JAPANS OFFSHORE WIND MARKET COST REDUCTION STUDY TO 2050

April 2021

GWEC
GLOBAL WIND ENERGY COUNCIL

JWPA

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Attribution
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About the Global Wind Energy Council

Global Wind Energy Council (GWEC) is a member-based organisation that represents the entire wind energy sector. The members of GWEC represent over 1,500 companies, organisations and institutions in more than 80 countries, including manufacturers, developers, component suppliers, research institutes, national wind and renewables associations, electricity providers, finance and insurance companies.

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About the Japan Wind Power Association

As Japan's leading wind power industry group with over 400 members, we carry out and support all activities to achieve our vision of wind as an important power source in Japan's long-term energy supply and demand.

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Mitsubishi Research Institute, Inc.

About Mistubishi Research Institute

Mitsubishi Research Institute (MRI) is the leading think tank & consulting company in Japan.We research, conceptualize, and design a desirable future world and action plans for its realization and implement those plans in society in collaboration with customers and partners. Through this Value Creation Process, we help to realize a desirable future world. In renewable energy area including offshore wind, MRI works closely with the Japanese government, local governments and related companies. We act as a bridge between Japan and overseas, stimulating industries both domestically and abroad by drafting and implementing strategies to achieve sustainable future.

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BVGassociates

About BVG Associates

BVG Associates provides strategy consulting in the wind industry, globally. We combine deep wind industry knowledge with approaches from the world of business consulting. We help our clients succeed in a sustainable global electricity system founded on renewable.

BVG Associates was formed in 2006 and plays a key role globalising offshore wind:

- We have a client base including customers of all sizes active wherever the wind industry is active.
- We have published many landmark reports on the future of the industry, cost of energy and supply chain.
- BVGA was named as one of UK's Leading Management Consultants by the Financial Times, February 2021.

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Definitions

WACC: Weighted average cost of capital

JWPA: Japan Wind Power Association

GWEC: Global Wind Energy Council

BVGA: BVG Associates

MRI: Mitsubishi Research Institute

MW: Megawatts

GW: Gigawatts

O&M: Operations and Maintenance – the offshore wind project lifecycle stage which follows commissioning of the project

FIT: Feed-in Tariff – a policy to support renewable energy development by providing a guaranteed price on a long-term contract to generators

FIP: Feed-in Premium – a policy to support renewable energy development by providing a premium payment on top of the wholesale market price to generators

GHG: Greenhouse gas

PDCA: Plan, Do, Check, Adjust – a method for managing a business process.

LCOE: Levelized Cost of Electricity – the average cost of electricity generation over the lifetime of a plant. In this study, we calculate LCOE in accordance with the definition of METI method, with 3% discount rate and including property tax, in order to compare to its cost target (the cost of onshore/fixed type offshore in 2030 : 8 to 9 yen/kWh)

METI: Ministry of Economy, Trade and Industry in Japan

TWh: Terawatt hours

R&D: Research and Development

Note on currency conversion:
Any conversions to USD assume a rate of 1 USD = 103.79 JPY, at the time of writing.

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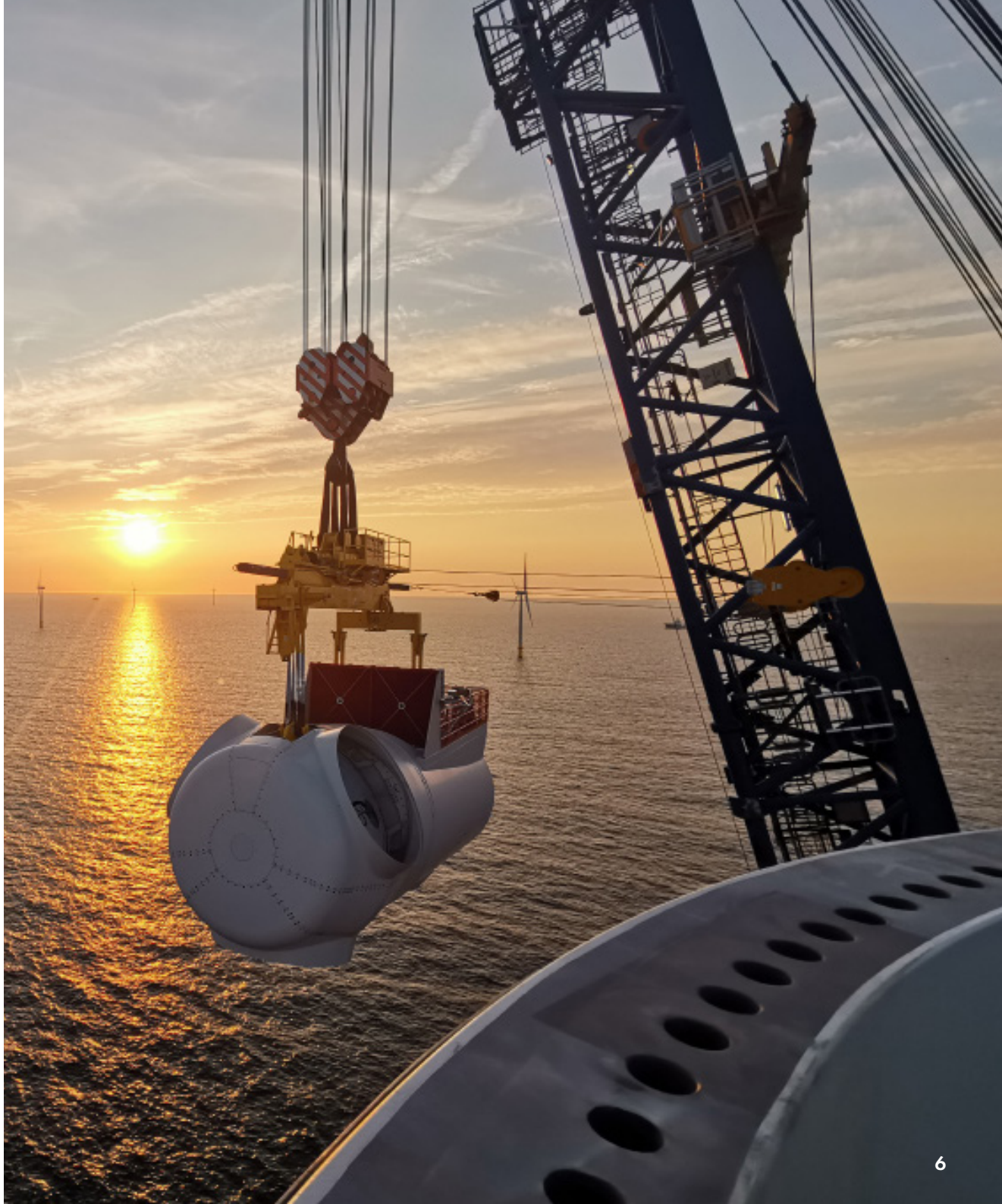

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Foreword

Memories are still fresh of the adoption of the Paris Agreement at COP21 in December 2015, which prompted a worldwide shift in national energy policies and marked a significant change of course toward promoting the large-scale introduction of renewable energy. Under the Biden administration, the US has decided to re-join the agreement. In many countries, offshore wind power is expected to play a core role in generating such renewable energy.

The impacts of the COVID-19 pandemic are currently disrupting public life around the world and severely affecting economic activity and employment. Green recovery that leverages investment in renewable energy is drawing attention as an effective policy response to the pandemic. In Japan, too, energy policy based on the assumption of large-scale introduction of renewable energy is being discussed as part of developing mid- to long-term growth strategy for 2050. Extensive introduction of offshore wind power is positioned as a key pillar of such efforts.

Offshore wind power is expected to play three crucial roles in Japan: form part of climate change responses, contribute to energy security by improving primary energy self-sufficiency, which had fallen to around 12% as of 2018, and aid new growth strategies. In particular, it is expected to generate new employment by creating new industries and building supply chains of related industries in Japan, where such industries scarcely exist at present.

Turning to the role that offshore wind power should play, in 2020 the Japanese government (Ministry of Economy, Trade and Industry and Ministry of Land, Infrastructure and Transport) established a public-private council, which agreed on a "Vision for Offshore Wind Power Industry" published in December 2020. This vision sets out three basic strategies on the enhancement of industrial competitiveness for offshore wind power generation: (1) attractive domestic market creation, (2) investment promotion and supply chain establishment, and (3) next-generation technology development and cross-border collaboration with a view to expansion into Asia. To achieve these basic strategies, the public and private sectors have set the following numerical targets for offshore wind power introduction:

1. Government targets: Generating projects of 10 GW by 2030 and 30–45 GW, including floating offshore wind, by 2040
2. Industry targets: Increase domestic procurement ratio to 60% by 2040. Reduce cost of fixed-bottom offshore wind turbine-generated power to 8–9 yen/kWh by 2030–2035

These are ambitious targets compared to other developed countries, and are expected to attract more players into the market and accelerate progress toward cost reduction and development of the domestic industry. However, many challenges must be overcome to achieve both cost reduction and domestic industry development and meet the targets. These include improving bidding processes to make them more rational and efficient, easing regulations, streamlining systems, and developing infrastructure such as electricity grids, ports, and harbors, as well as training personnel and establishing qualification systems for new industries. It is vital to take necessary measures in an appropriate sequence and a timely manner. JWPA aims to establish the foundation of the industry over the next 10 years, develop an internationally competitive industry in the early 2030s, and achieve the three goals for installed capacity, costs, and domestic procurement ratio. As an industry, we are committed to realizing these capacity targets, contributing to achievement of Japan's "3E+S" energy policy objectives, and aiming for offshore wind power to lead Japan's green recovery.

Jin Kato,
President, JWPA

Foreword

2021 marks the start of an exciting new period in Japan's clean energy transition: the era of offshore wind. This is a long-awaited moment, resulting from several years of dedicated efforts by the wind industry – represented by JWPA and GWEC – and policymakers to create the right conditions for the take-off of this key energy sector in Japan.

In December last year, building upon the evidence presented in this cost reduction study, METI made a landmark commitment to install 10 GW of offshore wind by 2030 and up to 45 GW by 2040 in its Offshore Wind Industry Vision. As one of the largest national capacity targets set to date, this sends a decisive market signal about the prominent role which offshore wind will play in Japan's energy mix.

The Vision outlined a cost reduction and industrial growth pathway, which will usher in nationally significant investments in the domestic supply chain, development of next-generation technology and strategic planning for grid and port transformation.

Achieving the Vision will require urgent and consistent work on the ground. Delivering 10 GW in the next decade will only be possible with a regular pace of auctions, steady delivery of projects in the pipeline and long-term planning on grid and port buildout. Permitting and consenting schemes, particularly in the environmental impact assessment phase, will need to be streamlined to ensure a consistent flow of investment into the supply chain.

At the same time, industry and government must work closely together in Japan to ensure that offshore wind is expanded in harmony with coastal communities and the natural ocean environment. The success of domestic supply chain development will also depend on openness to collaboration, particularly in floating technology, and the inclusivity of the future offshore wind workforce.

As one of the leading carbon-emitters globally, Japan has set a high ambition to shift away from coal-fired and other fossil fuel generation and reach net zero by 2050. Offshore wind is a solution of choice to support this transition, given the country's large industrial power demands and landscape of densely populated islands. Complemented by strategies for electrification of industry, transport and buildings, as well as market mechanisms like carbon pricing, offshore wind can be the key pillar for Japan's decarbonisation commitments.

The clean energy transition is now an unstoppable force worldwide. However, change is not happening at the pace and scale required for us to meet our Paris targets. As outlined in the Global Wind Report 2021, annual wind energy installations need to triple over the next decade to stay on-track for a net zero pathway by 2050.

Japan's pivot to offshore wind is an achievement for the whole global wind industry, reflecting the sector's advantages as a large-scale, clean and secure energy resource to displace fossil fuels. We will need this level of ambition adopted in countries across the world for wind and renewable energy to scale up to the levels needed. The conditions have been set for offshore wind to take off. We look forward to continuing to work together to deliver on its promise in Japan.

Ben Backwell
CEO, Global Wind Energy Council

Executive Summary

In October 2020, Japan announced the country's goal of achieving carbon neutrality by 2050. In order to realise this goal, the government has commited to fundamental review of its policy on the use of coal-fired power plants, and the construction of nuclear power plants is not supported by Japan's citizens. Therefore, offshore wind power will need to play a key role in Japan's energy future and on the country's path to achieving net zero.

Under its 2018 Basic Energy Plan, Japan is targeting 2.2 TWh of offshore wind generation by 2030. This plan is set to be revised in 2021, with the expectation that far more ambitious and longer-term targets can be set to accelerate the development of offshore wind. In 2020, new promotion zones and an initial small tender for offshore wind were introduced, paving the way for the sector to take off from 2025 onward. A series of Public-Private Dialogues was also established to promote offshore wind development and resolve existing market barriers. As Japan constructs its road to carbon neutrality by 2050, fixed and floating offshore wind are well-positioned to provide large-scale volumes of affordable clean energy and sustainable economic growth.

This report and cost reduction study, commissioned by the Japan Wind Power Association and Global Wind Energy Council, have two main objectives:

1. Outline pathways for cost reduction and enhancement of domestic offshore wind industry competitiveness, and the necessary measures required to achieve them.
2. Summarize a roadmap of recommendations to maximize cost reduction and domestic offshore wind industry competitiveness, which can be jointly undertaken by the public and private sectors.

