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Japan's Green Transformation (GX) investment policies and implications for EU companies

Report

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List of Abbreviations

Bn	Billion
CAPEX	Capital Expenditures
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization and Storage
CE	Circular Economy
CNF	Cellulose Nanofiber
CO_2	Carbon Dioxide
DER	Distributed Energy Resources
EMS	Energy Management System
ETS	Emission Trading System
EV	Electric Vehicle
FC	Fuel Cell
FCV	Fuel Cell Vehicle
FIP	Feed-in-Premium
FIT	Feed-in Tariff
FY	Fiscal Year
GHG	Greenhouse Gas
GW	Gigawatt
GWh	Gigawatt hour
GX	Green Transformation
H_2	Hydrogen
HVDC	High Voltage Direct Current
ICT	Information and Communications Technology
IEEJ	Institute of Energy Economics, Japan
JBIC	Japan Bank for International Cooperation
JETRO	Japan External Trade Organization
JIS	Japanese Industrial Standard
JISC	Japanese Industrial Standards Committee
JOGMEC	Japanese Organisation for Metal and Energy Safety
JPY	Japanese Yen
JV	Joint Venture
JWPA	Japan Wind Power Association
kWh	Kilowatt hour

LCCM	Life Cycle Carbon Minus
LNG	Liquefied Natural Gas
MaaS	Mobility as a Service
METI	Ministry of Economy Trade and Industry
MoEJ	Ministry of the Environment, Japan
MoF	Ministry of Finance, Japan
MOFA	Ministry of Foreign Affairs of Japan
MW	Megawatt
NAS	Sodium (Na) - Sulphur (S) battery System
NEDO	New Energy and Industrial Technology Development Organization
NEXI	Nippon Export and Investment Insurance
NIES	National Institute for Environmental Studies
Nm3	Normal Cubic Meter
OPEX	Operational Expenditures
PV	Photovoltaic
REMS	Regional Energy Management System
SAF	Sustainable Aviation Fuels
SME	Small and Medium Enterprises
TWh	Terawatt hour
USD	US Dollar
VPP	Virtual Power Plants
ZEH/ ZEB	Net-zero Energy Houses/ Buildings

Executive Summary

Japan has made two international commitments to address global climate change: to reduce greenhouse gas emissions by 46% until FY2030 and to become carbon neutral by 2050. In the future, Japan will need to overcome the challenges of ensuring a stable energy supply and decarbonization by leveraging the accumulated expertise of the private sector, while moving away from excessive dependence on fossil energy. This effort means the shift to a sustainable, clean energy-centred industrial and social structure, namely "Green Transformation" ("GX") and it is what Japan is aiming for.

In February 2023, the Cabinet approved the "Basic Policy for the Realization of GX" to support R&D, capital investment, and demand creation for GX in the following **22 areas:**

Green Transformation (GX) Target Areas	
Hydrogen/Ammonia	Zero Emission Ships
Battery Industry	Bio plastic
Steel Industry	Renewable Energies
Chemical Industry	Next generation network (grid and coordinating power)
Cement Industry	Next Generation Innovative Reactor
Pulp & Paper Industry	Transportation
Automotive Industry	Infrastructure
Resource Recycling	Carbon-recycled fuel
House/Building	CCS
Investment for Digital with aim for decarbonization	Food, agriculture, fishery Industries
Aircraft Industry	Local community etc.

More than **150 trillion yen of public-private investment** is required over the next 10 years for Green Transformation (GX) investment, and Japan had decided to issue **20 trillion yen of GX Economy Transition Bonds** to finance these investments.

