

Raise perspective/viewpoint, and use the sustainability frame (emissions, climate change, circular economy, biodiversity, human rights, etc.) as a lens to capture the business in a three-dimensional manner, in pursuit of ultimate accountability

Sustainability is the ultimate accountability

Finally, a reflection on what sustainability really means. Through our work on the MUFG Transition Whitepaper, we have understood that sustainability is about being self-sustaining, which means fulfilling the ultimate accountability of where we stand in the movement of society as a whole and what we are doing and/or trying to do right now.

In the past, MUFG and many of our customers have focused on immediate business partners and have constantly compared the prices, quality, services, and differentiation of services and products with competitors. However, we have learned that we must zoom out. How much GHG is being emitted by the supply chain we belong to? As emission reduction efforts progress, with circularity gradually coming into consideration, are our company's actions aligned with the supply chains of the future? Can we imagine the impact on working conditions (human rights) at the end of the supply chain and on natural capital (biodiversity)? By using the frameworks of climate change, the circular economy, human rights, and biodiversity, we may be able to view our business three-dimensionally. Climate change, human rights, and biodiversity are not separate topics; they are lenses for viewing our business and ourselves.

Zooming out even further, we can see the entire earth. On a global scale, as we consider how to share and coexist with limited resources, food, and population, there is an increasing need for international cooperation. By zooming in and out, we can balance abstraction and solidity. And sustainability is the lens that enables us to fulfill the ultimate accountability and ensure that our business endures.


We speak in
"UNITED LANGUAGE"

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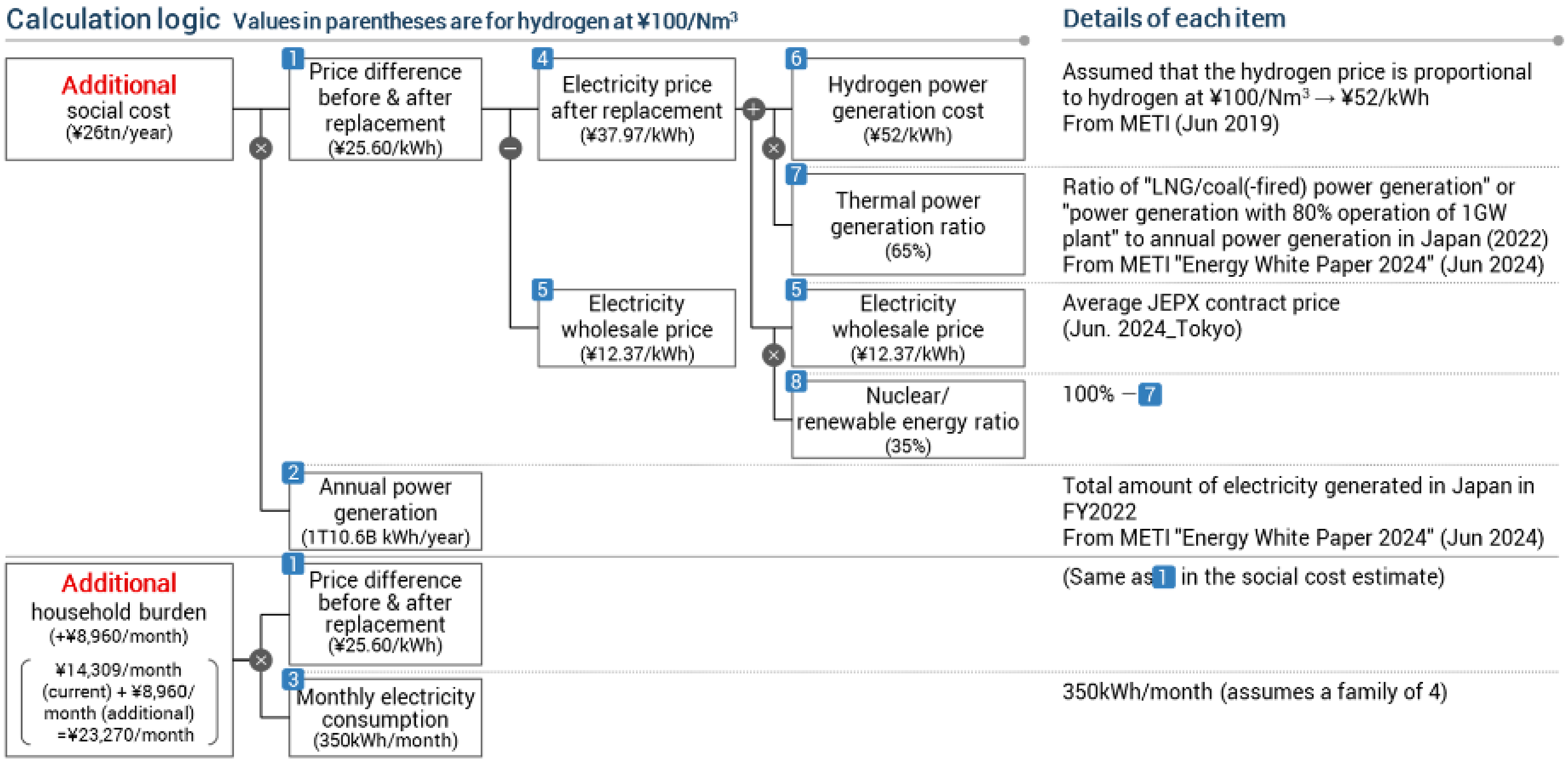
Appendices: 1. Estimation of the impact of hydrogen replacement

Structure of hydrogen replacement impact estimate



Source: [METI(2019/6)]、["Energy White Paper 2024" (2024/6)]; [JEPX HP]

Estimated change in retail electricity prices for industry with hydrogen power generation
(Case of replacing the equivalent of current domestic thermal power generation with H_2 power generation at ¥100 /Nm³)

	Current electricity prices (as of Jun 2024)		Electricity prices after introducing hydrogen	
Assumption	• Total: Industrial electricity prices as of 2022 (IEA) • Wheeling Charge: Average unit price for extra-high-voltage supply • Wholesale electricity price: EPX spot (Average for Jun 2024, Tokyo)	• Thermal power generation ratio in JP: 65% - Coal:30.8%(2022) - LNG:33.8%(2022)	• Only the equivalent of thermal generation replaced by hydrogen • Hydrogen power generation unit price: ¥52/kWh (hydrogen price: ¥100/Nm³)	• No change before/after introducing hydrogen except for wholesale electricity prices (energy procurement costs)
Industrial burden	**¥13.34mm/month** (¥26.7/kWh × 500MWh/month)		**¥26.14mm/month(+¥12.8mm)** (¥52.3/kWh × 500MWh/month)	

Note: Figures are rounded to the first decimal place
Source: TEPCO (1/2); TEPCO (2/2); JEPX; METI; IEA

Estimation the impact of hydrogen replacement (additional industrial burden shown by increased amounts)

Assumed electricity consumption of **500MWh/month**
(a factory size of hundreds of workers)

Small Industrial burden Large

Current:¥13.34mm/month

(¥/month)

Low → High

Replacement size	Hydrogen replacement	Hydrogen price (¥/Nm³) 30 (¥16/kWh)	50 (¥26/kWh)	100 (¥52/kWh)	200 (¥104/kWh)	300 (¥156/kWh)
Thermal power (65%[1] of power supply mix) 129GW 652.8bn kWh/year	100%	+¥1.04mm	+¥4.4mm	+¥12.8mm	+¥29.6mm	+¥46.39mm
	50%	+¥0.52mm	+¥2.2mm	+¥6.4mm	+¥14.8mm	+¥23.2mm
	20%	+¥0.21mm	+¥0.88mm	+¥2.56mm	+¥5.92mm	+¥9.28mm
One plant (1% of power supply mix) 1GW 7B kWh/year	100%	+¥0.01mm	+¥0.05mm	+¥0.140mm	+¥0.32mm	+¥0.5mm
	50%	+¥0.01mm	+¥0.02mm	+¥0.07mm	+¥0.16mm	+¥0.25mm
	20%	+¥0.002mm	+¥0.01mm	+¥0.03mm	+¥0.06mm	+¥0.1mm

Replacement size: Large → Small

(Estimated only based on fuel price differences. Does not include equipment and other costs related to replacement)

1: Total output of coal- and LNG-fired power generation in Japan as of April 2023
Source: TEPCO (1/2); TEPCO (2/2); JEPX; METI (1/3); METI (2/3); METI (3/3); CAO; IEA

Estimation the impact of hydrogen replacement (additional industrial burden shown by increased rates)

Assumed electricity consumption of **500MWh/month**
(a factory size of hundreds of workers)

Industrial burden: Small → Large

Current:¥13.34mm/month

(%)

Hydrogen price (¥/Nm³): Low → High

Replacement size	Hydrogen replacement	30 (¥16/kWh)	50 (¥26/kWh)	100 (¥52/kWh)	200 (¥104/kWh)	300 (¥156/kWh)
Thermal power (65%[1] of power supply mix) (129GW 652.8bn kWh/year)	100%	+8%	+33%	+96%	+222%	+348%
	50%	+4%	+17%	+48%	+111%	+174%
	20%	+2%	+7%	+19%	+44%	+70%
One plant (1% of power supply mix) (1GW 7B kWh/year)	100%	+0.1%	+0.4%	+1%	+2%	+4%
	50%	+0.04%	+0.2%	+1%	+1%	+2%
	20%	+0.02%	+0.1%	+0.2%	+0.5%	+1%

Replacement size: Large → Small

(Estimated only based on fuel price differences.
Does not include equipment and other costs related to replacement)

1: Total output of coal- and LNG-fired power generation in Japan as of April 2023
Source: TEPCO (1/2); TEPCO (2/2); JEPX; METI (1/3); METI (2/3); METI (3/3); CAO; IEA