Mitsubishi Research Institute, Inc. (MRI) and BVG Associates (BVGA) were engaged to carry out the cost reduction study, and deliver quantitative analysis and recommendations to establish a cost-competitive domestic supply chain while reducing the costs of offshore wind in the long term. This work was undertaken in recognition of the importance to promote industrial policies that will enable the formation of internationally competitive domestic supply chains, and to balance the trade-off between long-term cost reduction and short-term cost increases to develop domestic industrial capacity. The report identifies three underlying measures for public and private sector cooperation:

Underlying Measure	Implementation areas
Development of a large-scale, stable and highly visible market	• Setting large and long-term targets • Stable operation of an auction system and FIT/FIP system • Development of port and grid infrastructure
Streamlined and transparent regulations consistent with the global market	• Rationalization of grid interconnection rules • Standardization of certification standards • Streamlining relevant regulatory frameworks and institutions
Industrial policies to foster a cost-competitive domestic industry	• Development of a vision for the offshore wind industry • Public-private sector dialogues on an ongoing basis • Support for technology and product development, as well as personnel training and skills programs

Findings

Based on the experience of leading offshore wind markets in Europe and the results of the questionnaire and interviews, in order to achieve LCOE of 8-9JPY/kWh, it is necessary for the government to formulate sufficient market ambition. This ambition should be **more than 1GW/year up to 2030, and more than 2-4 GW/year up to 2040**, in order to accelerate the entry of related industries and strengthen the competitiveness of domestic industries. The following two scenarios are based on this concept. These scenarios can be realized by the government taking necessary measures, as outlined in Chapter 4, and stimulating private investment.

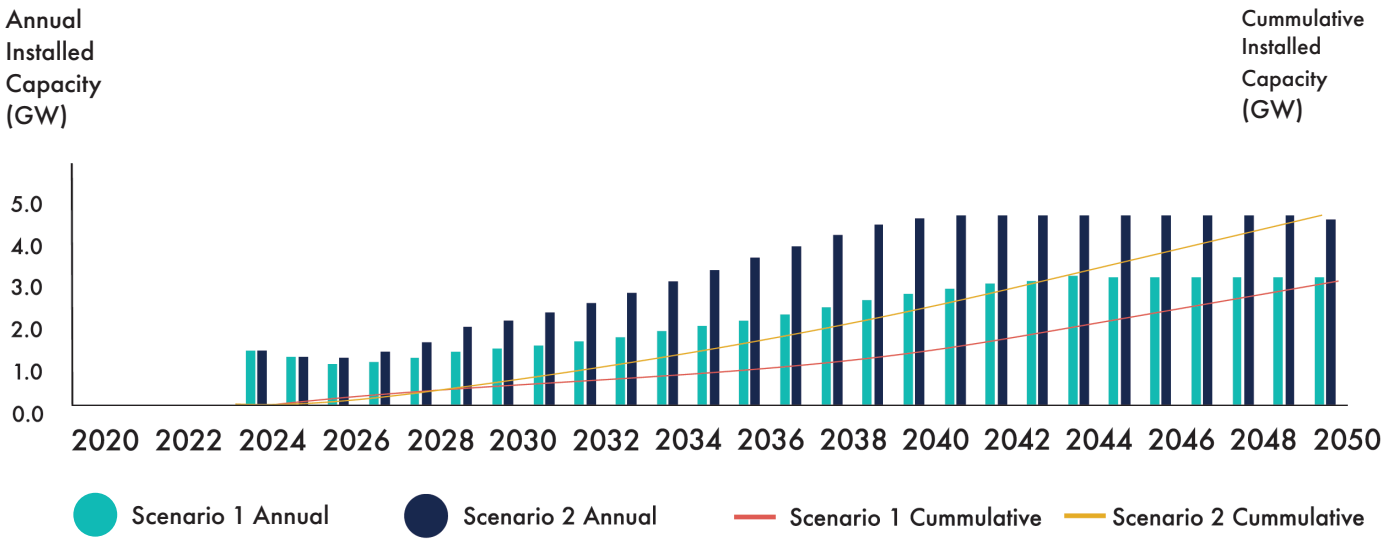
Scenario 1

Bidding of approximately **1GW/year up to 2030.** The development of domestic supply chains will progress, and cost reductions will progress to a certain extent between 2030 and 2035. By 2050, a cumulative capacity of 60GW of fixed-type and floating-type can be installed.

Scenario 2

Bidding of about **2GW/year up to 2030.** The development of domestic supply chains and market-specific innovation will progress rapidly, accelerating cost reduction. Grid parity will be achieved between 2030 to 2035. By 2050, a cumulative capacity of 90GW of fixed-type and floating-type can be installed.

Figure 1: Volume of installation capacity by scenario

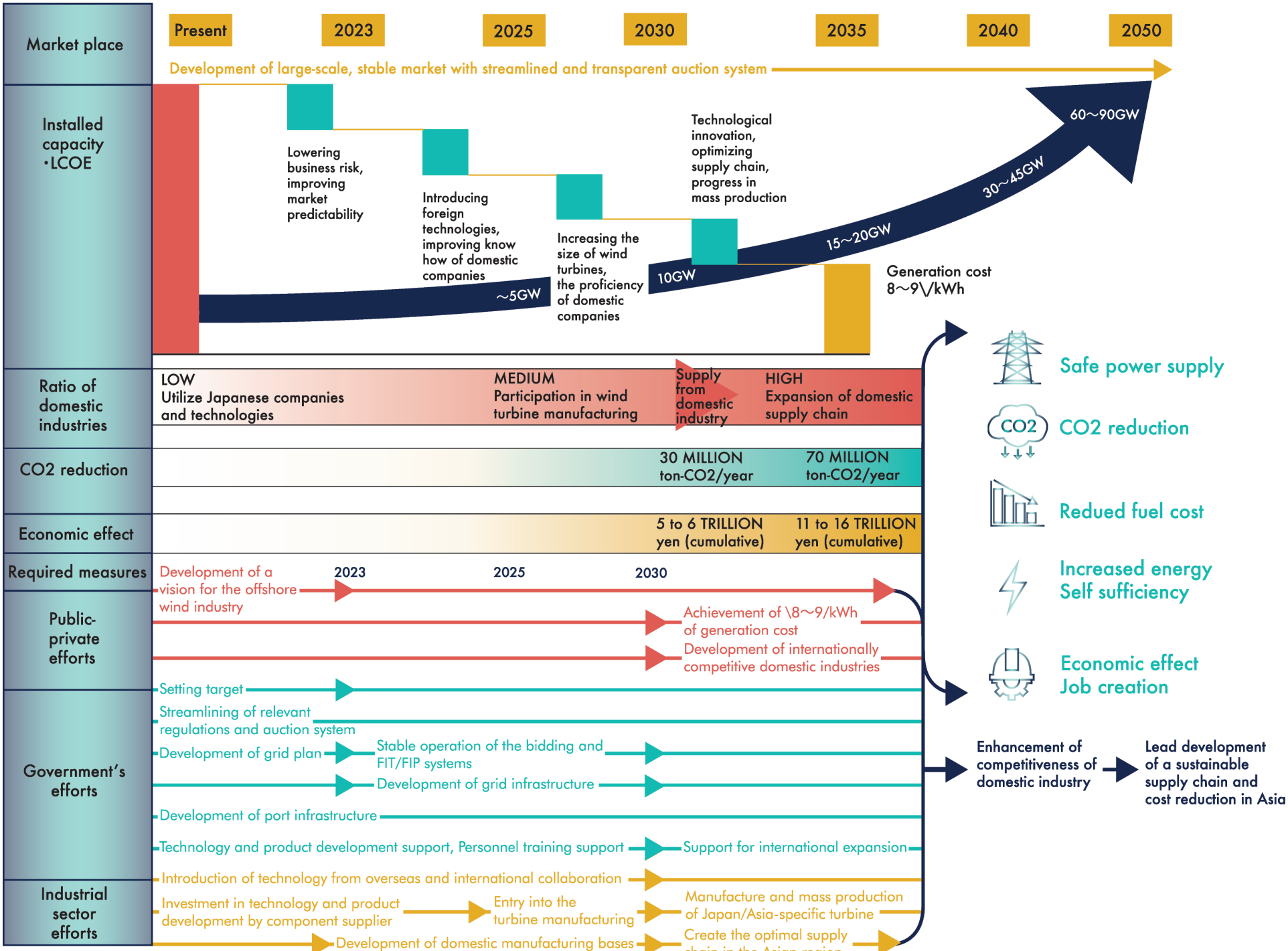


		2030	2035	2040	2050	
Fixed	Scenario 1	Approx. 8GW	Approx. 13GW	Approx. 20GW	Approx. 30GW	Scenario 1 60GW
	Scenario 2	Approx. 9GW	Approx. 20GW	Approx. 30GW	Approx. 40GW	
Floating	Scenario 1	Approx. 1GW	Approx. 4GW	Approx. 10GW	Approx. 30GW	Scenario 2 90GW
	Scenario 2	Approx. 1.2GW	Approx. 6GW	Approx. 15GW	Approx. 50GW	

By carrying out the recommendations outlined in Chapter 4 of this report in a timely manner, and ensuring channels of public-private cooperation are sustained on an ongoing basis, we believe **the target of 8-9 JPY/kWh can be achieved between 2030 and 2035**, if not before. By 2035, this pathway could deliver **15-20 GW of offshore wind capacity, 11-16 JPY trillion in cumulative economic effects, as well as a reduction of 70 million tons of CO2 on an annual basis.** Depending on the measures implemented, Japan's offshore wind capacity could total from **60-90GW by 2050, across both fixed and floating offshore wind installations.**

The development of the offshore wind market and industry will bring benefits such as **reliable power supply, CO2 reductions, higher energy self-sufficiency, reduced expenditures for fossil fuel procurement and substantial economic effects and job creation,** all of which are directly linked to the 5th Basic Energy Plan, as well as to green economic recovery plans from COVID-19. It will be vital that each recommendation outlined is advanced and materialized through discussions in the existing public-private sector dialogues and a long-term vision for offshore wind is urgently formulated by government and other stakeholders.

Figure 2: Pathway and recommendations for cost reduction and development of competitive domestic industry



Chapter 1

Introduction and Methodology

Introduction

Japan initiated the offshore wind market in Asia with a small 1.2 MW project off Setana Port in 2003. While capacity in the country only reached 21 MW by the end of 2019, several markets in the region have gained a foothold in the sector, including in China, South Korea and Vietnam. This growth has been driven by increasing public commitments to renewable energy, combined with the value proposition of offshore wind as a scalable, affordable, clean and reliable energy source with far-reaching socioeconomic benefits.

Japan is now set to reclaim a leading position in the sector, targeting 2.2 TWh of offshore wind generation by 2030 under its 2018 Basic Energy Plan. This plan is set to be revised in 2021, with the expectation that far more ambitious and longer-term targets can be set to accelerate the development of offshore wind. In 2020, new promotion zones and an initial small tender for offshore wind were introduced, paving the way for the sector to take off from 2025 onward. A series of Public-Private Dialogues was also established to promote offshore wind development and resolve existing market barriers.

Japan is now set to reclaim a leading position in the sector, targeting 2.2 TWh of offshore wind generation by 2030 under its 2018 Basic Energy Plan.

As a result of these dialogues, Japan has now declared a new ambitious offshore wind target: 10 GW by 2030 and 30GW – 45 GW by 2040 - in the "Offshore Wind Power Industry Vision", announced at the second Public-Private Dialogues held on 15 December 2020. As Japan constructs its road to carbon neutrality by 2050, fixed and floating offshore wind are well-positioned to provide large-scale volumes of clean energy and sustainable economic growth.

In order to support long-term, cost-competitive offshore wind industry development, JWPA and GWEC commissioned this report and cost reduction study with two main objectives:

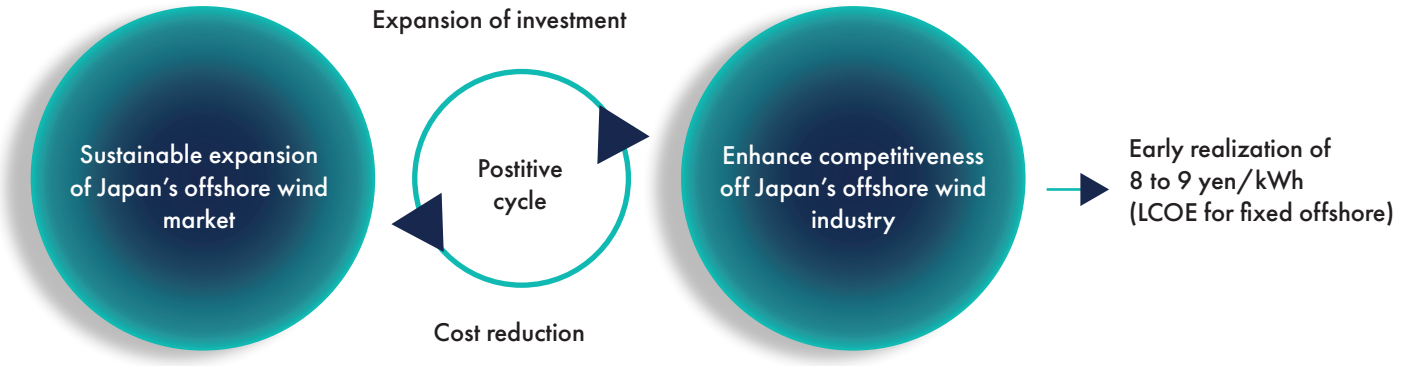
1. Outline pathways for cost reduction and enhancement of domestic offshore wind industry competitiveness, and the necessary measures required to achieve them.
2. Summarize a roadmap of recommendations to maximize cost reduction and domestic offshore wind industry competitiveness, which can be jointly undertaken by the public and private sectors.

MRI and BVGA hold deep insights and knowledge of the global offshore wind market, cost reduction case studies and Japan's offshore wind market, policy and industry trends. They were engaged to carry out the cost reduction study, and deliver quantitative analysis and recommendations to establish a cost-competitive domestic supply chain while reducing the costs of offshore wind in the long term.

The report sought to create a set of recommendations which could form positive cycle of reinforcing efforts from the public and private sectors. This work was undertaken in recognition of the importance to promote industrial policies that will enable the formation of internationally competitive domestic supply chains, and to balance the trade-off between long-term cost reduction and short-term cost increases to develop domestic industrial capacity.

The goal of this work extended beyond growing the offshore wind market and industrial competitiveness in Japan, to early realization of the LCOE target of 8-9 JPY/kWh for fixed-bottom offshore wind.