The political targets and "GX technology" fields related to renewable energies, smart grids/Virtual Power Plants, energy storage, hydrogen, mobility & transport, CCU/CCS, housing & construction, circular economy, and farming & food production include:

Renewable Energies & Energy Storage

- increase the share of renewable energies to 36-38 percent by 2030
- reach an installed capacity of 104-118 GW solar power by 2030
- install 10 GW of Offshore Wind Power by 2030 and 30-45 GW by 2040
- develop the power grid based on the Power Grid Establishment Masterplan issued by 2022
- install a distance submarine HVDC power transmission system from offshore wind power generation site to large consumption areas
- encourage stationary battery development, including grid storage batteries
- achieve a cumulative installation of approximately 24 GWh for the total of home-use and business/industrial-use storage batteries by 2030
- invest in the development of a decentralized energy system and create a "next generation grid" including aggregators, demand-side management, and Virtual Power Plants (VPP)

Hydrogen

- scale up the hydrogen market to 3 million tons per year by 2030
- realize 800,000 fuel cell vehicles, 1,200 fuel cell buses, 10,000 fuel cell forklifts, and 5.3 million residential fuel cell units by 2030.
- establish success cases of ammonia/ hydrogen co-firing by 2024, so as to support development of supply chain starting 2025
- achieve lower costs for hydrogen (30yen/Nm3) and ammonia (10~20yen/Nm3-H2) by 2030
- expand supply of “green” steel to 10 million tonnes by 2030

Mobility

- achieve 20~30% EVs in commercial vehicle sales by 2030
- achieve 100% EVs and HEVs by 2035 for new private car sales
- enhance charging infrastructure by rolling out 150,000 EV chargers (incl. 30,000 fast chargers) and 1,000 hydrogen stations by 2030
- cut CO_2 emissions cut by 1.8 million tonnes in shipping industry by 2030 through introduction of ammonia/hydrogen-fuelled ships
- introduce carbon-neutral fuels for shipping and aviation sectors by 2050
- 10% of the aviation fuel used in Japan, or about 1.7 million kilolitres per year, shall be SAF (sustainable aviation fuel) by 2030

Construction

- build a CCUS value chain and capture 120-240 million tonnes of CO2 by 2050.
- realize ‘net zero’ for new houses and buildings by 2030
- promote LCCM (Life Cycle Carbon Minus) and ZEH/ ZEB (net-zero energy houses/ buildings) with the aim of absorbing 5.6 million tons of CO2 by 2030
- expand supply of carbon neutral cement to 2 million tonnes by 2030
- introduce approx. 2 million tons of bioplastics by 2030

CE & Farming

- establish technologies for the electrification and hydrogenation of agricultural and forestry machinery and fishing boats by 2040.
- complete shift to horticultural facilities that do not use fossil fuels by 2050 through the development of heat pumps
- establish technology for next-generation organic agriculture by 2040 and increasing in organic farming to 25% (1 million hectares) of farmland by 2050.

With a view on the targets and main investment fields of Japan's GX policy, EU companies offering expertise in the following related technology fields should have excellent opportunities in the market:

Energy & Hydrogen

- innovative, next-generation battery cells
- innovative, next-generation fuel cells
- innovative, next-generation PV technology, e.g. flexible panels, or Perovskite solar cells
- technologies for efficient use of woody biomass energy
- smart grid related technologies and systems, e.g. smart metering, real-time monitoring systems (tracking systems), demand response systems
- technologies for CAPEX and OPEX reduction for electrolysers
- ammonia production units
- energy management systems that optimize the hydrogen production using intermittent renewable power sources
- hydrogen transportation technologies
- technologies for wind turbines and floating turbines
- carbon capture and storage (CCS) related technologies

Construction & Housing

- insulation material
- insulating windows
- innovative sustainable building material with low carbon footprint in regard to the whole life-cycle (production, use, disposal/re-use)
- innovations for carbon-neutral cement production of alternatives to cement
- innovative wooden building materials
- wooden construction of high-rise buildings
- intelligent low-voltage and high-voltage electricity meters
- water heaters with heat pumps
- efficient and sustainable home air conditioning systems
- innovative energy-efficient lighting systems

Mobility

- light-weight material for EV, aircrafts, and ships
- innovative, next-generation EV batteries
- innovation for bio-based fuels and SAF (sustainable aviation fuels)
- electric vehicle chargers
- MaaS (Mobility as a Service) solutions

Circular Economy

- highly functional biobased materials such as bioplastics
- advanced technologies and mechanisms for waste sorting, e.g. identification and sorting technologies for the mechanical recycling of black plastics
- high-performance materials and recycling technologies
- development of new materials such as lignin derivatives and CNF to replace plastic
- technologies for recovery of CO2 from waste treatment facilities

- technology for waste heat recovery
- improvement and cost reduction of heat storage and transportation technologies.