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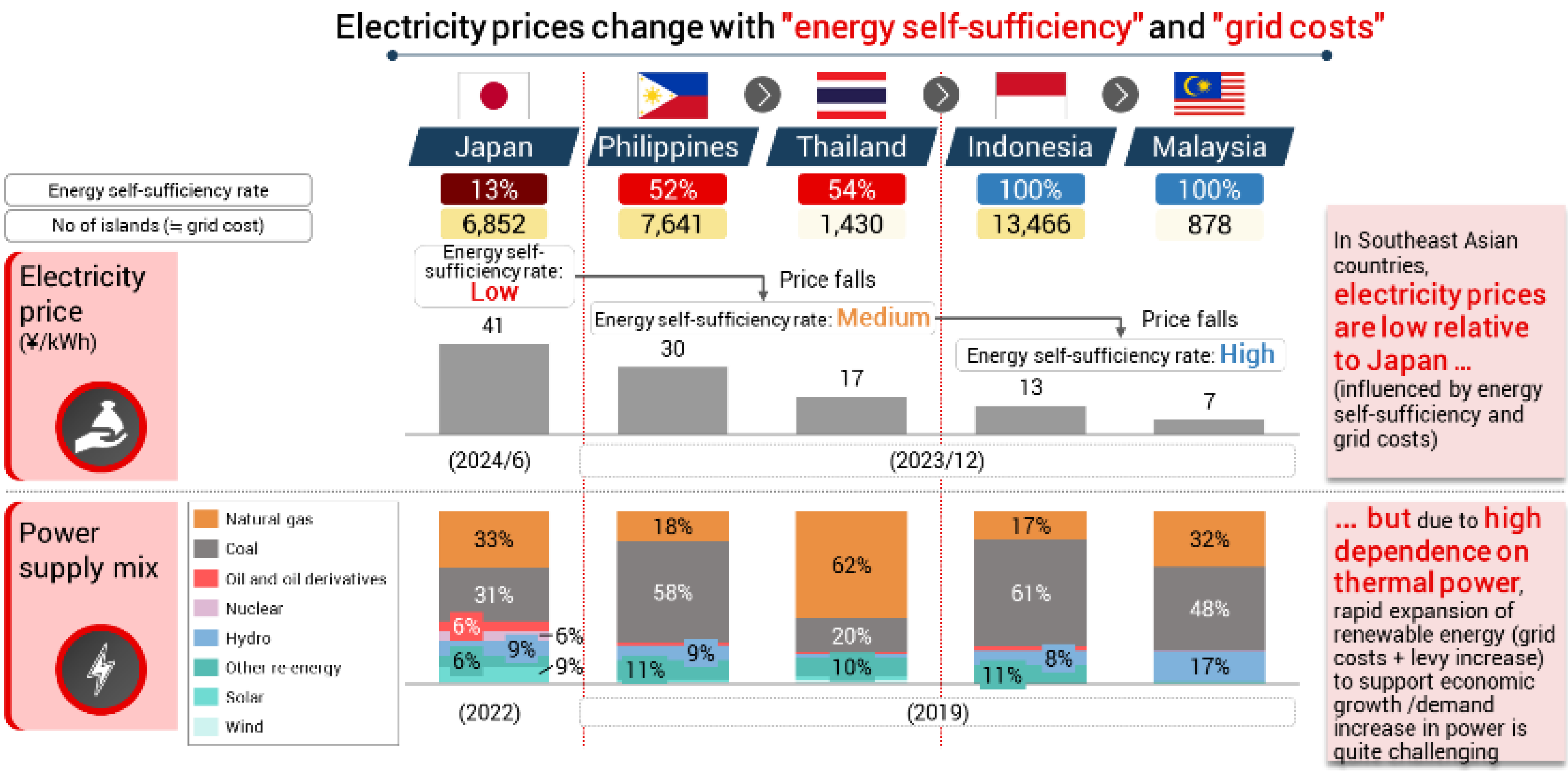
Appendices:2. Comparison of electricity prices by country

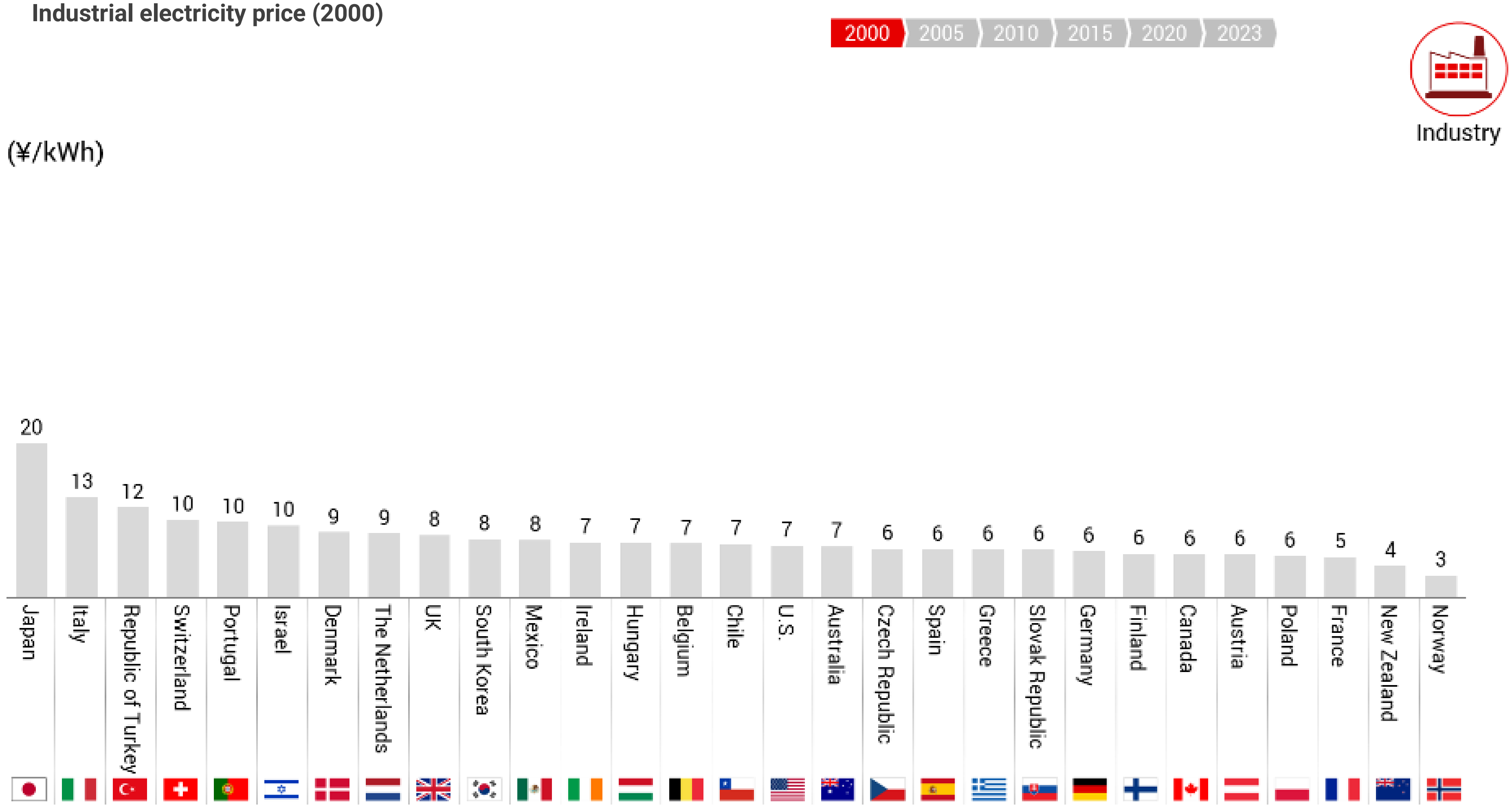
International comparison of factors affecting electricity prices



Note: Converted at $1=¥150

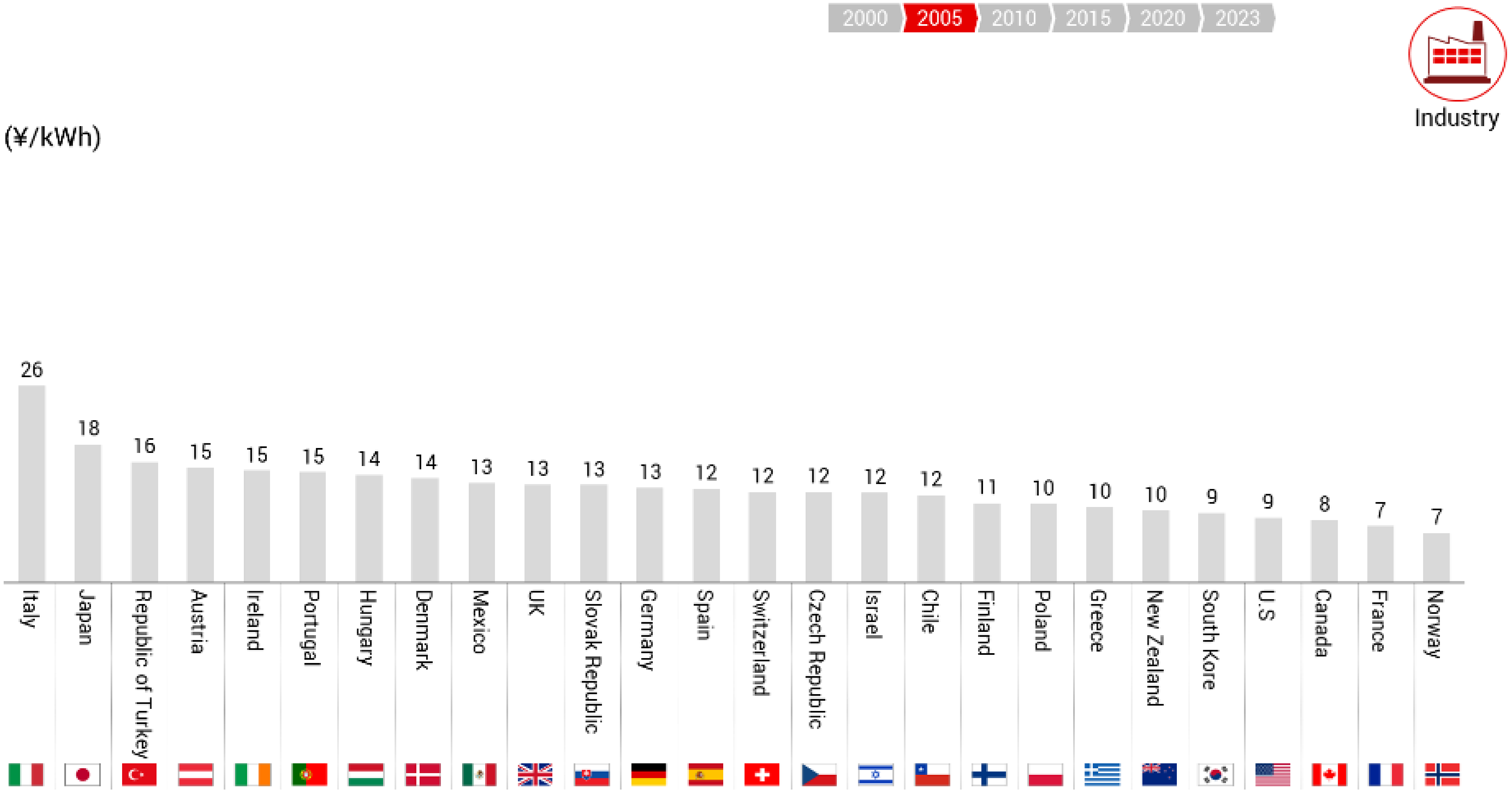
Source: Estimated based on open info by TEPCO and JEPX; Global Petrol Prices「Electricity Prices」; IEA; Lowry Institute, etc.