Figure 3: Goals to be realized in cooperation between the public and private sectors



Methodology

In order to understand the issues and measures needed to accelerate the offshore wind market in Japan, MRI and BVGA conducted a questionnaire survey and interview survey with various stakeholders, mainly JWPA members which constitute the offshore wind industry in Japan and overseas. The survey received responses from 100 companies. The survey asked questions on the challenges of the offshore wind industry and necessary measures for its development in Japan, which were then substantiated through gathering of opinions and information from a wide range of perspectives for this study. In particular, with regard to costs, MRI and BVGA conducted a survey for each supply chain element and analyzed current and future costs based on the results of the survey.

Overview of survey and interviews

Survey Respondent		Companies related to wind power - Power utility - company - Turbine manufacturer - Components supplier - EPC - Shipping company - O&M company - Research and consulting firm - Financial institution - Insurance company
Questionnaire survey	Number of distributions	401 companies
	Number of collected	100 companies
	Response rate	25%
Interviews		20 - 25 companies

In the interview stage, which covered around 25 companies, a wide range of opinions were collected on the answers to the questionnaire survey and issues and necessary measures for cost reduction.

In parallel, this study also mapped out the impacts of various policies which have achieved LCOE and expansive offshore wind growth in leading offshore wind markets in Europe and Asia. Lessons for the Japan context were taken from this mapping exercise.

As Japan constructs its road to carbon neutrality by 2050, fixed and floating offshore wind are well-positioned to provide large-scale volumes of affordable clean energy and sustainable economic growth.

Key questions in the Questionnaire survey

Questions on costs of offshore wind

- Cost level for developing a wind farm now in Japan
- Factors affecting costs in Japan
- Cost reduction potential in the future
- Important measures and market size for cost reduction

INPUT

Future cost analysis of offshore wind in Japan

Questions on challenges and necessary measures

- Status and intention to enter the Japanese offshore wind market
- Measures needed to accelerate entry into the offshore wind market

INPUT

Challenges of the offshore wind industry and necessary measures for its development

Chapter 2

The global experience of offshore wind cost reduction

2.1. Policy impacts on LCOE in leading offshore wind markets

Leading markets for offshore wind in Europe have adopted competitive environments, and fostered a long-term and stable regional market based on clear targets and strong commitment to innovation. They have typically avoided high local content requirements – this has been key to the cost reduction achieved.

Figure 4: Policy impacts of LCOE in leading offshore wind markets

Country	Competitive environment	Strong and stable market	Innovation and new products	Good coastal infrastructure	Local content requirements
Denmark	High	Medium (1.6GW by the end of 2020; 3.5GW forecast by 2025) (Target: 5.3GW by 2030)	Strong historical turbine R&D capability	Good. Esbjerg is one of the leading offshore wind ports	No requirements but national culture of collaboration within Danish supply chain, where possible
France	Weak	Low (no commercial projects by the end of 2020; 3.5GW forecast by 2025) (Target: 8.75GW by 2028)	Limited	Weak, reflecting current market status	Heavy requirements in early leasing rounds have slowed market and the government is likely to relax these to stimulate the market
Germany	High	High (7.6GW by the end of 2020; 11.0GW forecast by 2025) (Target: 20GW by 2030, 40GW by 2040)	Strong historical R&D capability in turbines and many other areas of supply	Medium. Bremerhaven and Cuxhaven were significant early movers but have not capitalised on this lead	No requirements but strong, competitive supply chain already established, including via onshore wind
Netherlands	High	Medium (2.0GW by the end of 2020; 6.5GW forecast by 2025) (Target: 11.5GW by 2030)	Strong capability in offshore engineering product development	Strong. Several ports active and well located for the industry	No requirements with the government confident that its companies can compete in selected areas
United Kingdom	High	High (10GW by the end of 2020; 22.5GW forecast by 2025) (Target: 40GW by 2030)	Some blade R&D and significant public/industry collaborations	Medium. Several ports have been used but investment has been limited	No requirement but there is a local content reporting framework and developers make small concessions to procure in the UK Government applies pressure for increased local supply
USA	High	Medium (no commercial projects by the end of 2020; 9.0GW forecast by 2025)	Limited though significant investment in federal R&D	Weak. US ports have significant limitations in size and location.	More onerous requirements in New York and Maryland Limits on the use of global vessels will impact costs and risks
Taiwan	Medium (high at developer level; lower in areas of the supply chain)	Medium (1.1GW by the end of 2020; 9.4GW forecast by 2025) (Target: 15GW by 2035)	Low. The market is likely to rely on innovations in the global supply chain	Medium. Industrial ports with potential but investment needed	High requirements specified by government

Positive effect on LCOE Neutral effect on LCOE Negative effect on LCOE

2.2. Lessons learned on key factors affecting cost reduction

Based on the mapping exercise for impacts of policies on LCOE, leading offshore wind markets, several key lessons can be adopted for an emerging offshore wind market. Balancing these factors and their respective upward or downward pressures on LCOE necessitates a holistic and comprehensive approach for governments wishing to foster long-term cost reduction. This in turn will require coordination across different ministries and governmental bodies.

Balancing these factors and their respective upward or downward pressures on LCOE necessitates a holistic and comprehensive approach for governments wishing to foster long-term cost reduction.

Figure 5: Lessons learned on key factors affecting cost reduction

Key factor	Importance	Lesson learned
Competitive environment	Competition, especially between project developers, has had a significant effect on LCOE. It has driven efficiencies, learning and innovation and kept margins low.	The shift in Germany and UK to competitive auctions has contributed to a 60% reduction in LCOEs for projects in five years.
Strong and stable market	A predictable, large and stable market, with clear policies and streamlined regulations, provides confidence to invest and lowers project risk. These help to reduce LCOE, by increasing innovation and enable longer-term planning, which accelerates learning.	The US states, particularly New York, have given the market high visibility by legislating the procurement of offshore wind power. Developers and suppliers have responded by making long-term commitments.
Innovation and new products	Need for reduction in cost of energy is the driver of offshore wind innovation and product development. Most technology innovation can be transferred to new markets but there is always an opportunity for local suppliers to innovate to reduce lifetime cost and enhance their competitiveness.	The strong wind R&D culture in Denmark has given its turbine suppliers confidence to invest long term in products for the offshore wind market. Much of the investment in innovation can come from industry if the government sets the market vision and gives confidence.
Good coastal infrastructure	Good coastal infrastructure in good locations reduces logistics costs and project risk.	Investments in Denmark and the Netherlands have created strong port infrastructure for the industry which has been used for home and overseas projects.
Low cost of finance	The cost of capital[1] can contribute a third of the cost of energy. Reductions in the cost of capital have had a big impact on lower LCOEs in Europe.	Aligned polices and processes have reduced project risks have lowered to costs of finance in countries such as the Netherlands.
Learning by doing	Industry learning has optimised processes, reduced mistakes and created a better understanding of risks. It also enables developers to bid lower in auctions because they have more knowledge.	The UK's early-stage and large-scale leasing system for projects has enabled developers to develop aligned pipelines of projects. In some cases, mega projects will be built with economies of scale and sustained learning.
Aligned grid infrastructure	Large-scale offshore wind deployment often needs to go alongside changes in the grid and energy system. Without timely investment, grid connections can be costly and delay projects.	Strategic planning of grid, alongside leasing and getting the timing of grid investments right are both important. In Netherlands, the TSO worked closely with the government to optimize grid connections for a series of projects in the 2020s. leads to cost reduction and subsidy-free auction bids.
Local content requirements	Strong local content requirements distort procurement decisions based on market principles. They can lead to increased cost or decreased competition, quality and sustainability if the requirements are too high or improperly focused.	An effective industrial policy based on government-industry dialogue can be beneficial in growing a competitive local supply chain and international competition long-term, even if it leads to small increases in some costs in the short term.

Increases LCOE Decreases

1. Cost of capital combines the interest and fees charged by a finance provider with the hurdle rate imposed at the point of financial investment decision by the project owners. The one third is the difference between LCOE calculated with the assumed weighted average cost of capital (WACC) and LCOE calculated with zero WACC.

2.3. Issues for consideration in Japan

Bringing together the conclusions from leading offshore wind markets in Europe, this study finds that the optimal pathways for Japan to reduce LCOE while creating local benefit are to:

- **Create predictable, large-scale and stable markets with clear policies and streamlined regulations**
- **Address regulations and certifications – making them as transparent and consistent with other markets as possible**
- **Effective industrial policy to create an internationally competitive local supply chain**

The following points are particularly relevant for sustainable growth of the Japanese offshore wind market.

Figure 6: Issues for consideration in Japan

Key Factor	Main points of each factor and issues to consider
Competitive environment	• Competition, both between project developers and suppliers, has had a significant effect on LCOE. Auctions have been the best way to create competition. Competition at the highest level of the value chain has most impact, hence between project developers. • In order to maintain a certain number of suppliers and keep the sufficient competition, it is important to create large enough markets with long-term visibility, domestic and regional.
Strong and stable market	• A large and stable market with high visibility provided by government, with clear policies and aligned regulations, gives confidence for industry to invest and lowers project risk. Such a market will promote the investment needed for cost reduction: research and development to bring products and services to market, workforce skills, and new equipment and infrastructure, such as vessels, ports and production facilities. • Government-industry deals, enabling all to have a common understanding about the future of the industry, give increased confidence and focus to invest.
Innovation and new products	• Much of the investment in innovation will come from industry as long as the government sets the market vision and gives confidence. • Development of low-wind variants with larger rotors will be key for Japan, both for fixed and floating projects. Japan offers new challenges regarding natural conditions specific to Japan and the Asian region (e.g. earthquakes, typhoons and tsunamis) which will require innovation in turbines. • Incorporation of technical standards covering these natural conditions into international standards will not only improve wind farm reliability, but also strengthen the international competitiveness of the industry.
Good coastal infrastructure	• Ports for offshore wind can need new large investment because of the large area needed, and the length and high load-bearing capacity of the quaysides, and it is necessary to assume use for multiple projects. • Effective utilization of existing industrial port facilities, such as for thermal power plants, should be actively considered.
Low cost of finance	• The cost of capital can contribute a third of the cost of energy. Governments have an important role to play in lowering the cost of finance, mainly through reducing development and operating revenue risks perceived by project owners and market risks perceived by the supply chain and lenders by the following measures. • Providing simple, transparent, fair and timely leasing and permitting processes, one-stop service for permitting through a single point of contact. • Creation of a predictable, large and stable market with the prospect of reasonable returns. • De-risking revenue per MWh during operation through the stable operation of FIT/FIP system.
Learning by doing	• Industry learning will be promoted through repeat delivery of projects. Learning has enabled optimization and standardization of planning and work processes, sharing of risk management methods, standardization of contracts and dispute resolution methods etc. • Joint ventures and international collaboration with global perspectives also accelerate learning. Also education of the local supply chain about offshore wind accelerate learning.
Aligned grid infrastructure	• Large-scale offshore wind deployment often needs to go alongside changes in the grid and energy system. Reform of the entire electricity market and system, including electricity trading and grid use needs to be promoted as soon as possible. • A Flexible grid system that enables wide-area grid operation throughout Japan can reduce system costs by better aligning supply and demand and reducing storage needs. It will contribute to the reduction of consumer bills and the expansion of offshore wind.
Local content requirements	• Even with a low local content rate, establishing a large, sustainable and competitive market can result in more local economic benefits than establishing a small market with a high local content rate and low sustainability. • For government, it is important to create a large market (nationally / regionally) to enable investment and sustain local supply by providing policy incentives to achieve sustainable local content in logical areas.

Chapter 3

Analysis of the Japanese offshore wind market and industry

3.1 Status of the Japanese offshore wind industry and necessary measures

In order to understand the issues and measures needed to accelerate the offshore wind market in Japan, the authors conducted a questionnaire survey and interview survey with various stakeholders, mainly JWPA members which constitute the offshore wind industry in Japan and overseas.

Of the 100 companies that responded to the survey, 51 responded that they had already entered the offshore wind market and 36 indicated that they were considering market entry. In all sectors, a number of potential players of equivalent of larger size than those which have already entered the market were identified, mainly domestic companies. The results illustrate a potential basis to support Japanese offshore wind industry in the future.

It should be noted that this survey was mainly conducted for JWPA member companies, and the results are not representative of the manufacturing industry as a whole.

In the questionnaire survey, the largest number of respondents chose 'setting ambitious targets' as a measure to promote the market entry and increase private investment. Also, the **importance of enhancing market visibility through formation of stable, long-term market** was highlighted by many respondents.