Farming

- ICT and smart farming technologies such as robots for agricultural use, technologies for precision farming, Artificial Intelligence, drones for agricultural use
- smart farming services
- technologies and solutions to realize the shift from fossil fuels in horticultural facilities, e.g. heat pumps, agrivoltaics, technologies for the electrification and hydrogenation of agricultural and forestry machinery
- technologies for next-generation organic agriculture

Related **laws and regulations** as well as differing standards can be hurdles when entering the Japanese market. A main challenge is public tenders, which are theoretically open to foreign companies but often not easy to find and to get involved in. Language is still quite a barrier as English-speaking staff, especially in Japanese SME is rather rare.

To be successful in the Japanese market, European companies should pay close attention collaboration with local partners, to the high requirement of time and human resources, the uncompromising expectations of customers towards high quality and an intensive after-sales-service.

Scope of the Report

Green Transformation (GX) refers to the transformation of the entire economic and social system from an economy, society, and industrial structure dependent on fossil fuels to “structures driven by clean energy”. *(GR Japan 2023)*

This report aims to provide basic information on the Green Transformation (GX) policy of the Japanese government and its implication on the main technological fields ("GX Technologies") affected by it.

Chapter 1 explains the background and content of Japan's overall GX strategy, including an overview of the technological fields, financing plan, and involved stakeholders (ministries, governmental bodies, associations, research institutes).

Chapter 2 goes into detail and highlights the political targets and future prospects in each of the selected "GX technology" fields, including renewable energies, smart grids/Virtual Power Plants, energy storage, hydrogen, mobility & transport, CCU/CCS, housing & construction, circular economy, and farming & food production.

Based on this, chapter 3 assesses the business and technological cooperation potential for European SME in the GX technology fields in Japan, explains some specific challenges and provides recommendations for market entry.

The aim is to give small and medium-sized EU-based companies an insight into the business opportunities and framework conditions for innovative technologies and/or know-how which can contribute to the ongoing Green Transformation (GX) in Japan.

The information in this report is based on desk research of relevant publications and media in Japanese, English and German including publications by Japanese ministries, government bodies, research institutes, associations as well as articles in expert journals, economic journals, company reports, company websites, press releases, newspapers, statistical websites.

1. Overview on GX policy in Japan

a. GX Government Strategy

On 26th October 2020, then Prime Minister Suga announced that Japan's economy shall reach the target of "Net Zero" greenhouse gas (GHG) emissions until 2050. This declaration was followed by a more detailed “Green Growth Strategy” document published by the Ministry of Economy Trade and Industry (METI) on 25th December 2020. In April 2021, Prime Minister Suga raised the target to reduce GHG emissions by 46 per cent (formerly: 26 per cent) by 2030, compared with 2013 levels. *(Oxford Institute for Energy Studies, 2021)*