Industrial electricity price (2000)



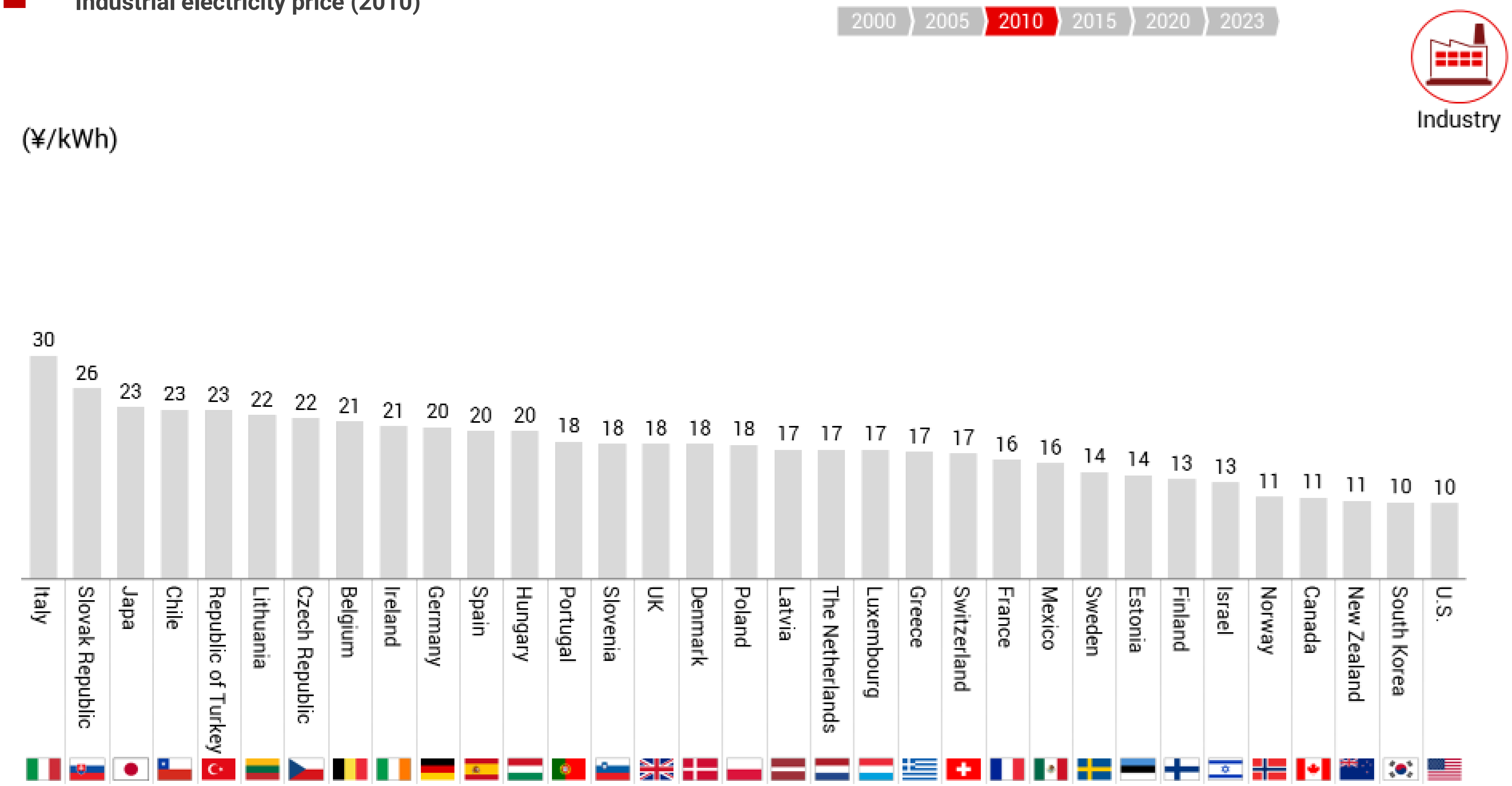
Note: Converted at $1=¥150
Source: IEA 'Energy Prices'

Industrial electricity price (2005)



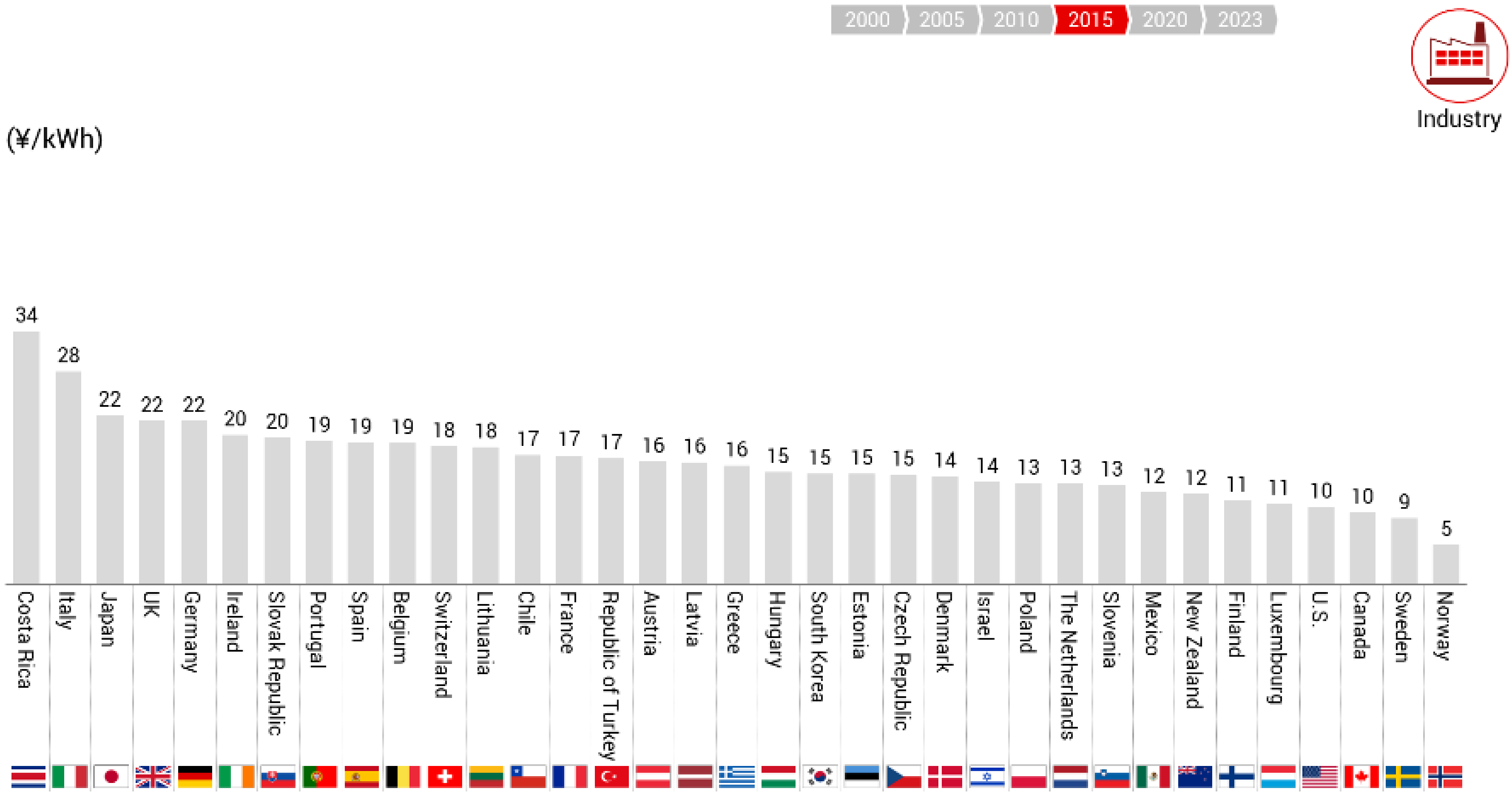
Note: Converted at $1=¥150
Source: IEA 'Energy Prices'

Industrial electricity price (2010)



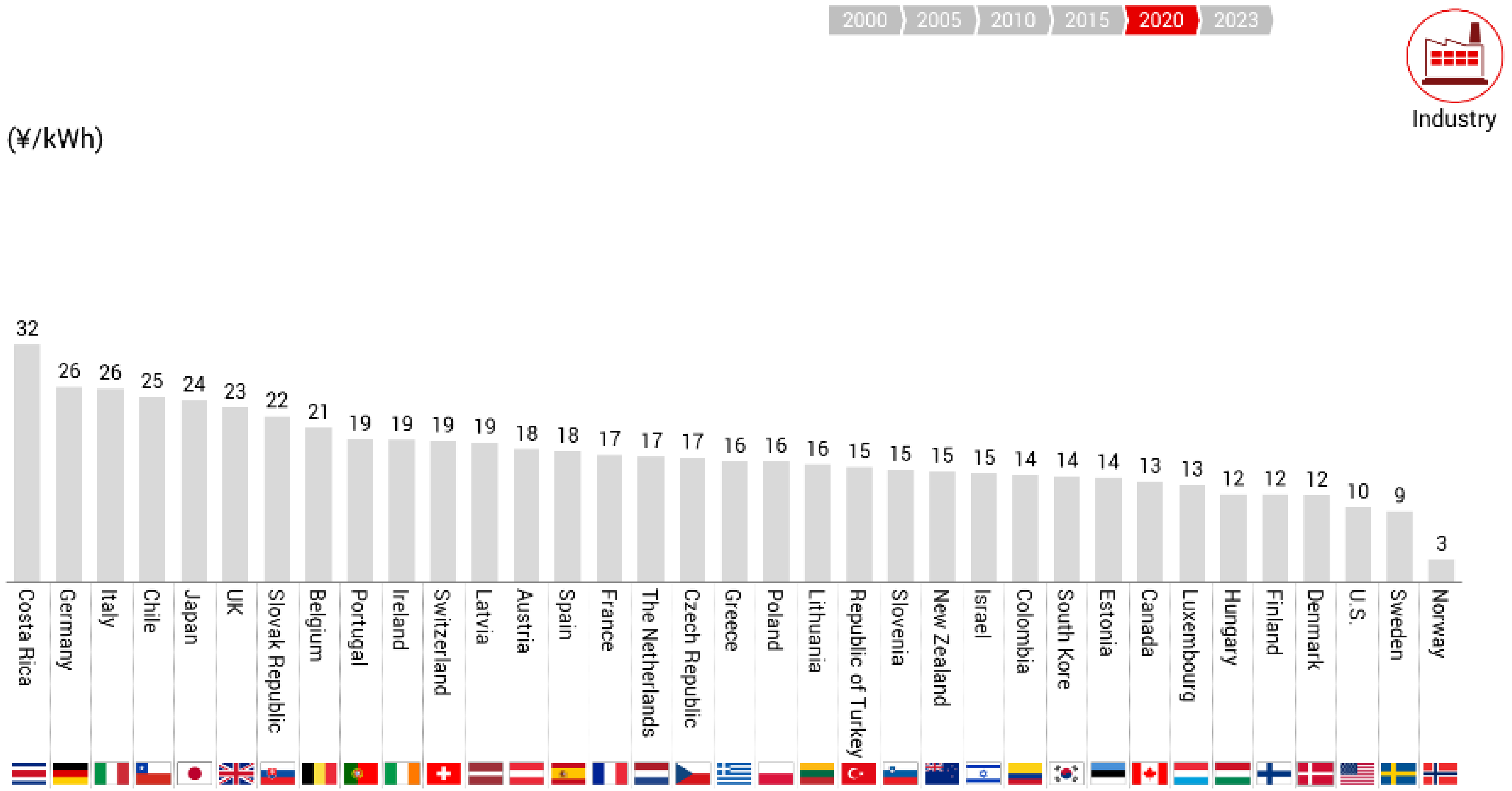
Note: Converted at $1=¥150
Source: IEA 'Energy Prices'