Figure 7: Status of entry into and intention to enter offshore wind market

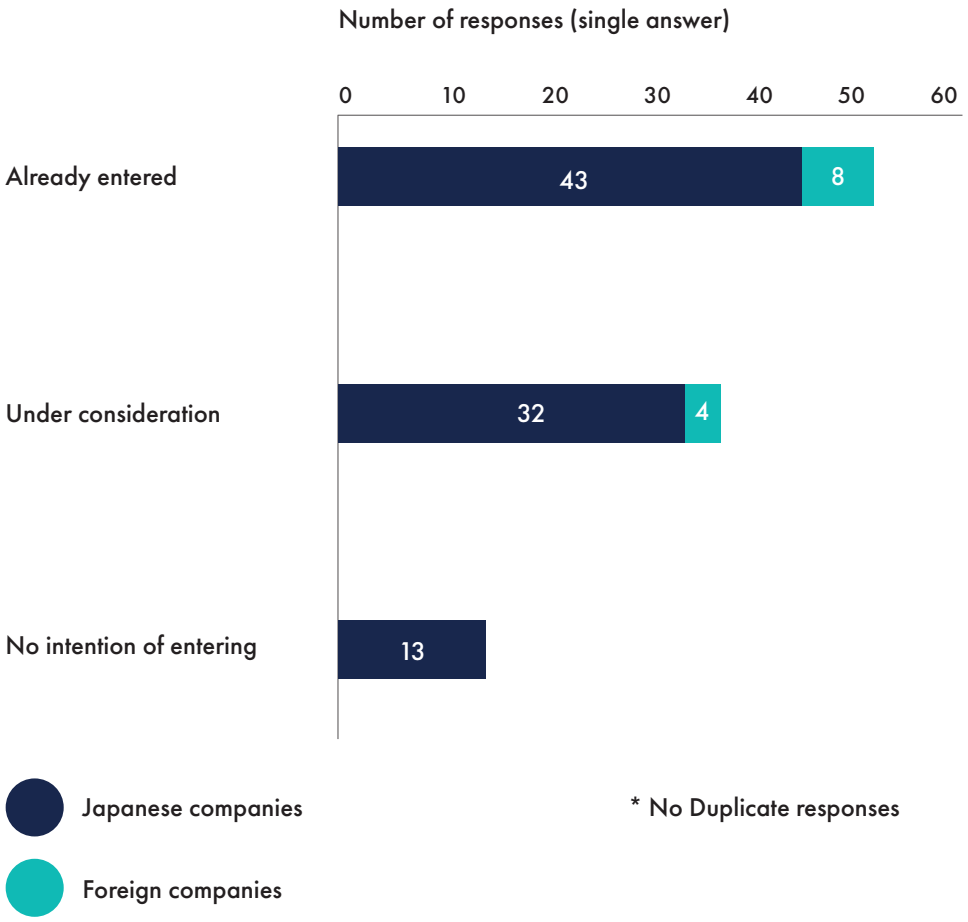
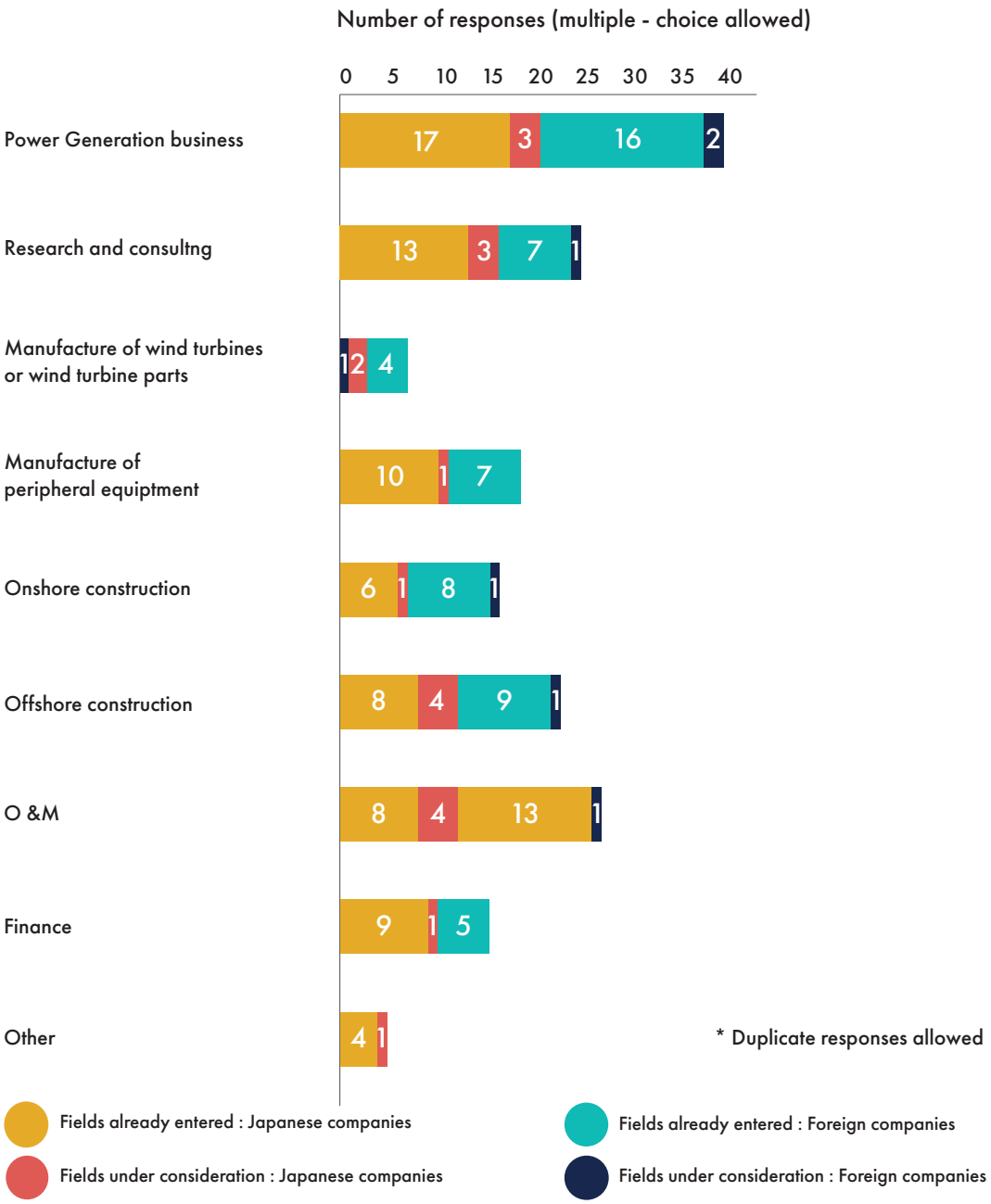


Figure 8: Fields already entered or under consideration for entry by companies



3.1 Status of the Japanese offshore wind industry and necessary measures

'Setting ambitious introduction targets' and 'formation of supply chain and promotion of competition' emerged as the main measures needed to reduce costs by many business. In forming the supply chain, it was pointed out that the viewpoint of optimization in the whole Asian region and the balance between cost reduction and forming the domestic supply chain were important.

When analysing the responses by field of the offshore wind supply chain, there were many comments on the improvement of the operation of the bidding system in the Act of Promoting Utilization of Sea Areas in Development of Power Generation Facilities Using Maritime Renewable Energy Resources (government-led local consensus-building, collection and sharing of various survey data, etc.) and requests for the development of domestic manufacturing sites, development of construction port and the introduction of new technologies and construction methods.

Furthermore, in order to implement the measures needed to reduce costs, it was suggested that the relaxation of relevant regulations and the rationalization of the system should be considered in combination.

Figure 9: Status of the Japanese offshore wind industry and necessary measures

Major measures needed to reduce costs (Questionnire results)

Trend by field / Most common answers

Cross-cutting

- These options were selected by the highest number of respondents in all fields, especially companies in 'Manufacturing' and "Construction and Installation' placed importance in the options.
- Regarding introduction target, a majority of respondents said that **continuous market with a certain size is necessary for investment decisions and business planning, and that this should be clearly presented.**
- In addition, many respondents cited the importance of **forming domestic supply chain and fostering competitive environment** to reduce costs. In forming the supply chain, it was pointed out that the viewpoint of **optimization in the whole Asian region** and **the balance between cost reduction and forming the domestic supply chain** were important.

Project development

- Many responded that the following measures are particularly important. At present, each power producer conducts local coordination and surveys of wind conditions, etc. on their own, but there are many requests for the government to take the lead in carrying out these tasks collectively and share them with all developers to improve efficiency **(strengthening of the central system)**.
  - Rationalization of environmental impact assessment
  - Local consensus building by the government
  - Provision of detailed wind condition survey data and detailed hydrographic and seabed data
- There were calls for rationalization of the system, including clarification of standards such as wind farm certification.

Manufacturing

- There were many requests for **the development of manufacturing factories and production bases in Japan,** particularly in the manufacturing industry (wind turbine parts and related parts).
- Some demanded for the rationalization of the system, including faster approval procedures for parts such as bolts.

Construction & Installation

- Many respondents from a wide range of industries have expressed demand for **the development of construction ports and dedicated vessels.**
- There was a comment on the need to **extensively review the Cabotage Regulation so as to cover the relaxation of the Cabotage Regulation and the special permission requirement** because vessels that can work in the territorial waters are limited to those with Japanese flag due to such regulation.
- Issues on hub ports are currently discussed by the MLIT, but there were calls for **a mid- to long-term port development plan** to improve the visibility.

O & M

- A large number of respondents said that the **proficiency in offshore operations** and the r**ationalization of O&M through technological development** are necessary to reduce costs.
- There was a comment that it is necessary to remove barriers to accepting experienced foreign talents and introducing foreign technologies in order to enhance the effect of proficiency.

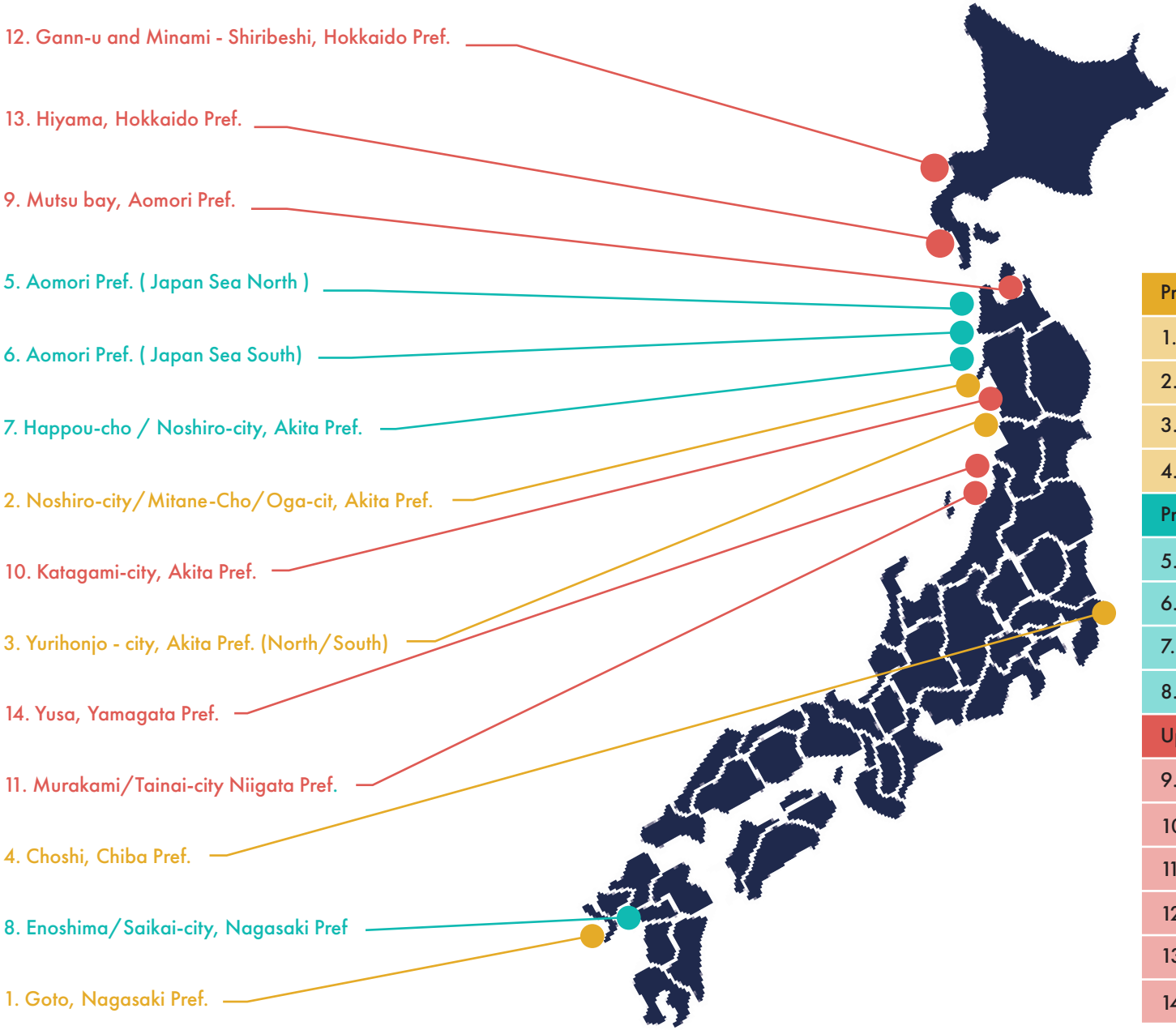
3.1 Status of the Japanese offshore wind industry and necessary measures

The main opinions on the necessary measures highlighted from the questionnaire and interview stages of this study can be categorized into the following viewpoints. Each measure will require a specific strategy for formulation by government, in collaboration with industry.

Figure 10: Key opinions from industry on necessary measures to reduce costs and enhance competitiveness

Setting large-scale, long-term target	• In order for companies to make proactive investment decisions, they need a **future market that allows for a return on investment**, and this requires increased market visibility through **setting of large-scale targets** by the government. • In addition to the scale, it is important to develop **a long-term and stable market** with targets for each year and plans for development areas and scale.
Formation of supply chain and promotion of competition	• In forming a supply chain, it is important to **be competitive in the global market and to optimize the supply chain for the entire Asian region.** • Since the formation of a domestic supply chain will lead to increased costs in the short term for the recovery of that investment, it is important to **have an industrial policy that balances cost reduction through overseas cooperation and domestic supply chain formation.**
Stable operation of auction system and FIT/FIP system	• In order to eliminate inefficiencies and reduce project risks in project development stage, the **Central System needs to be strengthened** through **consensus building with the stakeholders(fisheries, local community) led by the government, securing the grid connection** (including ensuring consistency of short-term grid securing rules), and conducting and sharing surveys on wind conditions, sea conditions, etc. • There is a need for **a stable operation of the FIP/FIP system** that will enable the recovery of new investments in the formation of domestic supply chains.
Development of port and grid infrastructure	• In order to reduce construction costs, it is necessary to **develop construction port at an early stage.** It is also necessary to **clarify the rules for the use of the construction port** (occupancy period, response to construction period delays, etc.). • It is necessary to consider a master plan that includes the **development of grid infrastructure consistent with the potential of offshore wind power** and submarine DC transmission. • Integrated development and reinforcement of inter-regional and intra-regional transmission lines should be examined.
Rationalization of grid interconnection rules	• In order to reduce the risk money and bidding prices, **early review of the grid securing rules** is necessary to ensure consistency and rationality of the Act on Utilization of Sea Areas for Developing Renewable Energy <provisional translation>and the existing rules. • **Early development of master plan** is needed to increase the visibility of grid connection rules (e.g. applicability of non-firm access) and reduce business risks.
Standardization of certification standards	• There **are certification items for which certification standards are unclear** in terms of the calculation of turbulence intensity at wind turbine locations, etc., and this is a factor that prolongs the certification period. • Differences between national and international standards can lead to a delay in the certification process. It is important that **important national standards are reflected in international standards and widely applied globally.**
Streamlining of relevant regulations and institutions	• It is important to **promote rationalization of relevant regulations and systems in all areas of the supply chain** according to the actual situation of offshore wind power development, referring to European examples, etc., and to reduce the overall project cost by shortening and improving the efficiency of project development period and construction period. • Rationalization of the relevant regulations and institutions will **significantly reduce business risks for developers and consequently contribute to lowering bidding prices.**
Support for technology and product development	• **Support for technology development** that contribute to reducing costs of product development and O&M, as well as s**upport for new capital investment** in new equipment and dedicated vessels are effective.
Support for human resource development	• It is necessary to **develop and secure human resources** in cooperation with educational institutions such as universities, technical colleges, and technical high schools. • It is effective to subsidize the cost of overseas training and various certifications for employees after they are hired. • **Developing strong health and safety attitudes and the right culture** is important – it is not enough just to have written standards.