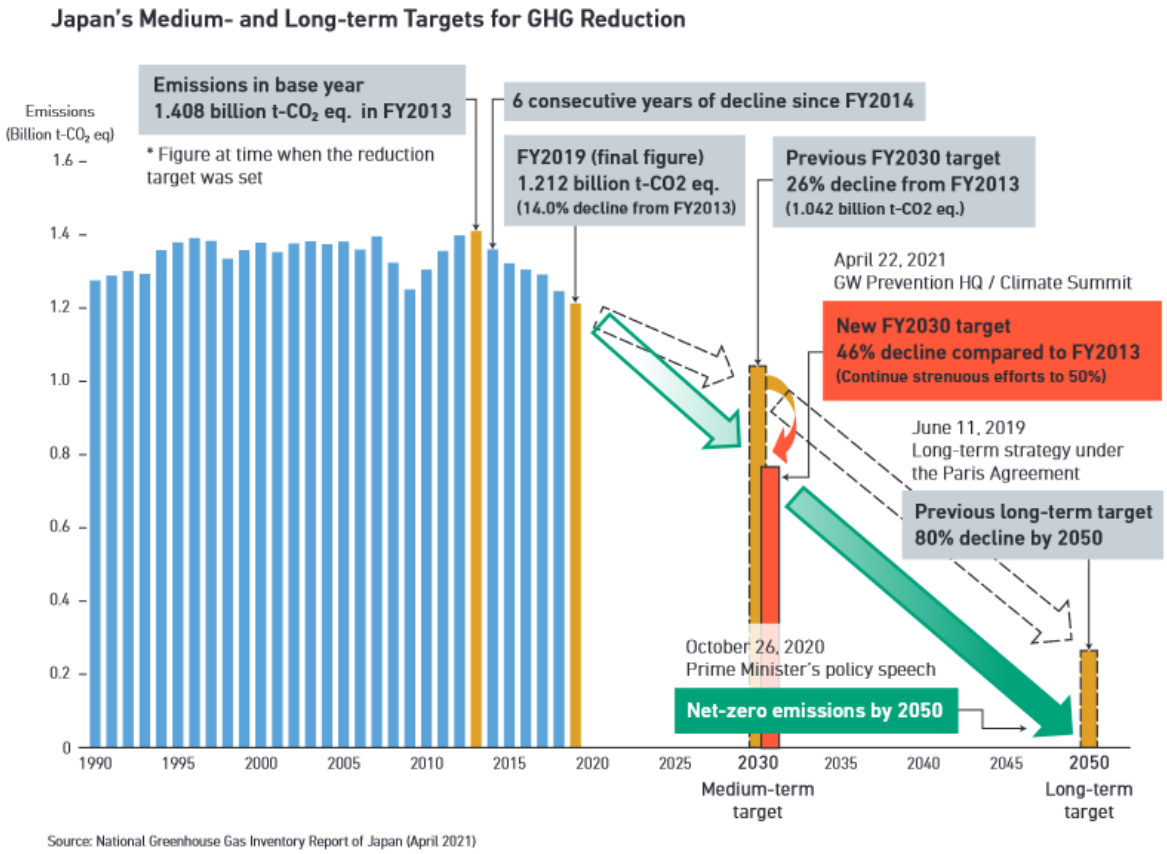


Fig. 1: Japan’s targets for GHG reduction (Source: MoE, 2021)

In October 2021, the **6th Basic Energy Plan**, which aimed to be consistent with the 46 per cent reduction target by 2030, was adopted by the cabinet. According to the plan, renewables should account for 36-38% of power supplies in 2030, well above its previous 2030 target for 22-24%. 14-16% of green energy is to come from solar, 5% from wind, 1% from geothermal, 11% from hydropower and 5% from biomass. Newer fuels such as hydrogen and ammonia will account for about 1% of the electricity mix by 2030.