Industrial electricity price (2015)



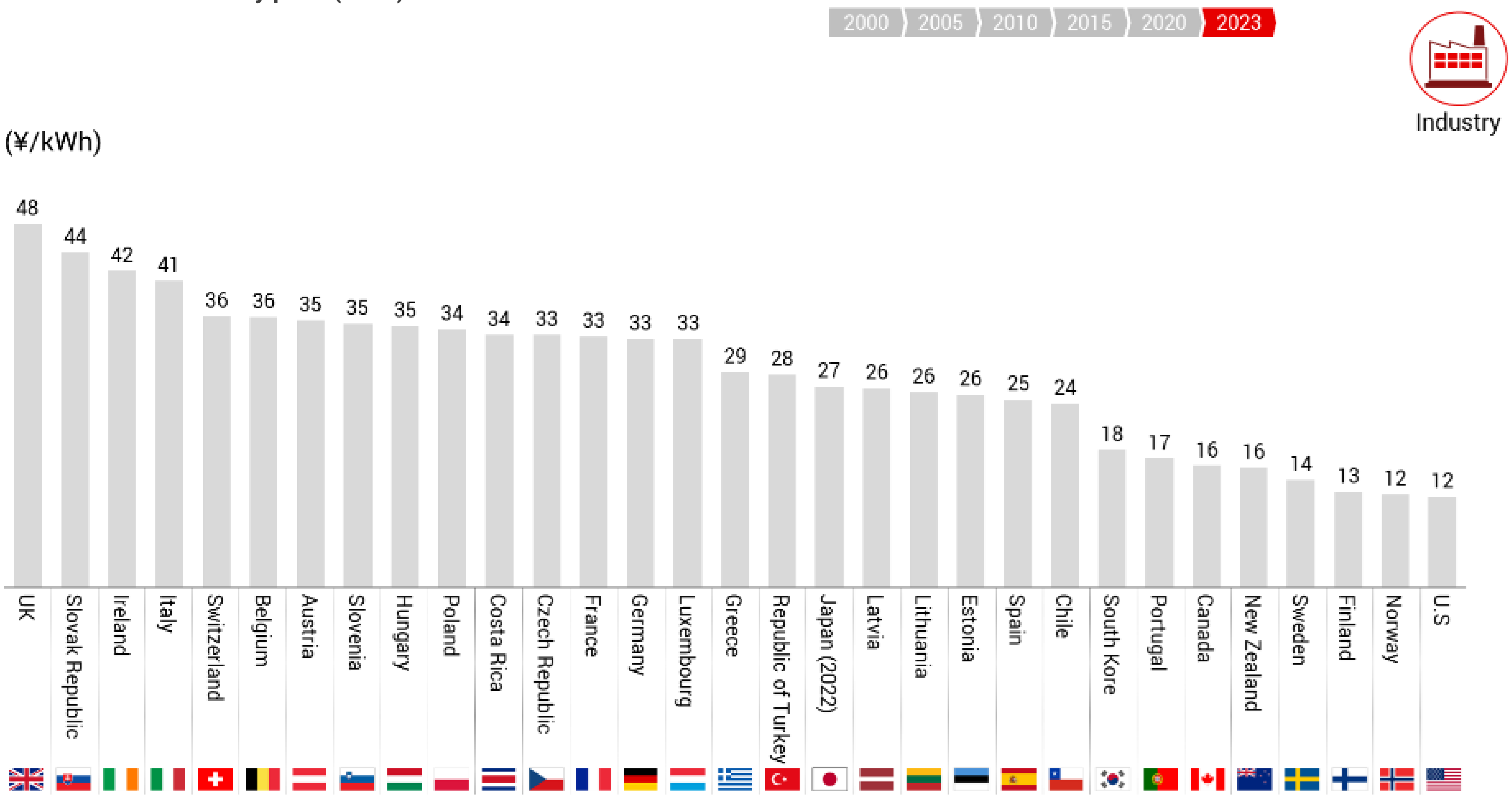
Note: Converted at $1=¥150
Source: **IEA 'Energy Prices'**

Industrial electricity price (2020)



Note: Converted at $1=¥150
Source: IEA 'Energy Prices'

Industrial electricity price (2023)



Note: Converted at $1=¥150
Source: IEA 'Energy Prices'

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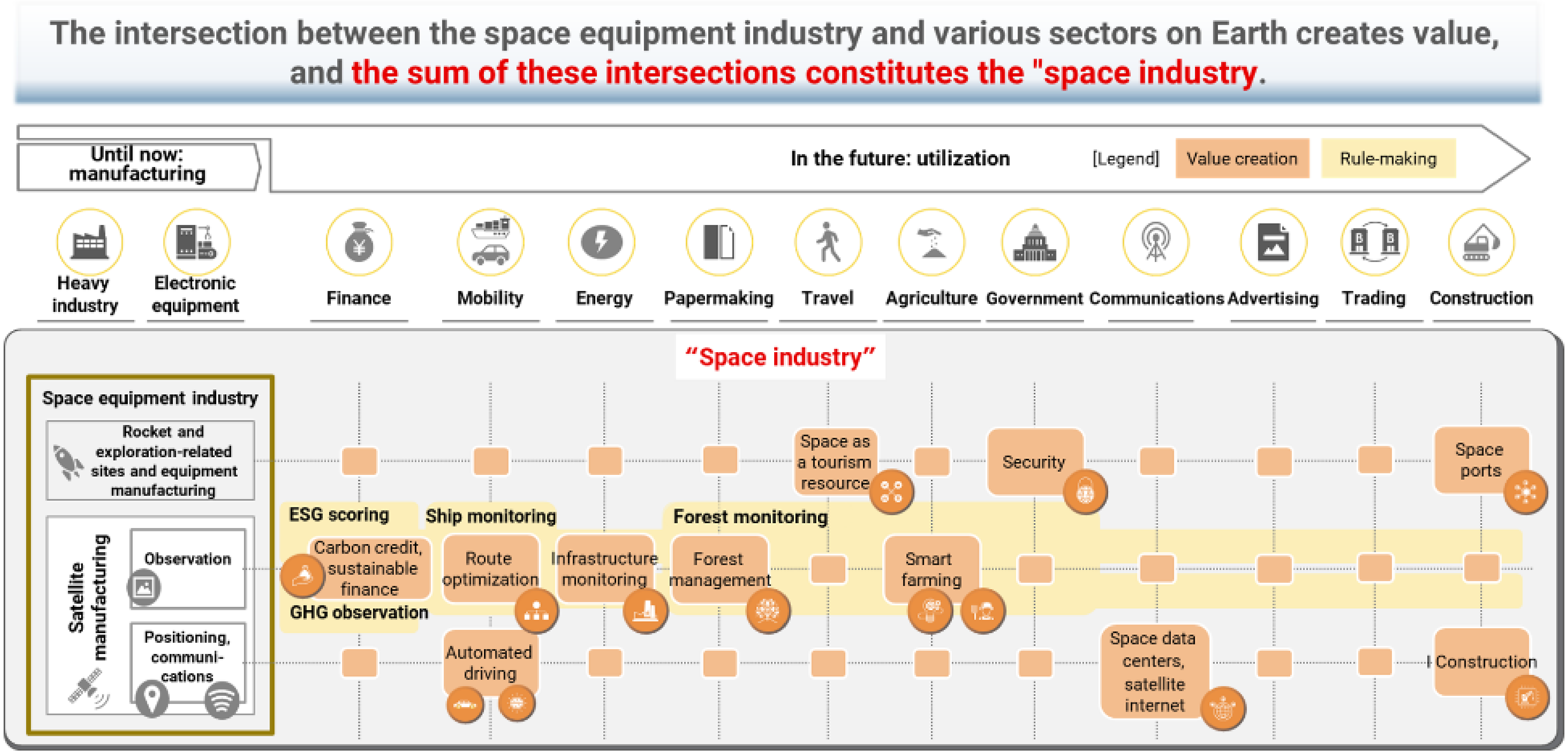
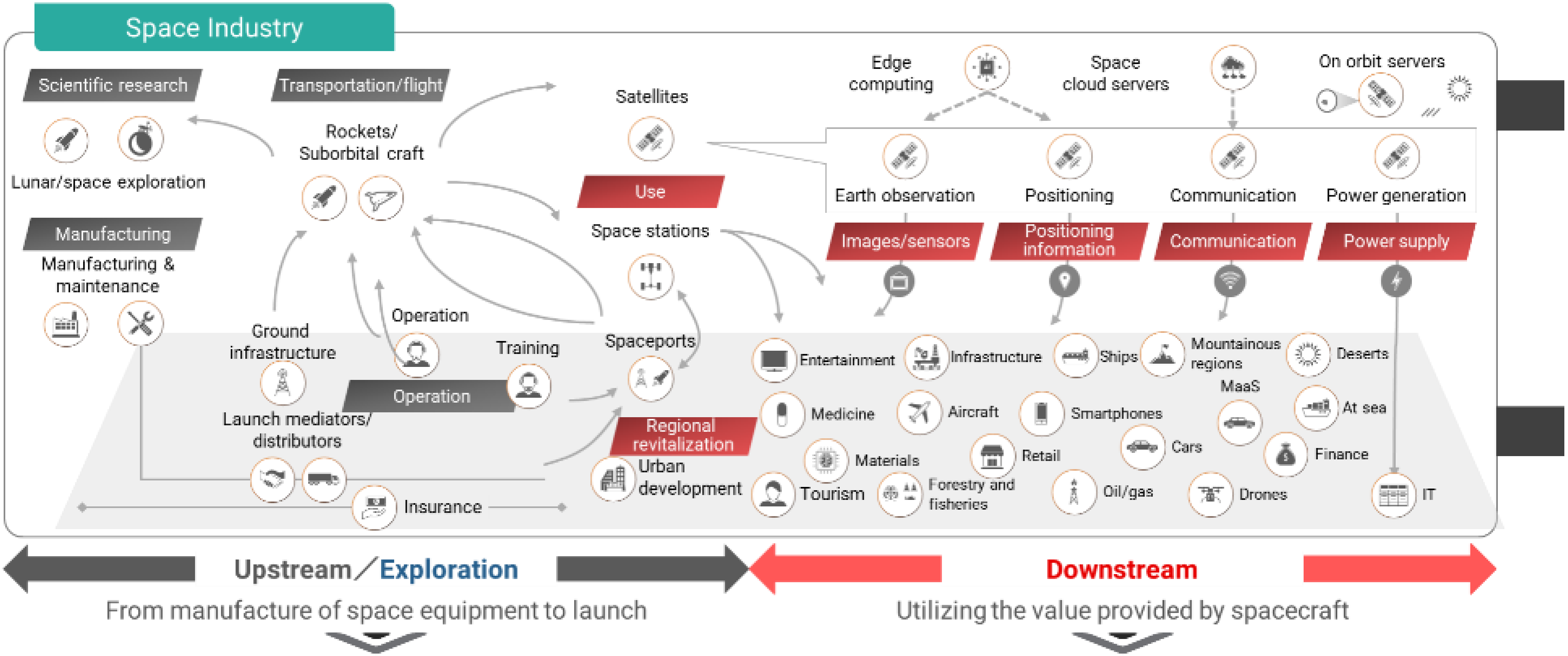
Space 1: Comprehensive definition of the "space industry."