Figure 11: Present status of Promotion Areas and Candidate Areas



Promoting Area (Round 1)
1. Goto, Nagasaki Pref.
2. Noshiro-city/Mitane-Cho/Oga-cit, Akita Pref.
3. Yurihonjo - city, Akita Pref. (North/South)
4. Choshi, Chiba Pref.
Promising Area (Round 2)
5. Aomori Pref. (Japan Sea North)
6. Aomori Pref. (Japan Sea South)
7. Happou-cho / Noshiro-city, Akita Pref.
8. Enoshima/Saikai-city, Nagasaki Pref
Upcoming Area (In preparation)
9. Mutsu bay, Aomori Pref.
10. Katagami-city, Akita Pref.
11. Murakami/Tainai-city Niigata Pref.
12. Gann-u and Minami - Shiribeshi, Hokkaido Pref.
13. Hiyama, Hokkaido Pref.
14. Yusa, Yamagata Pref.

Source: Offshore Wind Promoting Joint WG by METI & MLIT (17 February, 2021)

3.2 Future cost analysis of offshore wind in Japan

Based on the experience in Europe and the results of the questionnaire and interviews, in order to achieve LCOE of 8-9JPY/kWh, it is necessary for the government to formulate sufficient market ambition. This ambition should be **more than 1GW/year up to 2030, and more than 2-4 GW/year up to 2040,** in order to accelerate the entry of related industries and strengthen the competitiveness of domestic industries. The following two scenarios are based on this concept. These scenarios can be realized by the government taking necessary measures, as outlined in Chapter 4, and stimulating private investment.

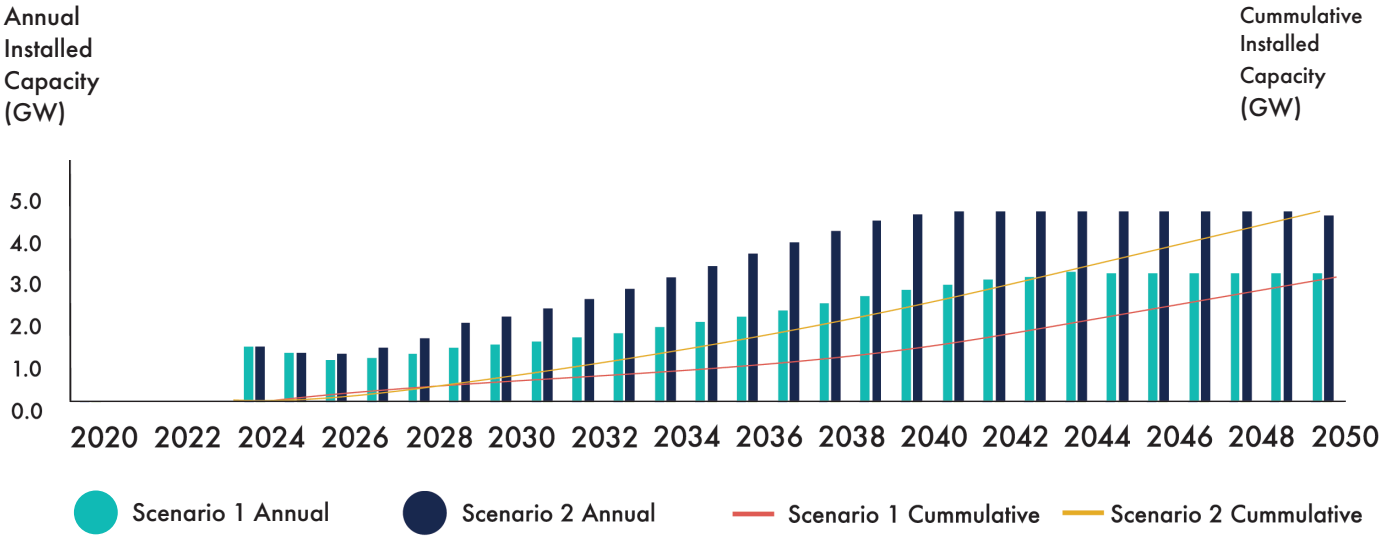
Scenario 1

FIT/FIP bidding of approx. **1GW/year will be promised up to 2030**. The development of domestic supply chains will progress, and cost reductions will progress to a certain extent between 2030 and 2035. By 2050, a cumulative capacity of 60GW of fixed-type and floating-type were assumed to be installed.

Scenario 2

FIT/FIP bidding of about **2GW/year will be promised up to 2030.** The development of domestic supply chains and market-specific innovation will progress rapidly, accelerating cost reduction. Grid parity will be achieved between 2030 to 2035. By 2050, a cumulative capacity of 90GW of fixed-type and floating-type were assumed to be installed.

Volume of installation capacity by scenario



		2030	2035	2040	2050	
Fixed	Scenario 1	Approx. 8GW	Approx. 13GW	Approx. 20GW	Approx. 30GW	
	Scenario 2	Approx. 9GW	Approx. 20GW	Approx. 30GW	Approx. 40GW	Scenario 1 60GW
Floating	Scenario 1	Approx. 1GW	Approx. 4GW	Approx. 10GW	Approx. 30GW	
	Scenario 2	Approx. 1.2GW	Approx. 6GW	Approx. 15GW	Approx. 50GW	Scenario 2 90GW

Based on the questionnaire survey, the authors calculated baseline cost considering the condition of Japanese market. In addition, based on the European experience, we also calculated the future costs considering the expected cost reduction effect by implementing various measures, the effect of global technological innovation, the cost increase factors specific to Japan (effect of earthquakes and typhoons, etc.), and the impact of market size on speed of cost reduction.

1st Calculation of the future cost in Japan

- Conduct a questionnaire survey and interview survey with various stakeholders, mainly JWPA members, which constitute the offshore wind industry in Japan and overseas.
- Calculate the baseline cost in Japan based on the results of questionnaire survey, considering the condition of Japanese market.

2nd Calculation of the future cost in Japan

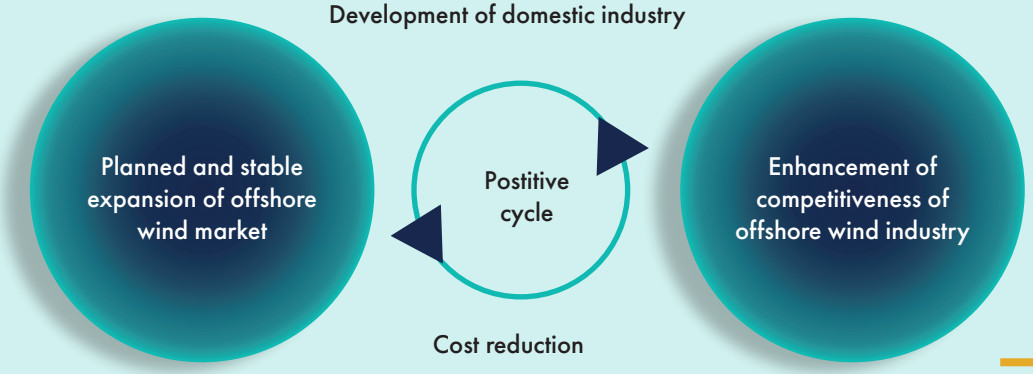
- Calculate the future costs considering the expected cost reduction effect by implementing various measures, the effect of global technological innovation, the cost increase factors specific to Japan (effect of earthquakes and typhoons, etc.), and the impact of market size on speed of cost reduction, when the positive cycle of cost reduction and the development of domestic industries will be formed.

Necessary measures to reduce cost and enhance the competitiveness of Japanese industry

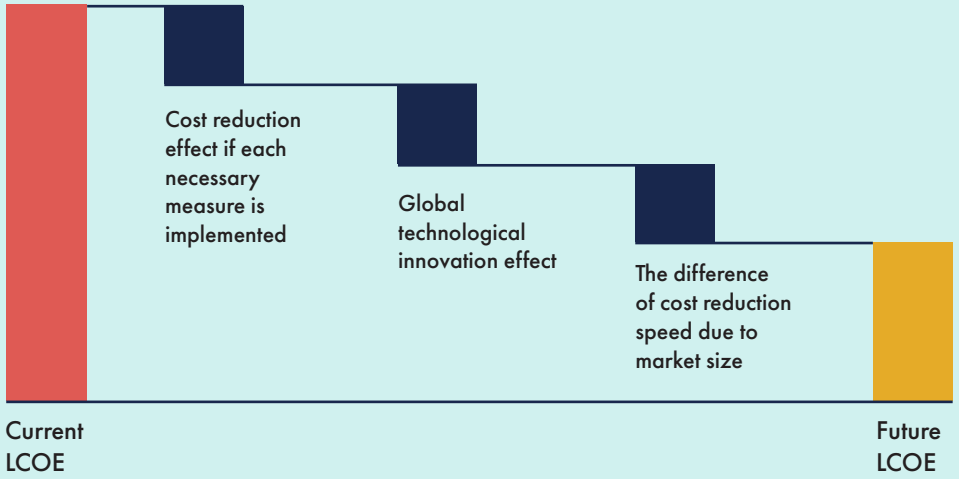
- Development of large-scale, stable and highly visible market
- Streamlined and transparent regulations consistent with the global market
- Industrial policies to foster internationally competitive domestic industry

Implement of these measures

Development of domestic industry



Analyze future LCOE if each necessary measure is implemented



In performing the analysis of LCOE in this study, the authors calculated LCOE in accordance with METI's method, adopting 3% discount rate and including property tax in order to compare to its cost target (the cost of onshore/fixed offshore in 2030: 8 to 9 yen/kWh). Normally, LCOE is calculated without tax, and a discount rate depending on risk and market conditions. In this study, we have also calculated this standard LCOE, with 10% discount rate.

LCOE (METI)

The future LCOE is calculated to be 10.3 to 12.3 JPY/kWh in 2030, and is calculated to be **7.5-9.5 JPY/kWh in 2035.**

LCOE (Standard)

The future LCOE is calculated to be 13.8~17.1 JPY/kWh in 2030, and is calculated to be **9-12.1 JPY/kWh in 2035.**

Formula of LCOE

$$\text{LCOE (yen/kWh)} = \frac{\sum_{t=s}^{n} \frac{I_t + M_t}{(1+r)^t}}{\sum_{t=s}^{n} \frac{E_t}{(1+r)^t}}$$

I_t : Investment expenditure in year t
M_t : Operation, maintenance and service expenditure in year t
E_t : Energy generation in years t
r : Discount rate
s : Start year of the project*, and
n : Lifetime of the project in years.

**We define 0 year as first operation year and we assumed that all CAPEX is in the first operation year.*

Figure 13: Calculation results of LCOE

	2030		2035	
	Scenario1	Scenario2	Scenario1	Scenario2
Farm capacity	500MW			
Turbine capacity	12MW	16MW	12MW[1]	16MW[1]
Average wind speed	7.5m/s at 100m height			
Capacity factor[2]	37.6%	38.9%	44.4%	47.2%
CAPEX	440,000¥/kW	400,000¥/kW	410,000¥/kW	360,000¥/kW
OPEX	12,000¥/kW/yr	10,000¥/kW/yr	11,000¥/kW/yr	8,000¥/kW/yr
Decommissioning cost	The equivalent to 5% of CAPEX is added			
Project lifetime	25years	25years	25years	25years
Future LCOE (METI)[3]	12.3yen/kWh	10.3yen/kWh	9.5yen/kWh	7.5yen/kWh
Future LCOE[4] (Standard)	17.1yen/kWh	13.8yen/kWh	12.1yen/kWh	9.0yen/kWh

1. We assumed the adoption of wind turbine with larger rotor which is suitable for low wind speed.
2. Capacity factors are calculated by combining an annual wind speed distribution (based on annual wind speed stated at 100m height, assuming Weibull shape factor 2) and power curve scaled for the turbine rating and rotor diameter anticipated at each point in time. Capacity factors include losses due to wake effects, turbulence, loss of availability etc.
3. Same definition of METI method, 3% discount rate and including property tax.
4. Discount rate is set at Baseline:10%. 2030: 7%. 2035 Scenario1: 6%. 2035 Scenario2: 5%

3.3 Status of floating offshore wind

Japan is one of the leading countries in the world to demonstrate floating offshore wind, and has accumulated data and knowledge on various types of floating foundations. However, the shift to commercialization has been limited to the spar type, and the demonstration results have not been fully utilized in other foundation types. **For Japan to take the lead in the Asian market, it will be necessary to urgently strengthen policy support for the development of floating offshore wind technologies.**

- Wind Europe[1] projected that **LCOE of floating offshore wind will reach 40-60 EUR/MWh by 2030.**
- France is planning auction for floating offshore wind with total capacity of 750MW (three project of 250MW) between 2021 and 2022. The upper limit of bidding price is set at 15.6 JPY/kWh in 2021 and 14.3 JPY/kWh in 2022. Although the price is about twice as expensive as that of fixed offshore wind, **the cost disparity is expected to decrease in the future.**
- China and South Korea are moving fully toward the development of floating offshore wind.