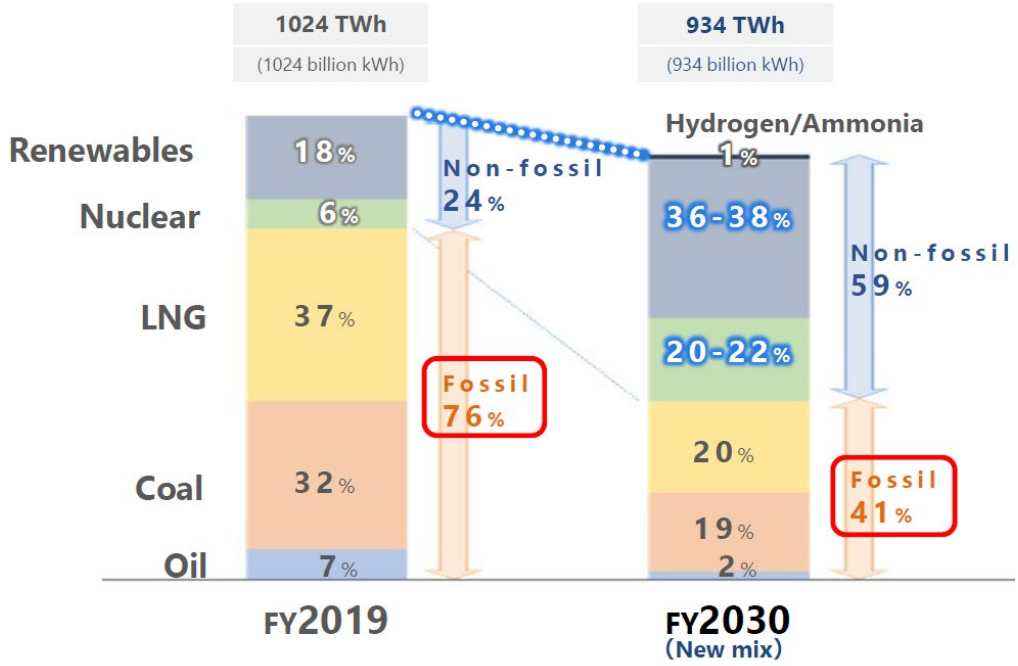


Fig. 2: 6th Basic Energy Plan (source: ANRE, 2021)

Also in October 2021, the government-appointed "Green Innovation Committee" published the **"Green Growth Strategy Through Achieving Carbon Neutrality"**. It lists up 14 key sectors of focus in order to develop and technologically further modernize Japan's economy by focusing on the growth of specific low-carbon and renewable sectors. According to METI, the Green Growth Strategy is an industrial policy which aims to create a "virtuous" circle of economic growth and environmental protection, in collaboration with the business community. The "Green Growth Sectors" include offshore wind energy, ammonia as a fuel, hydrogen, electric vehicles and resource cycles (see fig 3).

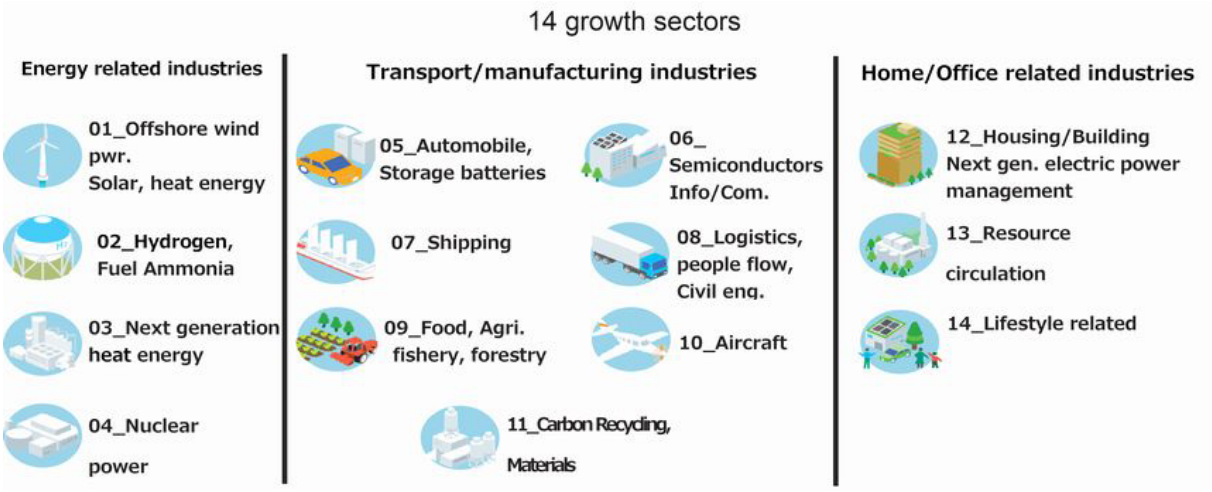


Fig. 3: 14 growth sectors (source: METI, 2022)

In February 2023, the Cabinet approved the "**Basic Policy for the Realization of GX"** based on discussions at the GX Implementation Council and other councils at various ministries and agencies since July 2022. The basic idea is

- to contribute to global decarbonization through the realization of GX and
- to strengthen Japan's industrial competitiveness and economic growth.