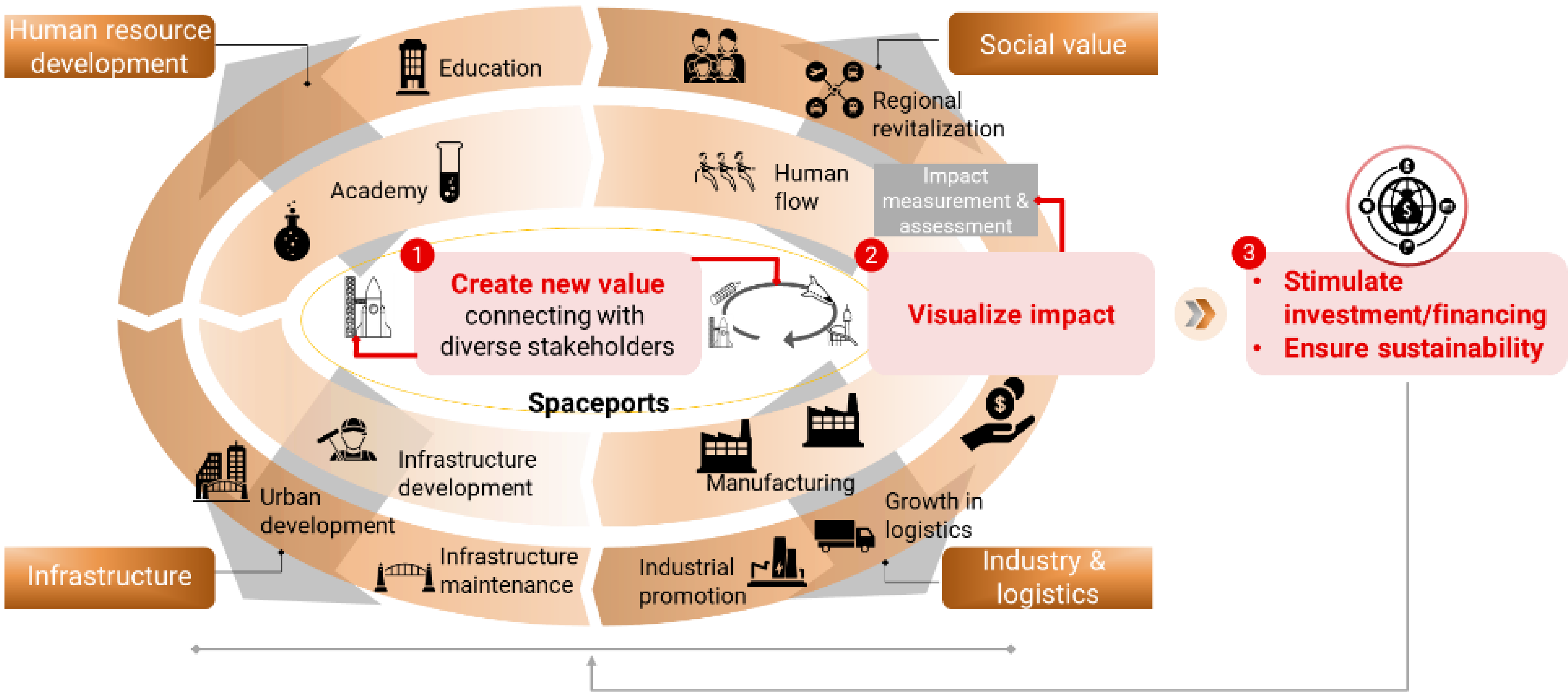
Space 2: Overview of the Space Industry



Create next-generation industrial infrastructure

Solve diverse social issues and create new value

Space 3: Maximizing the Potential and Impact of Spaceports



Space 4: Solving Social Issues through the Utilization of Satellite Data

Shipping Sector:
-GHG Emission Reduction Efforts and Route Optimization

Agricultural Resources:
-Agricultural Carbon Credits

Forest Resources:
-Forest Carbon Credits

Marine Resources:
-Biodiversity and Blue Carbon

Emission | Absorption

"See the Unseen"
~Value is created by making things visible~

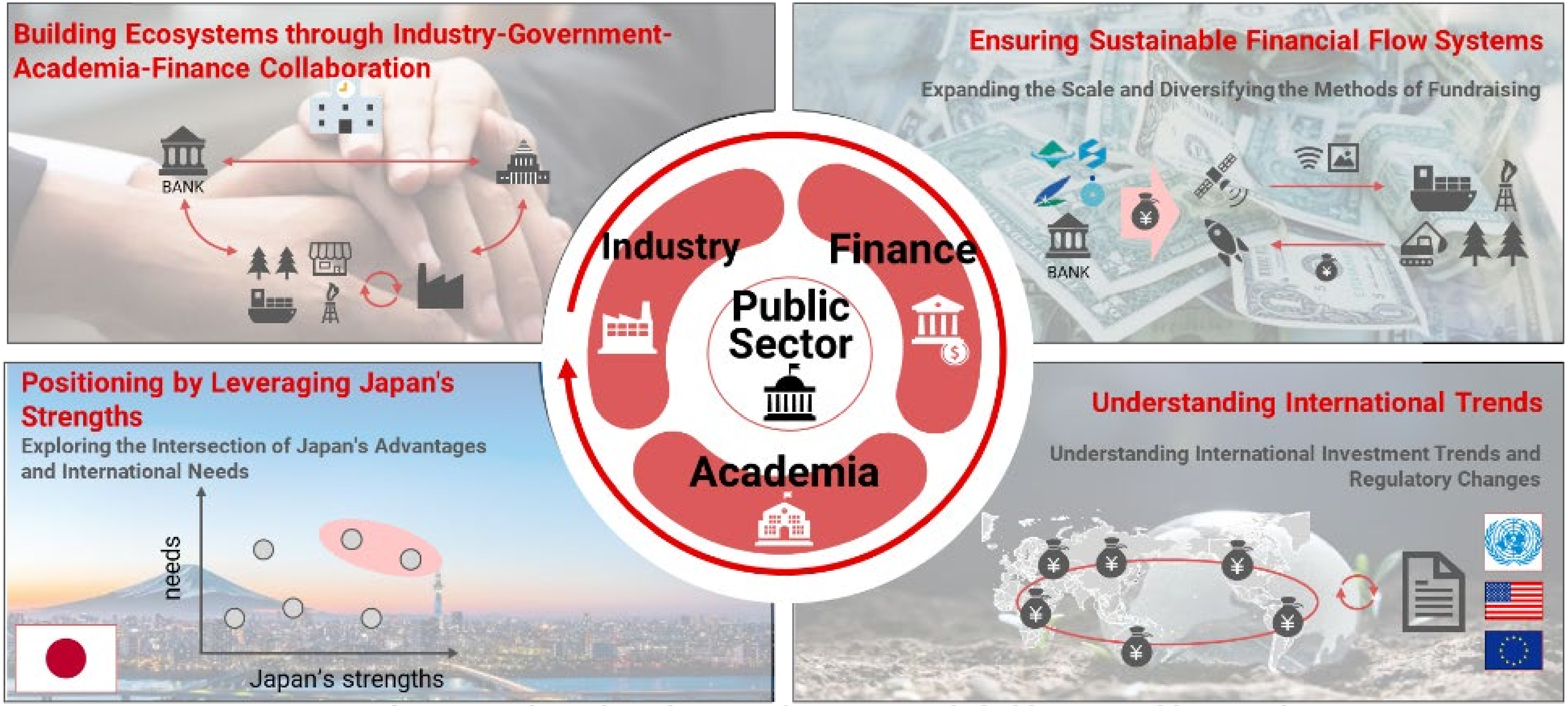
Economic Forecast:
-Consumer Behavior Predictions and Industry Reports

Mobility Sector:
-GHG Emission Reduction Efforts and Health Impacts

Factories and Other industries:
-GHG Emission Reduction Efforts and Health Impacts

Labor-Intensive Businesses:
-Infrastructure Management, etc.