For Japan to take the lead in the Asian market, it will be necessary to urgently strengthen policy support for the development of floating offshore wind technologies.

1. Wind Europe, "FLOATING OFFSHORE WIND ENERGY A POLICY BLUE-PRINT FOR EUROPE", p.5 (November 2018)

Figure 14: Offshore wind auction plan in France

Year	Type	Farm capacity	Upper limit of bidding price[1]
2019	Fixed	600MW	5.9 JPY/kWh (€45/MWh)
2020	Fixed	1,000MW	7.8 JPY/kWh (€60/MWh)
2021	Floating	250MW	15.6 JPY/kWh (€120/MWh)
2022	Floating	Total 500MW[2]	14.3 JPY/kWh (€110/MWh)

Source: French government "French Strategy for Energy and Climate – Multi Annual Energy Plan (Draft for comments)", p.126, 20/01/2020

1. Exchange rate: 1€=130yen
2. Two projects of 250MW
3. Provisional translation, the official title is "주민과 함께하고, 수산업과 상생하는해상풍력 발전 방안"
4. Exchange rate: 1 won=0.1 yen

Figure 15: Development strategy of floating offshore wind in China and South Korea

Development strategy of floating offshore wind in China and South Korea

CHINA

Roadmap
Energy Technology Innovation Action Plan 2016-2030 (April 2016)

Technology Development Policy
- "Construction of a large-scale wind power generation system in the far sea" is one of the strategies, and development of floating platform applicable to the deep sea, long-distance power transmission technology, and design/construction are positioned as research subjects.
- Wind farm deployment in the deep sea, Coupled analysis of turbine and floater, Technology for laying submarine cable in the deep sea, Construction technology, etc.

SOUTH KOREA

Roadmap
Offshore wind power development plan with residents and coexisting with the fisheries industry[3] (July 2020).

Technology Development Policy
- Positioned floating offshore wind as a target of support for strengthening industrial competitiveness, and aims to develop floating offshore wind system by December 2024.
- Support for R&D of floating offshore wind technology, with a total of 38 billion won subsidy (3.8 billion yen[4]) between 2020 and 2024.

Source: China government (国家发展改革委国家能源局), "能源技术革命重点创新行动路线图" (April 2016)
South Korean government, "주민과 함께하고, 수산업과 상생하는해상풍력 발전 방안" (July 2020)

3.4 Economic effects of Japanese offshore wind industry development

The offshore wind market consists of a very wide range of industries in the entire supply chain of project development, manufacturing, construction and installation, O&M and decommissioning. This study calculated the economic effects if the development of a large-scale, stable and highly visible offshore wind market is realized in Japan.

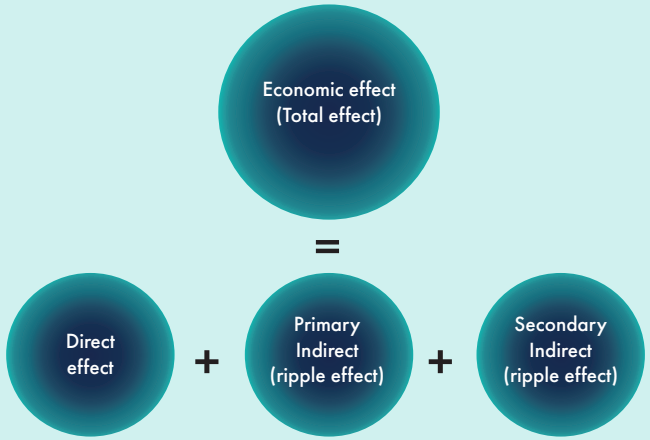
With sufficient market expansion and increased investment for offshore wind, the offshore wind sector can generate positive economic effects totalling JPY 5-6 trillion by 2030 to Japan.

Definition of Economic Effect

Direct effect
Effect of inducing production directly in a certain industry by creating new demand in the industry.

Primary effect
Effect induced by the purchase of raw materials and parts from other industries by industries that have had direct effects.

Secondary effect
Effect produced when a portion of the gross value added (employer's income) generated from production induced by the direct effects and the primary ripple effects flows to households, creating new demand and inducing production again.

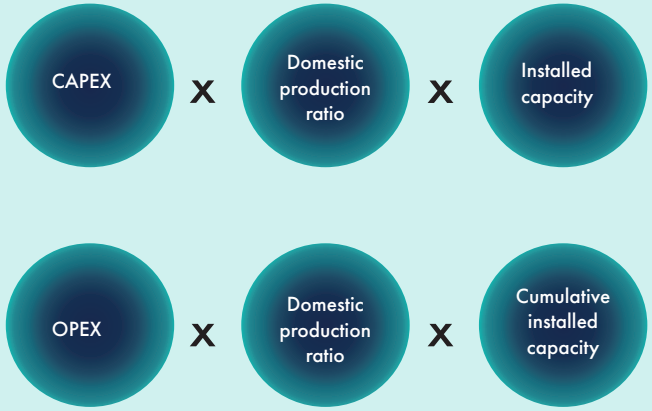


Flow of analysis of economic effect

1. Multiplying cost date by domestic production ratio

CAPEX
Calculated by multiplying the annual installed capacity at that point by the CAPEX (Yen/kW), considering the domestic production ratio.

OPEX
Calculated by multiplying the cumulative installed capacity up to the year by the OPEX (Yen/kW/year), considering the domestic production ratio



2. Analyze economic effect by inputting cost data into I/O table

Figure 16: Analysis of economic effect by offshore wind development

		2030		2040		2050	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Cumulative installed capacity up to the fiscal year		Approx. 9GW	Approx. 10GW	Approx. 30GW	Approx. 45GW	Approx. 60GW	Approx. 90GW
Domestic production ratio (Monetary amounts)		≈50%	≈60%	≈65%	≈75%	≈80%	≈90%
Economic Effect (Cumulative Total)[1]	Direct Effect	2.2 tril. Yen	2.7 tril. Yen	8.4 tril. Yen	12.6 tril. Yen	19.2 tril. Yen	28.3 tril. Yen
	Primary Effect	2.0 tril. Yen	2.4 tril. Yen	7.5 tril. Yen	11.6 tril. Yen	17.3 tril. Yen	25.9 tril. Yen
	Secondary Effect	1.0tril. Yen	1.3 tril. Yen	3.7 tril. Yen	5.5 tril. Yen	8.3 tril. Yen	12.3 tril. Yen
	Total	5.2 tril. Yen	6.4 tril. Yen	19.5 tril. Yen	29.6 tril. Yen	44.8 tril. Yen	66.5 tril. Yen
Employment Effect (Each point in time)[2]	Direct Effect	25 k people/year	36 k people/year	49 k people/year	77 k people/year	76 k people/year	106 k people/year
	Primary Effect	16 k people/year	24 k people/year	34 k people/year	55 k people/year	53 k people/year	74 k people/year
	Secondary Effect	13 k people/year	18 k people/year	25 k people/year	40 k people/year	39 k people/year	55 k people/year
	Total	54 k people/year	78 k people/year	108 k people/year	172 k people/year	168 k people/year	235 k people/year

1. Since construction of offshore wind power generation requires multiple years, CAPEX is a long-term expense. For convenience, it is assumed that 100% of CAPEX occurs in the year of installations, and the economic effect and employment effect are calculated respectively.
2. Employment effect include both full-time and part-time employees.
Note: Domestic production ratio is defined as the ratio of spend on business activities conducted in Japan with business offices or factories located in Japan, out of the total costs required for offshore wind development and operation. Therefore, companies with foreign capital are included in the domestic production ratio if they have business offices or factories and are conducting business activities in Japan.

In order to achieve 80% reduction of GHG in Japan by 2050, **nearly all electricity will need to be generated from renewable energy sources by 2050.** Considering the potential of PV and onshore and offshore wind, **it is essential to deploy offshore wind on a large scale to realize at least 20-30% of the roughly 300 GW of potential by 2050,*** and then continue to develop the remaining potential beyond this date.

The development of the offshore wind market and industry will bring benefits such as reliable power supply, CO2 reductions, higher energy self-sufficiency, reduced expenditures for fossil fuel procurement and substantial economic effects and job creation, all of which are directly linked to the advanced "3E+S" concept set out in the 5th Basic Energy Plan, as well as to green economic recovery plans from COVID-19:

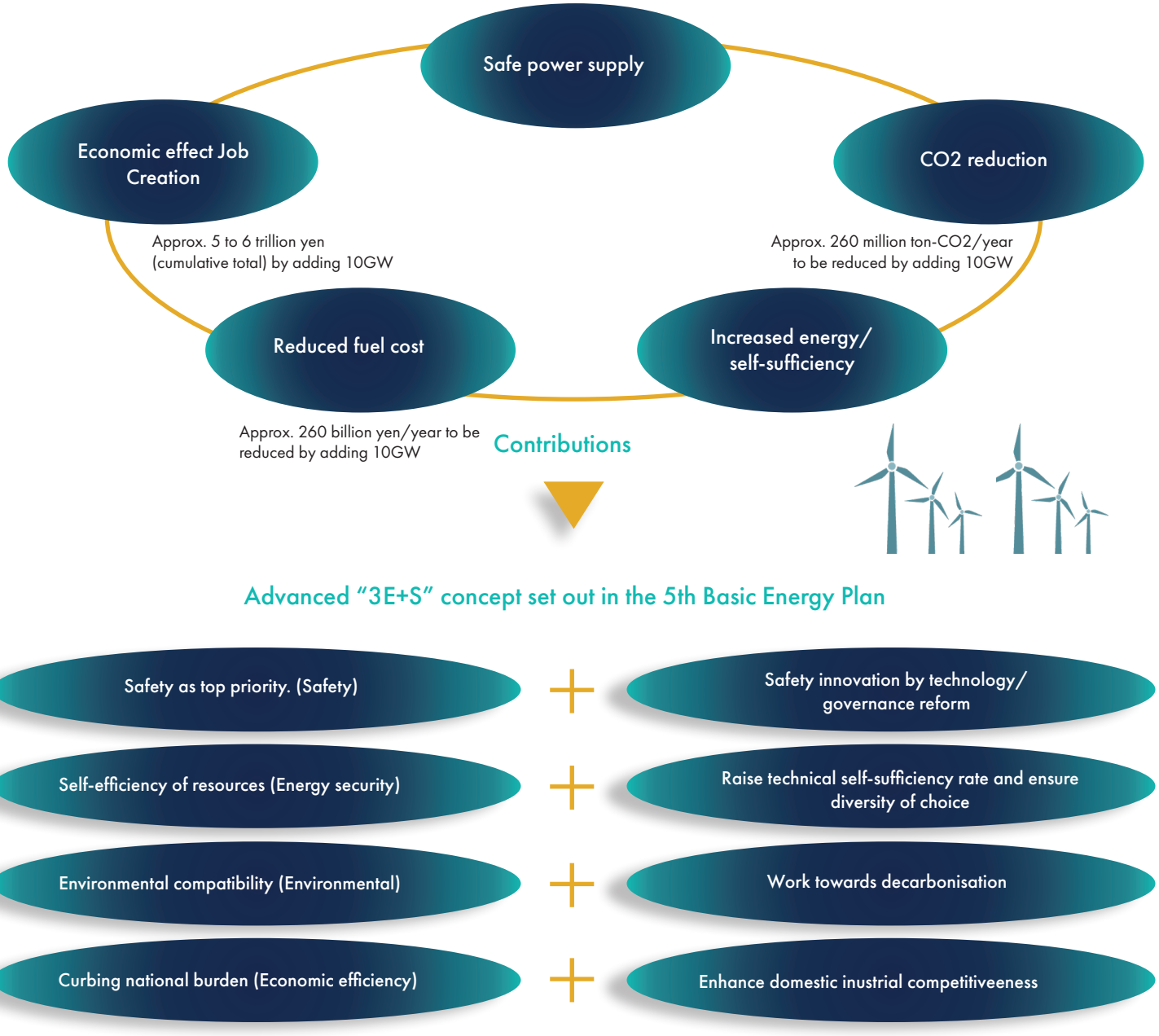
- In terms of CO2 reductions, the introduction of 10 GW of offshore wind power would generate approx. 31.5 billion kWh/year[1]. If coal-fired thermal power were to be replaced, **the CO2 reduction effect would be approx. 26.45 million ton-CO2/year** (approx. 5% of the entire power sector)[2].

- Based on the target values of METI as of 2030 (fuel cost of 5.3 trillion JPY/year[3]), the installation of 10 GW of offshore wind power (approx. 40 billion kWh/year) would **reduce fuel costs by approx. 260 billion JPY/year.**

- The economic effects from the installation of 10 GW of offshore wind power is **approx. 5 to 6 trillion JPY (cumulative total)[4]**.

*Source: JWPA, "洋上風力の産業競争力強化に向けた官民協議会第1回会合資料 洋上風力の主力電源化を目指して", p.14, 16 (July 2020)
1. The activity to promote environmental measures such as the installation of renewable energy, low-carbon transportation, and energy conservation to lead to economic recovery, in order to recover the stagnant economy caused by COVID19.
2. Simple estimation by MRI.4. Exchange rate: 1 won=0.1 yen.
3. Assuming that 24% of the electricity demand (1,065 billion kWh) in the energy mix in 2030 will come from renewable energy sources and the remaining 76% from nuclear and thermal power, the fuel cost per kWh is estimated to be about 6.5 yen/kWh. (Source: 総合資源エネルギー調査会 基本政策分科会 (第29回会合) 資料1).
4. See section 3.4 for details.

Figure 17: Benefits of offshore wind



Chapter 4

Recommendations

Advantages of Japan's offshore wind industry and market

Japan's industrial and market advantages include **market size, heavy industry and industrial machinery industries and floating offshore wind technology.** Japan has sufficient potential to attract domestic and foreign investment, foster domestic industry and lead the optimal supply chain and cost reduction in Asia.