The government plans to support R&D, capital investment, and demand creation for GX in various key areas, including thorough energy conservation, the use of renewable energy as a main power source, nuclear power, hydrogen, ammonia, and others. The following **22 areas are targeted for investment**:

Green Transformation (GX) Target Areas	
Hydrogen/Ammonia	Zero Emission Ships
Battery Industry	Bio plastic
Steel Industry	Renewable Energies
Chemical Industry	Next generation network (grid and coordinating power)
Cement Industry	Next Generation Innovative Reactor
Pulp & Paper Industry	Transportation
Automotive Industry	Infrastructure
Resource Recycling	Carbon-recycled fuel
House/Building	CCS
Investment for Digital with aim for decarbonization	Food, agriculture, fishery Industries
Aircraft Industry	Local community etc.

(Source: METI, 2023)

b. Budget and investment plan

In order to realize the Green Innovation (GX) investments, which aim to achieve the three goals of decarbonization, economic growth and energy security, a "sector-specific investment strategy" for the next ten years was developed by a "GX Implementation Expert Working Group" for each of the 22 focus areas mentioned above. The "roadmap" was adopted as a "sector-specific investment strategy" in July 2023. It includes long-term, multi-year commitments and prospects for regulatory and institutional measures. *(METI, 2023a)*

More than **150 trillion yen of public-private investment** is required over the next 10 years for Green Transformation (GX) investment, and Japan had decided to issue **20 trillion yen of GX Economy Transition Bonds** to finance these investments (see fig. 4).

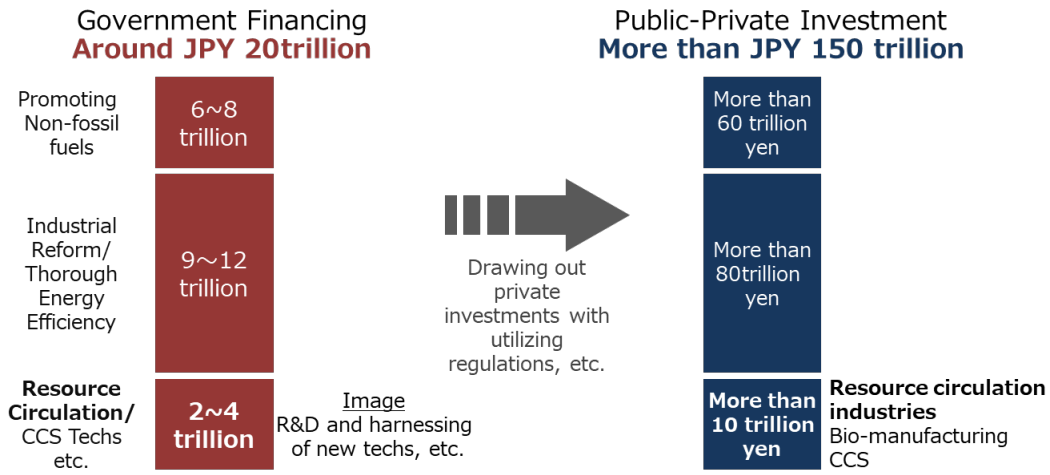


Fig. 4: GX Financing Plan (source: METI, 2024)

Five key initiatives being discussed by the government to achieve 150 trillion JPY (approx. US$1 trillion) of private-public investment to bring about Japan's green transformation (GX):

1. Growth-oriented carbon pricing (including GX transition bonds)
2. Integrated regulatory/assistance promotion measures
3. New financing methods
4. International development strategy, including formation of Asia Zero Emissions Community
5. Development of GX League (forum for cooperation between companies, government and academia)

In order to realise the 150 trillion yen of investments needed for GX, as well as to fulfil international commitments and to maintain industrial competitiveness, the concept of "growth-oriented carbon pricing" has been designed consisting of two pillars:

1) Upfront investment support (GX Transition Bonds, backed by financial resources generated from the introduction of carbon pricing)
2) Measures to promote emission reductions such as a Carbon Levy, targeting fossil fuel importers such as power, oil and gas companies, and an Emission Trading Scheme ("GX-ETS") for sectors with high emissions, first through the launch of voluntary trading among GX League. Auctioning of allowances, like the ETS in EU, will be introduced in the future for electric power companies to expedite decarbonisation of the power sector. *(GR Japan, 2023)*

An overview of the complex financing strategy of Japan's "Green Transformation" can be seen in fig 5. Some key elements are explained in the following.