Space 5：Consideration for Industrialization



Integrating Information through Dialogue with Diverse Stakeholders to Build a Foundation for Industry-Government-Academia-Finance Collaboration

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Abbreviations and acronyms

ANGEA	Asia Natural Gas & Energy Association
ARCHES	Alliance for Renewable Clean Hydrogen Energy
bn	billion
B/S	balance sheet
CAPEX	capital expenditure
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilization and Storage
CfD	Contracts for Difference
CHP	Combined Heat and Power
CII	Carbon Intensity Indicator
CN	carbon neutrality
COP	Conference of the Parties
CRMA	Critical Raw Materials Act
CSRD	Corporate Sustainability Reporting Directive
DAC	direct air capture
dev	development
DOE	U.S. Department of Energy
ECB	European Central Bank
EEXI	Energy Efficiency Existing Ship Index
ESPR	Eco-design for Sustainable products Regulation
ESRS	Europe Sustainability Reporting Standard
EU	European Union
EU-ETS	EU Emissions Trading System
EV	electric vehicle
FCV	Fuel Cell Vehicle
FDIs	Foreign Direct Investment
FIP	Feed in Premium
FIT	Feed in Tariff
FLOWRA	Floating Offshore Wind Technology Research Association
F/S	feasibility study
GDP	gross domestic product
GHG	greenhouse gas
GI	Green Innovation
GX	Green Transformation
HEC	hybrid electric vehicle
HH2H	Heartland Hydrogen Hub
ICE	Internal Combustion Engine
IIJA	Infrastructure Investment and Jobs Act
IMO	International Maritime Organization
IRA	Inflation Reduction Act
ITC	Investment Tax Credit
JAXA	Japan Aerospace Exploration Agency
LNG	liquefied natural gas
MACH2	Midwest Alliance for Clean Hydrogen
METI	Ministry of Economy, Trade and Industry
mm	million
MMRV	Measurement, Monitoring, Reporting and Verification

NCEAP	New circular economy action plan
NDC	Nationally Determined Contribution
NZBA	Net-Zero Banking Alliance
NZIA	Net-zero industry act
OEM	original equipment manufacturer
OGMP	Oil Gas Methane Partnership
OPEX	operational expenditure
ONE	Ocean Network Express
PHEV	Plug-in Hybrid Electric Vehicle
PJ	project
P/L	profit and loss
PNWH2	Pacific Northwest Regional Hydrogen Hub
PPA	power purchase agreement
PTC	Production Tax Credit
SAF	Sustainable aviation fuel
tn	trillion
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
U.S.	United States

Glossary

CO_2	carbon dioxide
GW	gigawatt
GWh	gigawatt hour
H_2	hydrogen
kW	kilowatt
kWh	kilowatt hour
MTPA	million ton per annum
MW	megawatt
MWh	megawatt-hour
NH_3	ammonia

References

ACEA (2024) New car registrations: +10.1% in February 2024; battery electric 12% market share
https://www.acea.auto/pc-registrations/new-car-registrations-10-1-in-february-2024-battery-electric-12-market-share/
Asia Natural Gas & Energy Association homepage
https://angeassociation.com/
Automotive News (2024) GM will bring plug-in hybrids back to North America in strategy shift
https://www.autonews.com/manufacturing/gm-bring-phevs-back-north-america
BCG (2023) Turning the European Green Hydrogen Dream into Reality: A Call to Action
https://media-publications.bcg.com/Turning-the-European-Green-H2-Dream-into-Reality.pdf
BDEW (2024) BDEW-Strompreisanalyse
https://web.archive.org/web/20240221002058/https:/www.bdew.de/media/documents/240201_BDEW-Strompreisanalyse_Februar_2024_06.02.2024.pdf
BIS Data Portal "Consumer prices"
https://data.bis.org/topics/CPI/data?data_view=table&rows=REF_AREA&cols=TIME_PERIOD&filter=FREQ%3DM%255EREF_AREA_TXT%3DCanada%257CFrance%257CGermany%257CItaly%257CJapan%257CRussia%257CUnited%2520Kingdom%257CUnited%2520States%255EUNIT_MEASURE%3D771
Bloomberg NEF (2023) Hydrogen offtake is tiny but growing
https://about.bnef.com/blog/hydrogen-offtake-is-tiny-but-growing/
Bricker Graydon (2023) Inflation Reduction Act (IRA): Advanced Manufacturing Product Credit – A cheat sheet
https://www.brickergraydon.com/insights/publications/Inflation-Reduction-Act-IRA-Advanced-Manufacturing-Product-Credit-A-cheat-sheet
Bumper (2023) More Than 70% of Public EV Charge Ports Are in America's Wealthiest Counties
https://finance.yahoo.com/news/bumper-study-more-70-public-132200478.html
Business Insider(2023)Ford pauses a $12 billion EV investment, after saying electric vehicles are too expensive
https://www.yahoo.com/news/ford-pauses-12-billion-ev-112626222.html
Carbon Capture Investment Hits Record High of $6.4 Billion
https://about.bnef.com/blog/carbon-capture-investment-hits-record-high-of-6-4-billion/
Climate Group RE100「RE100 Members」
https://www.there100.org/re100-members
DIHK(2023)Energy Transition Barometer 2023
https://www.dihk.de/resource/blob/103418/8f8aae3e8c117045066a039dc0faa944/energy-transition-barometer-2023-data.pdf
EIA(2023)Electricity explained Factors affecting electricity prices
https://www.eia.gov/energyexplained/electricity/prices-and-factors-affecting-prices.php
EIB「EIB Investment Survey」
https://www.eib.org/en/publications-research/economics/surveys-data/eibis/index.htm?sortColumn=startDate&sortDir=desc&pageNumber=0&itemPerPage=10&pageable=true&la=EN&deLa=EN&tags=5bf8095afa70f13f9d3b51b3&ortags=true&orSubjects=true&orCountries=true
Engineering News-Record (2023) Developer Cancels UK Offshore Wind Project Amid Rising Costs
https://www.jmeagle.com/developer-cancels-uk-offshore-wind-project-amid-rising-costs
European Commission (2011-2023) Critical raw materials list
https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en
European Commission (2020) New circular economy action plan
https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en
European Commission (2020) The Taxonomy Regulation
https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en
European Commission(2023)European Sustainability Reporting Standards

https://finance.ec.europa.eu/news/commission-adopts-european-sustainability-reporting-standards-2023-07-31_en
European Commission(2023)'Fit for 55': Council adopts key pieces of legislation delivering on 2030 climate targets
https://www.consilium.europa.eu/en/press/press-releases/2023/04/25/fit-for-55-council-adopts-key-pieces-of-legislation-delivering-on-2030-climate-targets/
European Commission(2023)Study on the critical raw materials for the EU 2023
https://op.europa.eu/en/publication-detail/-/publication/57318397-fdd4-11ed-a05c-01aa75ed71a1
European Commission(2023)The Corporate Sustainability Reporting Directive
https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en
European Commission(2024)Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52024DC0062
European Commission(2024)Net-Zero Industry Act: Council and Parliament strike a deal to boost EU's green industry
https://www.consilium.europa.eu/en/press/press-releases/2024/02/06/net-zero-industry-act-council-and-parliament-strike-a-deal-to-boost-eu-s-green-industry/
European Commission(2024)The Ecodesign for Sustainable Products Regulation
https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/sustainable-products/ecodesign-sustainable-products-regulation_en
European Parliament and The Council Of The European Union(2023)REGULATION (EU) 2023/1542 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1542
Eurostat “Construction producer price and construction cost indices overview”
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Construction_producer_price_and_construction_cost_indices_overview
Eurostat “Natural gas price statistics”
https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Natural_gas_price_statistics#Natural_gas_prices_for_household_consumers
EV Database “Current and Upcoming Electric Vehicles” (as of March 2023)
https://ev-database.org/#sort:path~type~order=.rank~number~desc|rs-price:prev~next=10000~100000|rs-range:prev~next=0~1000|rs-fastcharge:prev~next=0~1500|rs-acceleration:prev~next=2~23|rs-topspeed:prev~next=110~350|rs-battery:prev~next=10~200|rs-towweight:prev~next=0~2500|rs-eff:prev~next=100~350|rs-safety:prev~next=-1~5|paging:currentPage=0|paging:number=10
FLOWRA (2024) Launch of the Floating Offshore Wind Technology Research Association
https://flowra.or.jp/files/libs/834/202403141219144167.pdf
Forbes Japan (2024) Why the “clean hydrogen” industry is opposing the Biden administration's tax credit proposal
https://forbesjapan.com/articles/detail/68446
Global Petrol Prices “Electricity Prices”
https://www.globalpetrolprices.com/electricity_prices/
IEA “Energy Prices”
https://www.iea.org/data-and-statistics/data-product/energy-prices
IMF (2023) Confronting Fragmentation Where It Matters Most: Trade, Debt, and Climate Action
https://www.imf.org/en/Blogs/Articles/2023/01/16/Confronting-fragmentation-where-it-matters-most-trade-debt-and-climate-action
IMF (2023) World Economic Outlook
https://www.imf.org/en/Publications/WEO/Issues/2023/10/10/world-economic-outlook-october-2023

InsideEVs (2023) China: Tesla Retail Electric Car Sales Down 40 Percent In December 2022
https://insideevs.com/news/630433/china-tesla-retail-ev-sales-december2022/
JEPX "Market Data"
https://www.jepx.jp/en/electricpower/market-data/spot/ave_day.html
JEPX "Trading Market Data"
https://www.jepx.jp/electricpower/market-data/spot/ave_month.html
JERA (2024) JERA Growth Strategy for Achieving the 2035 Vision
https://www.jera.co.jp/system/files/private/%E6%B7%BB%E4%BB%98%E8%B3%87%E6%96%99%EF%BC%9A%E3%80%8C2035%E5%B9%B4%E3%83%93%E3%82%B8%E3%83%A7%E3%83%B3%E5%AE%9F%E7%8F%BE%E3%81%AB%E5%90%91%E3%81%91%E3%81%9FJERA%E6%88%90%E9%95%B7%E6%88%A6%E7%95%A5%E3%80%8D%E3%80%81%E3%80%8C2035%E5%B9%B4%E3%81%BE%E3%81%A7%E3%81%AB%E7%9B%AE%E6%8C%87%E3%81%99%E5%8F%8E%E6%94%AF%E6%B0%B4%E6%BA%96%E3%83%BB%E8%B2%A1%E5%8B%99%E6%88%A6%E7%95%A5%E3%80%8D%E3%81%AB%E3%81%A4%E3%81%84%E3%81%A6.pdf
JERA (2024) JERA Begins Demonstration Test of Fuel Conversion to Ammonia at Hekinan Thermal Power Station - World's First Demonstration of 20% Conversion of Ammonia in Large-Scale Commercial Coal-Fired Power Generation -
https://www.jera.co.jp/news/information/20240401_1863
JERA "Highlights and Points of Hekinan Thermal Power Station"
https://www.jera.co.jp/static/files/corporate/business/thermal-power/list/hekinan/pdf/hekinan_2205.pdf
Lowy Institute Asia Power Index
https://power.lowyinstitute.org/data/resilience/resource-security/energy-selfsufficiency/
MUFG (2022) Transition Whitepaper
https://www.mufg.jp/dam/csr/report/transition/wp2022.pdf
MUFG (2023) Transition Whitepaper
https://www.mufg.jp/dam/csr/report/transition/wp2023.pdf
New Civil Engineer (2023) 1.8GW Norfolk offshore wind farm project halted amid 40% cost hike
https://www.newcivilengineer.com/latest/1-8gw-norfolk-offshore-wind-farm-project-halted-amid-40-cost-hike-20-07-2023/
NKSJ Risk Management Business Interruption Risk Caused by Instantaneous Voltage Drops
https://image.sompo-rc.co.jp/reports_org/101229_report.pdf
Norton Rose Fulbright (2024) Global offshore wind: UK
https://www.nortonrosefulbright.com/en/knowledge/publications/cd73eaf0/global-offshore-wind-united-kingdom
NREL (2021) 2020 Cost of Wind Energy Review
https://www.nrel.gov/docs/fy22osti/81209.pdf
OCCTO "Grid Information Service (June 2024)"
https://occtonet3.occto.or.jp/public/dfw/RP11/OCCTO/SD/CE01S020C?fwExtention.pathInfo=CE01S020C&fwExtention.prgbrh=0
OCED Carbon Capture Demonstration Projects Program Front-End Engineering Design (FEED) Studies Selections for Award Negotiations
https://www.energy.gov/oced/carbon-capture-demonstration-projects-program-front-end-engineering-design-feed-studies
OCED (2022) Carbon Capture Demonstration Projects Program Front-End Engineering Design (FEED) Studies
https://www.energy.gov/sites/default/files/2024-01/OCED_CCFEEDs_AwardeeFactSheet_Duke_1.5.2024.pdf
offshoreWIND.biz (2023) vangrid Terminates Long-Fought PPAs in Massachusetts at Cost of Almost USD 50 Million
https://www.offshorewind.biz/2023/07/19/avangrid-terminates-long-fought-ppas-in-massachusetts-at-cost-of-almost-usd-50-million/#:~:text=Massachusetts%27s%20electric%20distribution%20companies%20Eversource%20Energy%2C%20National%20Grid,by%20the%20state%27s%20Department%20of%20Public%20Utilities%20%28DPU%29.
ONE (2023) Information on the new surcharge "ETS (EU ETS SURCHARGE)"
https://jp.one-line.com/ja/news/120423euets
ONE "Company Profile"
https://holdco.one-line.com/ja/standard-page/company-profile
Renewable Energy World (2023) SouthCoast Wind agrees to pay $60M to scrap power purchase agreements