Market size

Japan is the largest power market in Asia excluding China, and if 90 GW of offshore wind is installed by 2050, a long-term market of an average of 3-4GW/year could be formed.

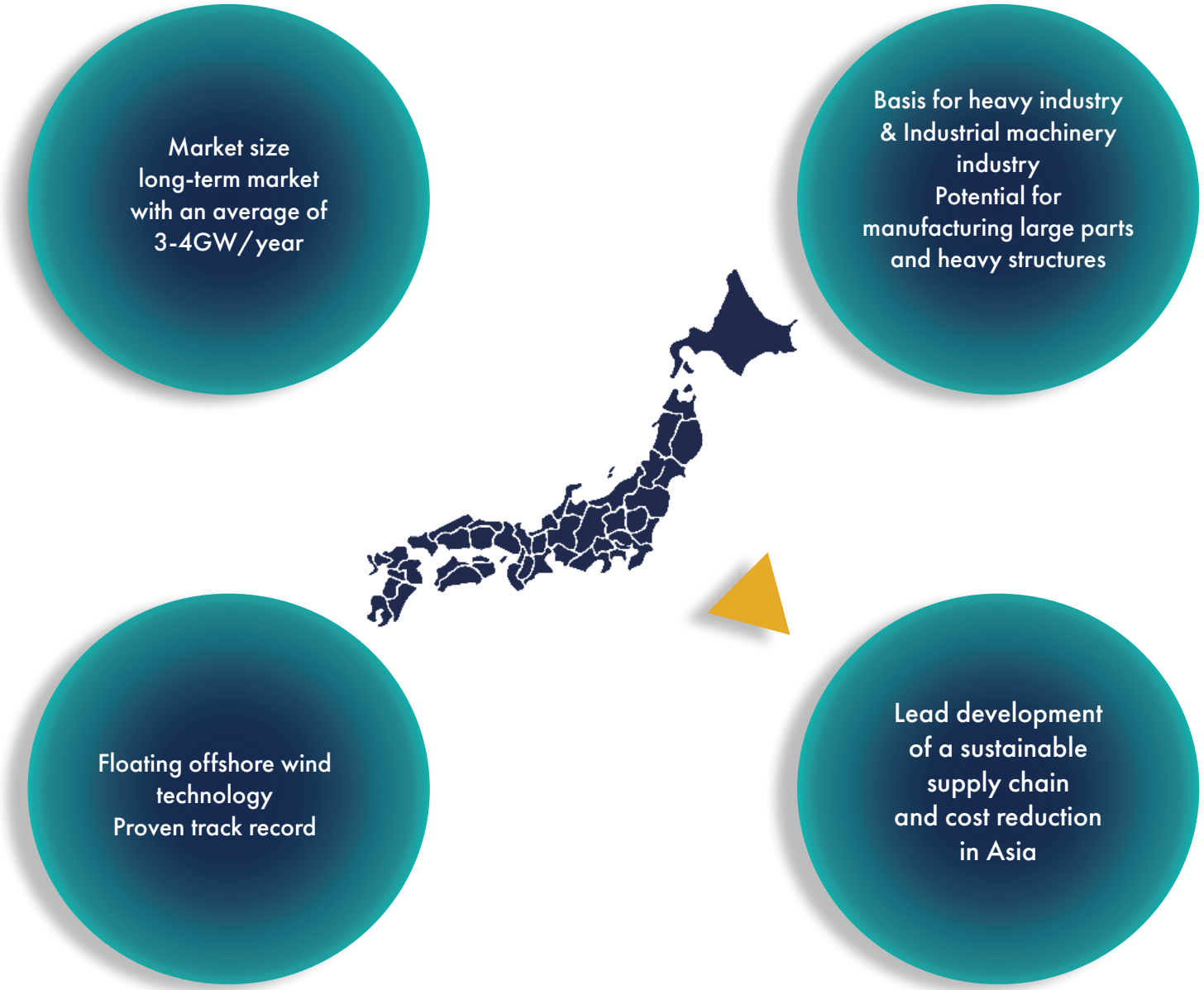
Heavy industry and industrial machinery industry

Japan has a strong industrial base in the heavy industry and machinery industries, and possesses technological capabilities that provide a basis for international competitiveness in the manufacturing of large parts and heavy structures. Utilization of idle docks and structural changes in the industry are also expected. In addition, with excellent performance in the domestic production of onshore wind turbines, it has the potential technological capability to manufacture main components in offshore wind nacelles, blades and towers.

Floating offshore wind technology

With a proven track record and data of all three types, i.e. spar, semi-sub and barge types, it has the potential to lead in technology development for cost reduction and standardization of certification standards by actively introducing floating-type in the same level as fixed type.

Figure 18: Advantages of Japanese industry and market



Form a positive cycle through joint public-private efforts

In order to establish a domestic supply chain that is internationally competitive in the long term while reducing the cost of offshore wind power and fostering domestic industrial capacity, there are three underlying measures that the public and private sectors should work together to achieve.

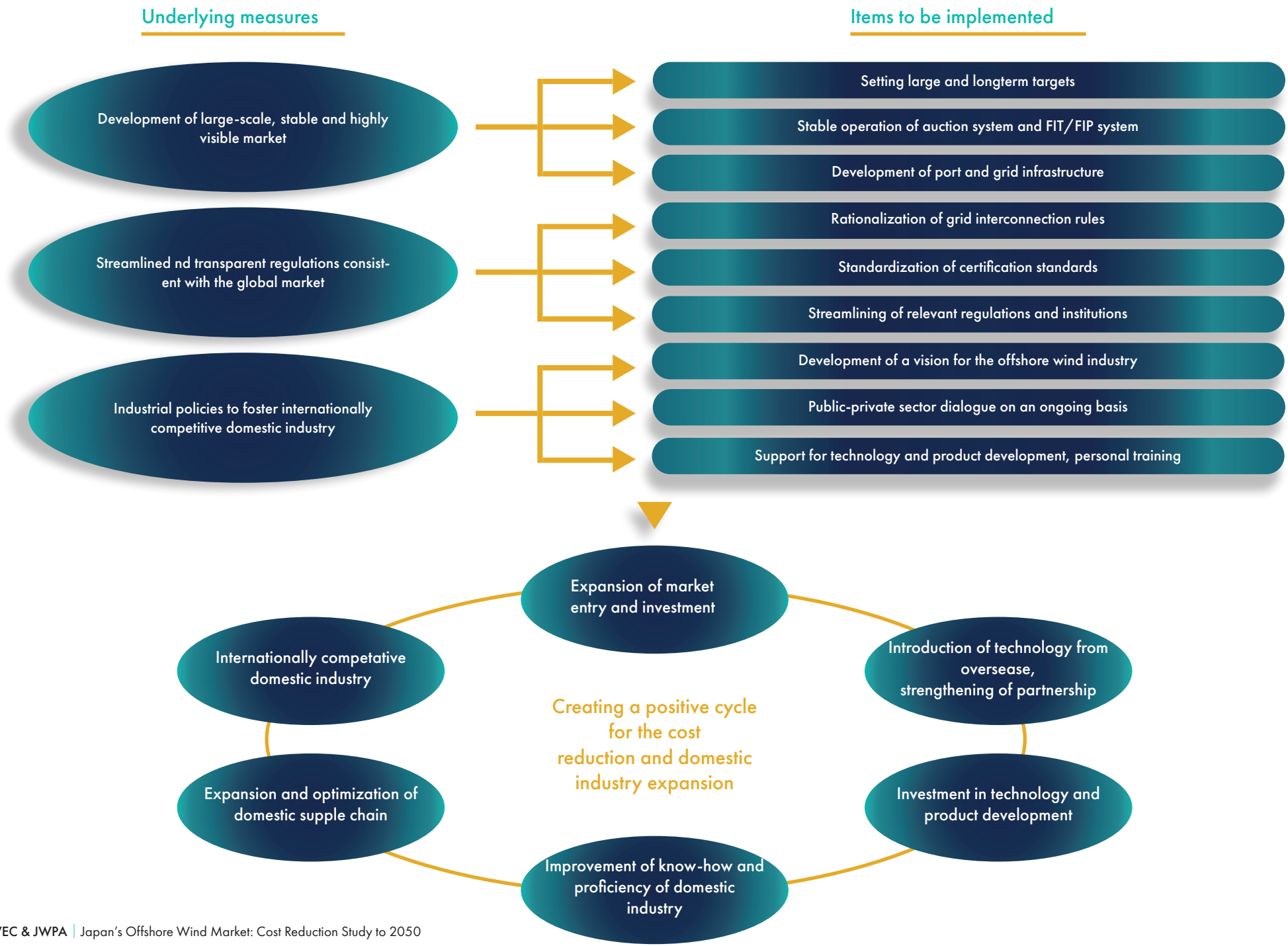
- **The development of large-scale, stable and highly visible offshore wind market** backed by the ambitious target for 80% CO2 reduction by 2050 and stable institutional operations. This is of paramount importance in order to facilitate large-scale investment required to reduce costs. Private investment can be encouraged by showing a future market with a potential return on investment and by reducing business risk.

- **Make regulation streamlined, transparent and consistent with the global market,** in order to improve the efficiency of the auction/permitting process and implement common safety and training standards to reduce project development risks and costs, and to increase competitiveness in the global market.

- **Formulate industrial policies that will foster an internationally competitive domestic industry,** and ensure that the public and private sectors share a long-term vision for the development of offshore wind power as a major power source and mainstay industry.

Based on these underlying measures, it is necessary for the public and private sectors to work together on various issues to **form a positive and reinforcing cycle for both cost reduction and development of domestic industry. Development of an Offshore Wind Industry Vision can serve as a basis for market formation and industrial development. Continuous public-private sector dialogues are also important.**

Figure 19: Positive cycle of joint public-private efforts



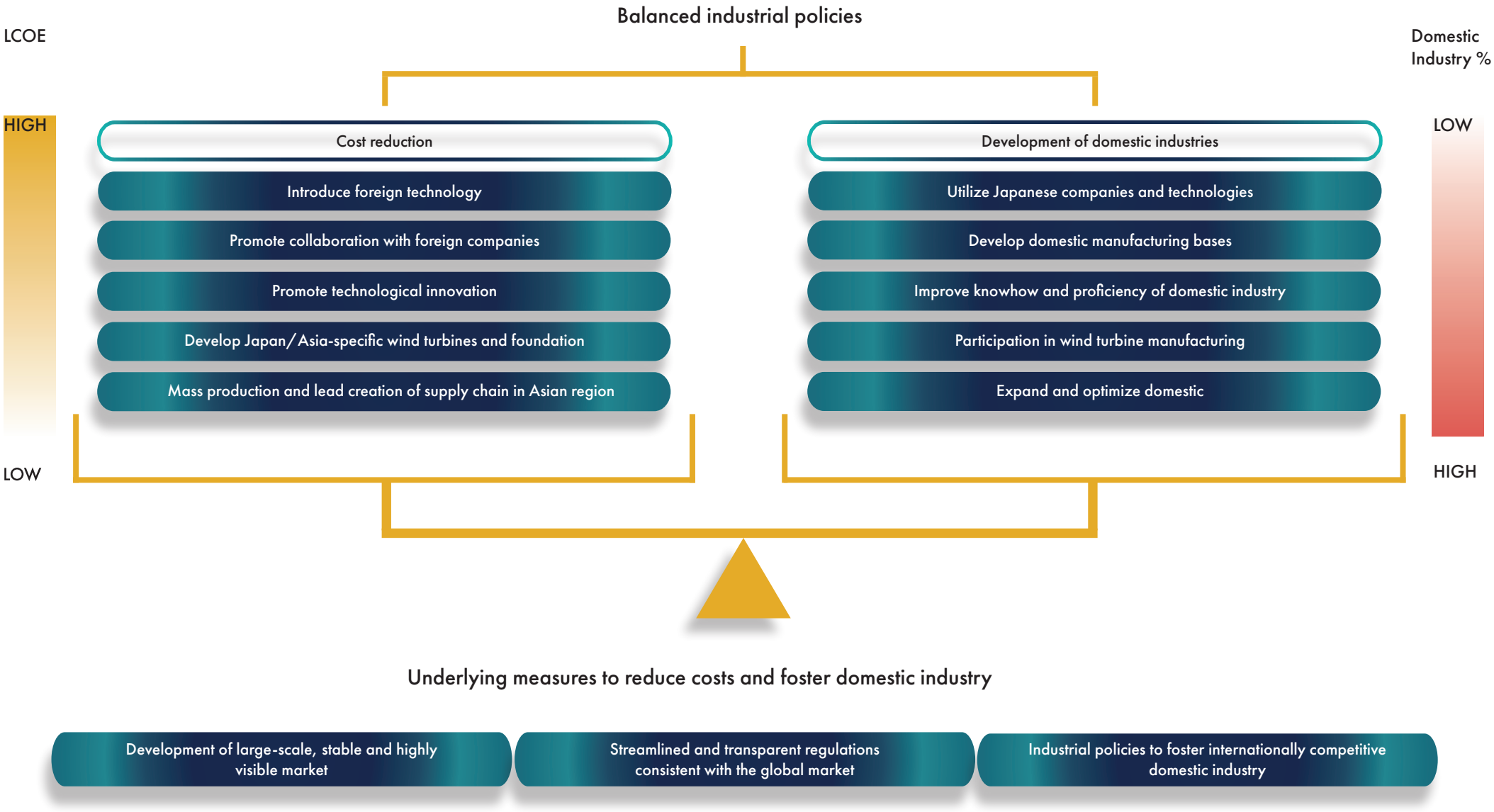
Balancing industrial policies for long-term sustainable growth

It is vital to implement industrial policies that will enable the formation of internationally competitive domestic supply chains in the long term, while balancing the trade-off between cost reduction based on market principles and cost increase through the development of domestic industries in the short term. These policies should include measures to attract potential Japanese players to the market, introduce overseas technologies and collaborate with overseas companies, thereby promoting the development of technologies and know-how of domestic companies while maximising learning and cost reduction from other markets that are further progressed than Japan.

In addition, it will be effective to promote technology innovation through cooperation between domestic and foreign companies, and to develop wind turbines and foundations suitable for the environment conditions in Japan and Asian region (low wind speed wind turbines, etc.). As a result, the expansion of domestic manufacturing bases and the optimization of supply chains will advance, and cost reductions will be accelerated through mass production as market expands. In the long run, these policies can realize long-term international competitiveness and **lead to the creation of a sustainable supply chain in Asia.**

It is vital to implement industrial policies that will enable the formation of internationally competitive domestic supply chains in the long term.

Figure 20: Balancing industrial policies for long-term sustainable growth



Pathway for cost reduction and development of domestic industry

The study concludes that **the target of 8-9 JPY/kWh can be achieved between 2030 and 2035,** if not before, by creating a positive cycle to realize cost reduction and the development of domestic industry, and promoting cost reduction through mass introduction, technological innovation, and industrial proficiency.

By 2035, this pathway could deliver **15-20 GW of offshore wind capacity, 11-16 JPY trillion in cumulative economic effects, as well as a reduction of 70 million tons of CO2 on an annual basis.** Depending on the measures implemented, Japan's offshore wind capacity could total from **60-90 MW by 2050, across both fixed and floating offshore wind installations.**

The long-term development of the offshore wind market and industry will bring benefits such as **reliable power supply, CO2 reductions, higher energy self-sufficiency, reduced expenditures for fossil fuel procurement and substantial economic effects and job creation,** all of which are directly linked to the 5th Basic Energy Plan, as well as to green economic recovery plans from COVID-19.

Pathway for cost reduction and development of domestic industry

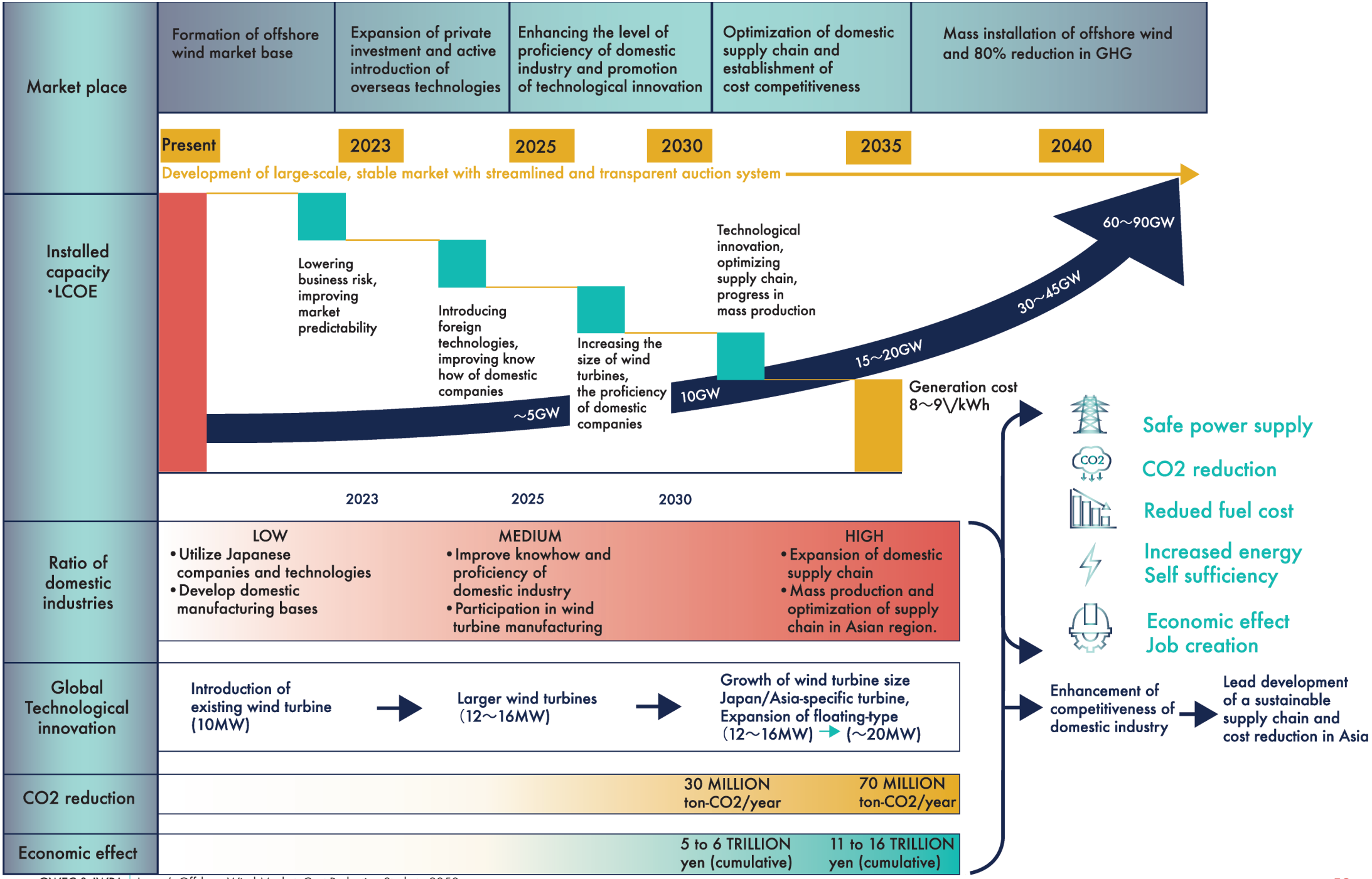


Figure 21: Roadmap of recommendations

By carrying out the recommendations outlined in this chapter in a timely manner, and ensuring channels of public-private cooperation are sustained on an ongoing basis, **the target of 8-9 JPY/kWh can be achieved between 2030 and 2035,** if not before. These recommendations will transform as the offshore wind market matures, but in the near term (2021-2023) include the initiation of the following. A full picture of the roadmap of recommendations is provided on the next page.

It will be vital that each recommendation outlined is advanced and materialized through discussions in the existing public-private sector dialogues and a long-term vision for offshore wind is urgently formulated by METI and other stakeholders. In addition, it can be effective to apply the PDCA Cycle for the implementation, ongoing monitoring and review of the vision for offshore wind industry, through public-private cooperation.

By 2035, this pathway could deliver 15-20 GW of offshore wind capacity, 11-16 JPY trillion in cumulative economic effects, as well as a reduction of 70 million tons of CO2 on an annual basis.

Group	Recommendation
Public-private efforts	Development of a vision for the offshore wind industry
	Public-private sector dialogue
Government efforts	Setting large-scale and long-term targets
	Strengthening the streamlined auction system
	Stable operation of the bidding and FIT/FIP systems
	Standardization of certification standards
	Streamlining of relevant regulations and institutions
	Rationalization of grid interconnection rules
	Development of port infrastructure
	Development of grid plan
	Introduction of policy incentives for the formation and expansion of domestic manufacturing bases
	Technology and product development support
	Personnel training support
	Introduction of technology from overseas and international collaboration
Industry efforts	Investment in technology and product development by component supplier
	Development and expansion of domestic manufacturing bases
	Training of engineers, enhancement of technique and proficiency of assembly & installation and O&M.
	Construction of special-purpose vessels such as SEP ships

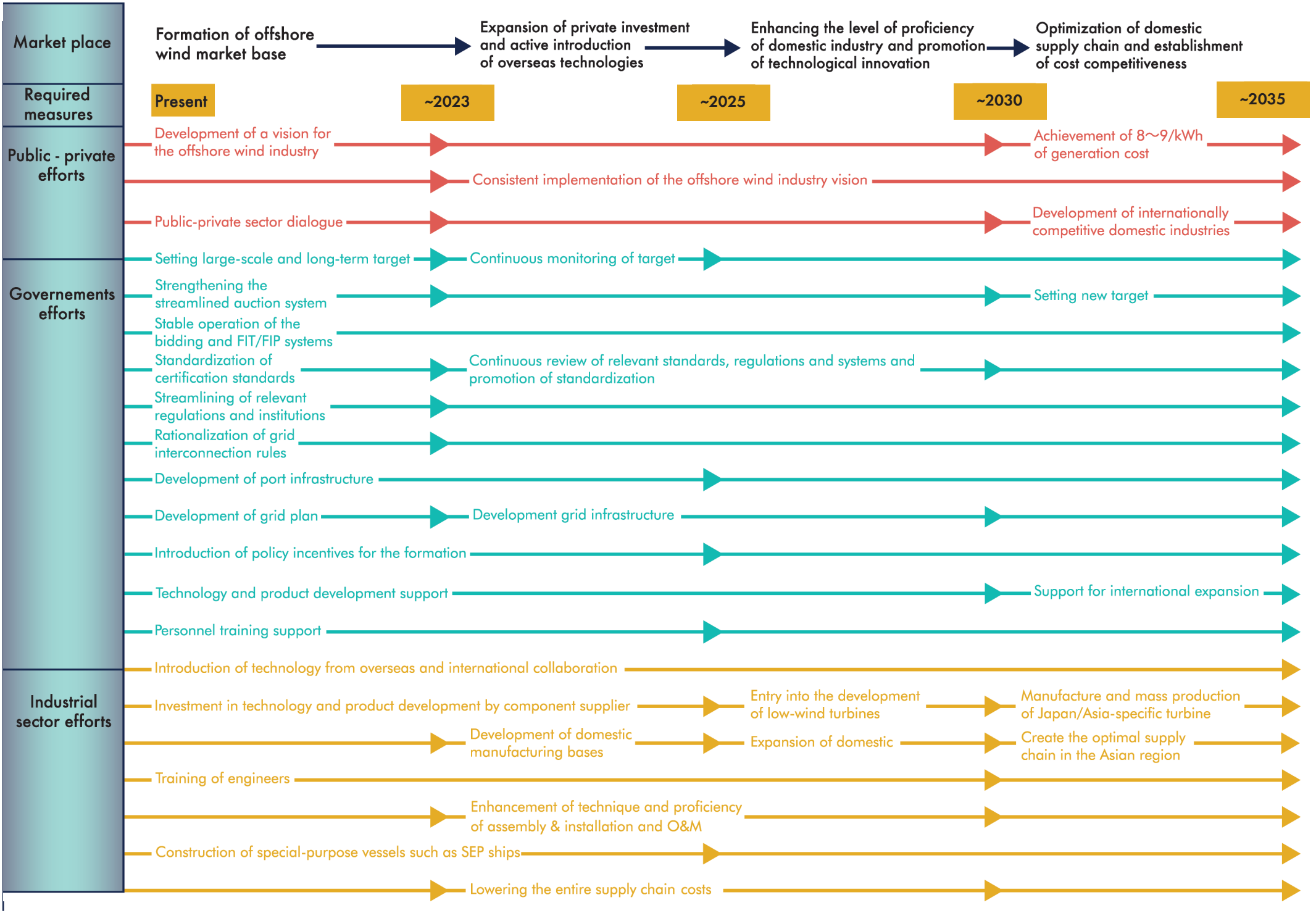

Market place
Formation of offshore wind market base
Expansion of private investment and active introduction of overseas technologies
Enhancing the level of proficiency of domestic industry and promotion of technological innovation
Optimization of domestic supply chain and establishment of cost competitiveness
Required measures
Present
~2023
~2025
~2030
~2035
Public - private efforts
Development of a vision for the offshore wind industry
Achievement of 8~9/kWh of generation cost
Consistent implementation of the offshore wind industry vision
Public-private sector dialogue
Development of internationally competitive domestic industries
Governements efforts
Setting large-scale and long-term target
Continuous monitoring of target
Strengthening the streamlined auction system
Setting new target
Stable operation of the bidding and FIT/FIP systems
Standardization of certification standards
Continuous review of relevant standards, regulations and systems and promotion of standardization
Streamlining of relevant regulations and institutions
Rationalization of grid interconnection rules
Development of port infrastructure
Development of grid plan
Development grid infrastructure
Introduction of policy incentives for the formation
Technology and product development support
Support for international expansion
Personnel training support
Introduction of technology from overseas and international collaboration
Industrial sector efforts
Investment in technology and product development by component supplier
Entry into the development of low-wind turbines
Manufacture and mass production of Japan/Asia-specific turbine
Development of domestic manufacturing bases
Expansion of domestic
Create the optimal supply chain in the Asian region
Training of engineers
Enhancement of technique and proficiency of assembly & installation and O&M
Construction of special-purpose vessels such as SEP ships
Lowering the entire supply chain costs

Figure 22: Recommendations for detailed study

In order to advance cost reduction and capacity-building for Japan's offshore wind industry, this study concludes by highlighting the following specific areas for future detailed study and planning:

Field	Considerations
Supply chain	• Develop and communicate the vision for offshore wind industry • Examination and implementation of specific measures to promote cooperation between domestic and overseas companies and entry of domestic companies • Examination and implementation of effective support measures to promote technological innovation and reduce LCOE
Regulations & systems	• Examination and implementation of specific measures to strengthen the streamlined auction system and healthy competition • Technical study for clarification and standardization of certification standards • Examination of specific measures to streamline related regulations and laws
Grid infrastructure	• Early review of grid connection rules (Ensuring consistency and rationality of the existing laws and rules) • Expanding the Japanese version of Connect & Manage • Examination of integrated development and enhancement of inter-regional transmission lines and intra-regional transmission lines • Examination of master plan to enable the transmission of offshore wind power, such as submarine DC power transmission, to demand areas
Port infrastructure	• Consideration of mid- to long-term plan for the development of a hub port consistent with the targets and designation of the promotion area for offshore wind • Rationalization of rules for the use of hub port consistent with designation of promotion area for offshore wind • Examination of the scale and functions required for the installation of floating offshore wind
Human resource development	• Cultivation and securing of human resources in cooperation with universities, technical colleges and technical high schools. • Establishment of system to develop human resources with expertise in planning, design, construction, and HSE risk management, and foundation of technical training center for offshore wind power • Construction of O&M human resource development system and establishment of training center • Establishment of related standards and certification systems in accordance with international standards

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