https://www.renewableenergyworld.com/wind-power/offshore/southcoast-wind-agrees-to-pay-60m-to-scrap-power-purchase-agreements/#gref
Reuters (2021) Exclusive: Global carmakers now target $515 billion for EVs, batteries
https://www.reuters.com/business/autos-transportation/exclusive-global-carmakers-now-target-515-billion-evs-batteries-2021-11-10/
Reuters (2024) Apple cancels decade-long electric car project
https://ca.finance.yahoo.com/news/apple-cancels-ev-moves-staff-192629772.html?guccounter=1
Reuters(2024)Exclusive: Tesla shares skid after China sales fell to the lowest level in over a year
https://www.reuters.com/business/autos-transportation/tesla-shares-skid-after-february-china-sales-slump-2024-03-04/
Royal HaskoningDHV(2017)Norfolk Boreas Offshore Wind Farm Environmental Impact Assessment Scoping Report
https://tethys.pnnl.gov/sites/default/files/publications/EIA_Scoping_report_Norfolk_Boreas_2017.pdf
RWE in UK「Norfolk Offshore Wind Zone」
https://uk.rwe.com/project-proposals/norfolk/#:%7E:text=Located%20over%2047km%20from%20the%20Norfolk%20coast%2C%20Boreas%20Offshore%20Wind,by%2C%20RWE%20(100%25).
Softbank(2023)Building a data center with a large-scale computing infrastructure that will be the cornerstone of the next-generation social infrastructure concept, "Core Brain"
https://www.softbank.jp/corp/news/press/sbkk/2023/20231107_01/
South Coast Wind(2023)SouthCoast Wind Moves Forward with Geotechnical Survey in Wind Lease Area
https://southcoastwind.com/southcoast-wind-moves-forward-with-geotechnical-survey-in-wind-lease-area/
The Crown Estate(2022)Offshore Wind Report
https://www.thecrownestate.co.uk/media/4378/final-published_11720_owoperationalreport_2022_tp_250423.pdf
The Register(2024)Ford pulls the plug on EV strategy as losses pile up
https://www.theregister.com/2024/02/07/ford_ev_strategy/
The White House(2023)Building A Clean Energy Economy: A Guidebook To The Inflation Reduction Act's Investments
https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf
In Clean Energy And Climate Action
https://data.bls.gov/timeseries/WPUID612&series_id=WPSID612
U.S. Bureau of Labor Statistics "PPI Commodity data for Intermediate demand by commodity type-Materials and components for construction, not seasonally adjusted"
https://data.bls.gov/timeseries/WPUID62221&series_id=WPSID62221
U.S. Department of Energy "Building America's Clean Energy Future"
https://www.energy.gov/invest
U.S. Department of Energy Project Selections for FOA 2735: Regional Direct Air Capture Hubs – Topic Area 1 (Feasibility) and Topic Area 2 (Design)
https://www.energy.gov/fecm/project-selections-foa-2735-regional-direct-air-capture-hubs-topic-area-1-feasibility-and
U.S. Department of Energy (2023) Biden-Harris Administration Announces $7 Billion For America's First Clean Hydrogen Hubs, Driving Clean Manufacturing and Delivering New Economic Opportunities Nationwide
https://www.energy.gov/articles/biden-harris-administration-announces-7-billion-americas-first-clean-hydrogen-hubs-driving
U.S. Department of Energy(2023)Biden-Harris Administration Announces Up To $1.2 Billion For Nation's First Direct Air Capture Demonstrations in Texas and Louisiana
https://www.energy.gov/articles/biden-harris-administration-announces-12-billion-nations-first-direct-air-capture
U.S. Department of Energy(2023)Clean Hydrogen Production Tax Credit (45V) Resources
https://www.energy.gov/articles/clean-hydrogen-production-tax-credit-45v-resources
US is Set to Expand Global Lead in Capturing Carbon
https://about.bnef.com/blog/us-is-set-to-expand-global-lead-in-capturing-carbon/
USA Today (2023) GM to lay off 1,300 workers across 2 Michigan plants as vehicle production ends

https://finance.yahoo.com/news/gm-lay-off-1-300-134616783.html

Utility Dive (2023) PPAs rejected for Avangrid, Orsted-Eversource offshore wind projects
https://www.utilitydive.com/news/avangrid-orsted-eversource-ppa-offshore-wind-development/688470/

Mitsubishi Heavy Industries (2024) Demonstration unit of next-generation, highly efficient hydrogen production technology "SOEC" begins operation at Takasago Hydrogen Park
https://www.mhi.com/jp/news/240425.html

Chubu Electric Power Company: Electricity Supply and Demand Status Q&A: Balance between Supply and Demand
https://powergrid.chuden.co.jp/denkiyoho/qa/06.html

Cabinet Office: "2022 National Accounts"
https://www.esri.cao.go.jp/jp/sna/menu.html

Cabinet Office: "National Accounts (GDP Statistics)"
https://www.esri.cao.go.jp/jp/sna/menu.html

Hokkaido Shimbun (2023): When mass production of Rapidas begins, power consumption will be around 100,000 kilowatts per plant
https://www.hokkaido-np.co.jp/article/944625/

Japan Weather Association: "Past Weather"
https://tenki.jp/past/2024/06/23/weather/

Nippon Steel Corporation "Nippon Steel Fact Book (2022)"
https://www.nipponsteel.com/factbook/2022/11-04.html

Nikkei Newspaper (2022) Which prefecture has the highest utility costs? Low population density has an impact. Prefecture ranking - cost of living - utility and water costs
https://www.nikkei.com/article/DGXZQOCC198PG0Z10C22A7000000/

Tokyo Gas (2024) Establishment of the international alliance "e-NG Coalition" for e-methane
https://www.tokyo-gas.co.jp/news/press/20240319-02.html

Tokyo Electric Power Company "Amounts equivalent to Wheeling Charges, etc."
https://www.tepco.co.jp/ep/private/plan2/chargelist06.html

Tokyo Electric Power Company "Overview of Facilities"
https://www.tepco.co.jp/niigata_hq/kk-np/profile/outline/index-j.html#:%7E:text=%E6%9F%8F%E5%B4%8E%E5%88%88%E7%BE%BD%E5%8E%9F%E5%AD%90%E5%8A%9B%E7%99%BA%E9%9B%BB%E6%89%80%E3%81%AF%E3%80%81%E6%96%B0%E6%BD%9F%E7%9C%8C%E3%81%AE%E6%9F%8F%E5%B4%8E%E5%B8%82%E3%81%A8%E5%88%88%E7%BE%BD%E6%9D%91%E3%81%AB%E3%81%BE%E3%81%9F%E3%81%8C%E3%81%A3%E3%81%A6%E7%AB%8B%E5%9C%B0%E3%82%92%E3%81%95%E3%81%9B%E3%81%A6%E3%81%84%E3%81%9F%E3%81%A0%E3%81%84%E3%81%A6%E3%81%84%E3%81%BE%E3%81%99%E3%80%82,%E7%B7%8F%E6%95%B7%E5%9C%B0%E9%9D%A2%E7%A9%8D%E3%81%AF420%E4%B8%87m2%E3%81%A7%E3%80%81%E6%9D%B1%E4%BA%AC%E3%83%89%E3%83%BC%E3%83%A0%E7%B4%8490%E5%80%8B%E5%88%86%E3%81%AB%E7%9B%B8%E5%BD%93%E3%81%97%E3%81%BE%E3%81%99%E3%80%82%20%E6%9F%8F%E5%B4%8E%E5%B8%82%E5%81%B4%E3%81%AB1%EF%BD%9E4%E5%8F%B7%E6%A9%9F%E3%80%81%E5%88%88%E7%BE%BD%E6%9D%91%E5%81%B4%E3%81%AB5%EF%BD%9E7%E5%8F%B7%E6%A9%9F%E3%80%81%E5%90%88%E8%A8%887%E3%81%A4%E3%81%AE%E7%99%BA%E9%9B%BB%E8%A8%AD%E5%82%99%E3%81%8C%E8%A8%AD%E7%BD%AE%E3%81%95%E3%82%8C%E3%81%A6%E3%81%8A%E3%82%8A%E3%80%81%E7%B7%8F%E5%87%BA%E5%8A%9B%E3%81%AF821%E4%B8%872%E5%8D%83kW%E3%81%A71%E3%81%A4%E3%81%AE%E7%99%BA%E9%9B%BB%E6%89%80%E3%81%A8%E3%81%97%E3%81%A6%E3%81%AF%E4%B8%96%E7%95%8C%E6%9C%80%E5%A4%A7%E7%B4%9A%E3%81%A7%E3%81%99%E3%80%82

Tokyo Electric Power Company "Charges, etc."
https://www.tepco.co.jp/ep/renewable_energy/institution/impost.html

Tokyo Electric Power Grid (2024) The Role and Challenges of the Power System in Achieving GX and DX Simultaneously
https://www.cas.go.jp/jp/seisaku/gx_jikkou_kaigi/gx2040/20240723/siryou5.pdf

Yuji Matsuo (2024) Evaluation of Power Generation Costs by Power Source
https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/mitoshi/cost_wg/2024/data/01_08.pdf

Ministry of Economy, Trade and Industry (2021) Basic Energy Plan
https://www.meti.go.jp/press/2021/10/20211022005/20211022005-1.pdf

Ministry of Economy, Trade and Industry (2023) Summary of Energy Supply and Demand Results for FY2022 (preliminary figures)

https://www.meti.go.jp/press/2023/11/20231129003/20231129003.html
Ministry of Economy, Trade and Industry (2023) Electric Power Survey and Statistics Table 1-(1) Number of Power Plants and Output of Electric Utilities
https://www.enecho.meti.go.jp/statistics/electric_power/ep002/xls/2023/1-1-2023.xlsx
Ministry of Economy, Trade and Industry (2023) Investment Strategy by Sector
https://www.meti.go.jp/press/2023/12/20231222005/20231222005.html
Ministry of Economy, Trade and Industry (2023) Status of Investment Promotion Policies in Foreign Countries
https://www.meti.go.jp/shingikai/economy/corporate_behavior/pdf/001_04_00.pdf
Ministry of Economy, Trade and Industry (2024) Tax system to promote domestic production in strategic fields
https://www.meti.go.jp/policy/economy/kyosoryoku_kyoka/senryaku_zeisei.html
Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (2019) Status of measures to achieve the hydrogen and fuel cell strategic roadmap
https://www.meti.go.jp/shingikai/energy_environment/suiso_nenryo/roadmap_hyoka_wg/pdf/001_03_00.pdf
Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (2020) Status of measures to achieve the hydrogen and fuel cell strategic roadmap
https://www.meti.go.jp/shingikai/energy_environment/suiso_nenryo/roadmap_hyoka_wg/pdf/002_01_00.pdf
Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (2023) Annual report on energy
https://www.enecho.meti.go.jp/about/whitepaper/2024/pdf/whitepaper2024_all.pdf
Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry (2024) The State of Energy
https://www.enecho.meti.go.jp/committee/council/basic_policy_subcommittee/2024/055/055_004.pdf
Statistics Bureau, Ministry of Internal Affairs and Communications (2024) The State of Prefectures as Seen in Statistics
https://www.stat.go.jp/data/k-sugata/pdf/all_ken2024.pdf
Electricity Transmission and Distribution Network Council (2021) Technical Issues Arising from the Decline in Synchronous Power Sources
https://www.tdgc.jp/information/docs/2785aa13a30ecb96df84519f3c93308a03b20f9c.pdf
Federation of Electric Power Companies of Japan (2023) Achieving a Balance between Thermal Power Generation, which is Essential for Stable Supply, and Decarbonization
https://www.fepc.or.jp/enelog/focus/vol_61.html
The Denki Shimbun (2020) How do we ensure inertia function? This is the key to expanding the introduction of renewable energy
https://www.denkishimbun.com/sp/50923
The Denki Shimbun (2019) The steel industry is on the verge of becoming CO_2-free through technological innovation in electric furnaces. If this is achieved, it will also become a large-scale adjustment force for renewable energy
https://www.denkishimbun.com/sp/45183

* The titles of some references are provisional translations since they are originally in Japanese.

Corporate names referred in this whitepaper

Abbreviated Company Names	Official Company Names
Adobe	Adobe Inc.
Aera	Aera Energy LLC
AGC	AGC Inc.
Air Liquide	L'Air Liquide S.A.
airbnb	Airbnb, Inc.
Ajinomoto	Ajinomoto Co., Inc.
Apple	Apple Inc.
Archeda	Archeda, Inc.
ArkEdge Space	ArkEdge Space Inc.
Asahi Kasei	Asahi Kasei Corporation
Asrc	ASRC Energy Services, Inc.
Avangrid	Avangrid, Inc.
BASF	BASF SE
Battelle	Battelle Memorial Institute, Inc.
Bloomberg	Bloomberg L.P.
BMW/Mini	Bayerische Motoren Werke Aktiengesellschaft
BP	BP p.l.c
BURBERRY	Burberry Group plc.
Carbon Capture	Membrane Technology and Research, Inc.
Central Glass	Central Glass Co., Ltd
CHANEL	Chanel S.A.
Changan	Chongqing Changan Automobile Company Limited
Chevron	Chevron Corporation
City Water, Light & Power	City Water, Light & Power
Cosmo Oil	Cosmo Energy Holdings Co., Ltd

Abbreviated Company Names	Official Company Names
Daimler	Mercedes-Benz Group AG
Denso	Denso Corporation
DKS	DKS Co., Ltd
Duke Energy Indiana	Duke Energy Indiana, LLC
ENEOS	ENEOS Holdings Inc.
Engie	Engie SA
Entergy	Entergy Corporation
Epri	Electric Power Research Institute, Inc.
Eversource energy	Eversource Energy
ExxonMobil	Exxon Mobil Corporation
Fervo	Fervo Energy Company
Fiat Chrysler	Stellantis N.V.
Ford	Ford Motor Company
Forest Value	Forest Value Inc
GAC	Guangzhou Automobile Group Co., Ltd.
Geely	Geely Automobile Holdings Limited
General Electric	General Electric Company
GHGSat	GHGSat Inc.
GM/General Motors	General Motors Company
Google	Alphabet Inc.
Great Wall	Great Wall Motor Company Limited
HEPCO	Hokkaido Electric Power Co., Inc.
Honeywell UOP	Honeywell UOP Inc.
Hyundai	Hyundai Motor Company
Idemitsu	Idemitsu Kosan Co., Ltd
INPEX	Inpex Corporation

Abbreviated Company Names	Official Company Names
ION Clean Energy	ION Clean Energy, Inc.
Iwatani	Iwatani Corporation
JAPEX	Japan Petroleum Exploration Co., Ltd
JERA	JERA Co., Inc.
JFE Steel	JFE Steel Corporation
Jianghuai Automobile (JAC)	Anhui Jianghuai Automobile Group Co., Ltd.
JR-East	East Japan Railway Co., Ltd
JX Nippon Oil&Gas	JX Nippon Oil & Gas Exploration Corporation
Kaneka	Kaneka Corporation
Kao	Kao Corporation
Kawasaki Heavy Indust.	Kawasaki Heavy Industries Ltd
Kawasaki Kisen Kaisha	Kawasaki Kisen Kaisha Ltd
Kia	Kia Corporation
Kyocera	Kyocera Corporation
Kyushu Elec	Kyushu Electric Power Co., Inc.
Lehigh Hanson	Heidelberg Materials US, Inc.
Linde Group	Linde plc
Lion Chem	Lion Chemical Co.,Ltd.
Mahindra & Mahindra	Mahindra & Mahindra Limited
Maxar	Maxar Technologies Inc.
MAZDA	Mazda Motor Corporation
Meta	Meta Platforms, Inc.
Microsoft	Microsoft Corporation
Mitsubishi & Co	Mitsubishi Corporation
Mitsubishi Chem	Mitsubishi Chemical Group Corporation
Mitsubishi Corp	Mitsubishi Corporation
Mitsubishi Electric	MITSUBISHI ELECTRIC CORPORATION
Mitsubishi Electric Corp.	MITSUBISHI ELECTRIC CORPORATION
Mitsubishi Gas Chem	Mitsubishi Gas Chemical Company Inc.

Abbreviated Company Names	Official Company Names
Mitsubishi Heavy Industries	Mitsubishi Heavy Industries Ltd
Mitsubishi Materials	Mitsubishi Materials Corporation
Mitsui OSK Lines	MITSUI O.S.K.LINES,LTD.
MTR CARBON CAPTURE	Membrane Technology and Research, Inc.
Nagoya Electric Works	Nagoya Electric Works Co., Ltd
National grid	National Grid plc
Navajo Transitional Energy Company	Navajo Transitional Energy Company, LLC
NEC	NEC Corporation
Nestle	Nestlé S.A.
Nikki	JGC Holdings Corporation
Nikon	Nikon Corporation
Nippon Steel	Nippon Steel Corporation
Nippon Yusen	NIPPON YUSEN KABUSHIKI KAISHA
Nissan	Nissan Motor Co., Ltd.
Nokia	Nokia Oyj
NTT	Nippon Telegraph & Telephone Corporation
NYK Line	NIPPON YUSEN KABUSHIKI KAISHA
Ocean Network Express(ONE)	Ocean Network Express Pte. Ltd.
Oji paper	Oji Paper Co., Ltd.
Orsted	Ørsted A/S
Osaka Gas	Osaka Gas Co., Ltd
OW Ocean Winds	OW Offshore S.L.
Oxy	Occidental Petroleum Corporation
Rapidus	Rapidus Corporation
Renault	Renault SA
Resonac	Resonac Holdings Corporation
Rhode Island Energy	The Narragansett Electric Company
Saibu Gas	Saibu Gas Holdings Co., Ltd

Abbreviated Company Names	Official Company Names
SAIC	SAIC Motor Corporation Limited
Santos	Santos Ltd.
SDS	Satellite Data Services Co., Ltd.
Sempra Infrastructure Net Zero	Sempra Infrastructure Net Zero Holdings LP
Shell	Shell plc
Shikoku Elec	Shikoku Electric Power Co., Inc.
Shimizu Corp.	Shimizu Corporation
Showa Yokkaichi Sekiyu	SHOWA. YOKKAICHI. SEKIYU CO.,LTD.
Siemens Energy	Siemens Energy AG
Softbank	Softbank Group Corporation
Sony	Sony Group Corporation
Southern States	Southern States Energy Board
Sumitomo Chem	Sumitomo Chemical Co., Ltd
Sunflame	SUNFLAME.CO.,LTD
Taiheiyo Cement	Taiheiyo Cement Corporation
Takasago Thermal	Takasago Thermal Engineering Co., Ltd
Tampa Electric	Tampa Electric Company
TEPCO	Tokyo Electric Power Company Holdings Inc.
TES	Tree Energy Solutions Belgium BV
Tesla	Tesla, Inc.

Abbreviated Company Names	Official Company Names
Toda Corp	Toda Corporation
Toho Gas	Toho Gas Co., Ltd
Tohoku Electric	Tohoku Electric Power Co., Inc.
Tokuyama	Tokuyama Corporation
Tokyo Gas	TOKYO GAS CO.,LTD.
Tokyu Real Estate	Tokyu Fudosan Holdings Corporation
Toshiba	TOSHIBA CORPORATION
Tosoh	TOSOH CORPORATION
Total Energies	TotalEnergies SE
Toyota	Toyota Motor Corporation
Toyota Hokkaido	TOYOTA MOTOR HOKKAIDO,INC.
Toyota Motor	TOYOTA MOTOR CORPORATION
Toyota Tsusho	TOYOTA TSUSHO CORPORATION
TSMC	Taiwan Semiconductor Manufacturing Co., Ltd.
Unilever	Unilever PLC
Vodafone	Vodafone Group Public Limited
VW	Volkswagen AG
YKK AP	YKK AP Inc.

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