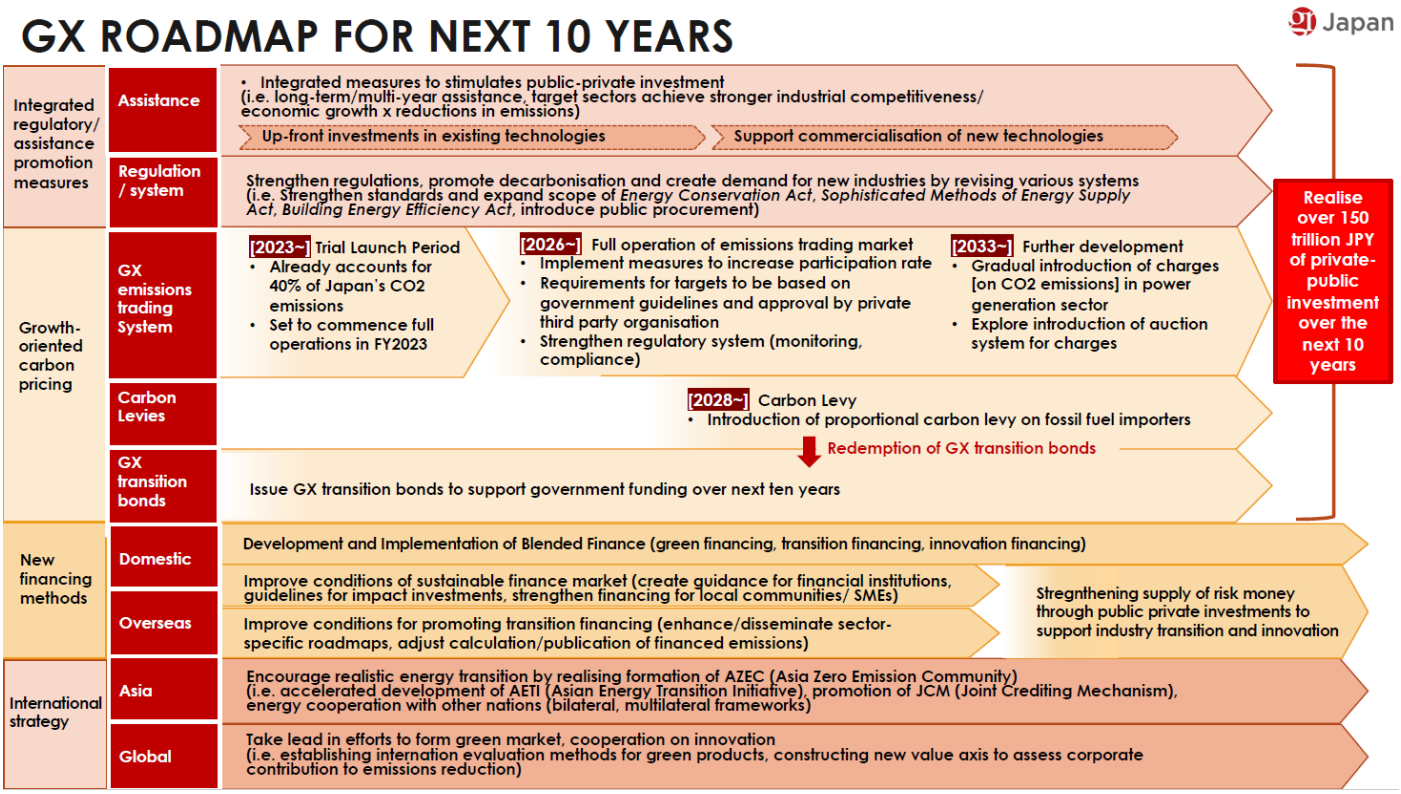
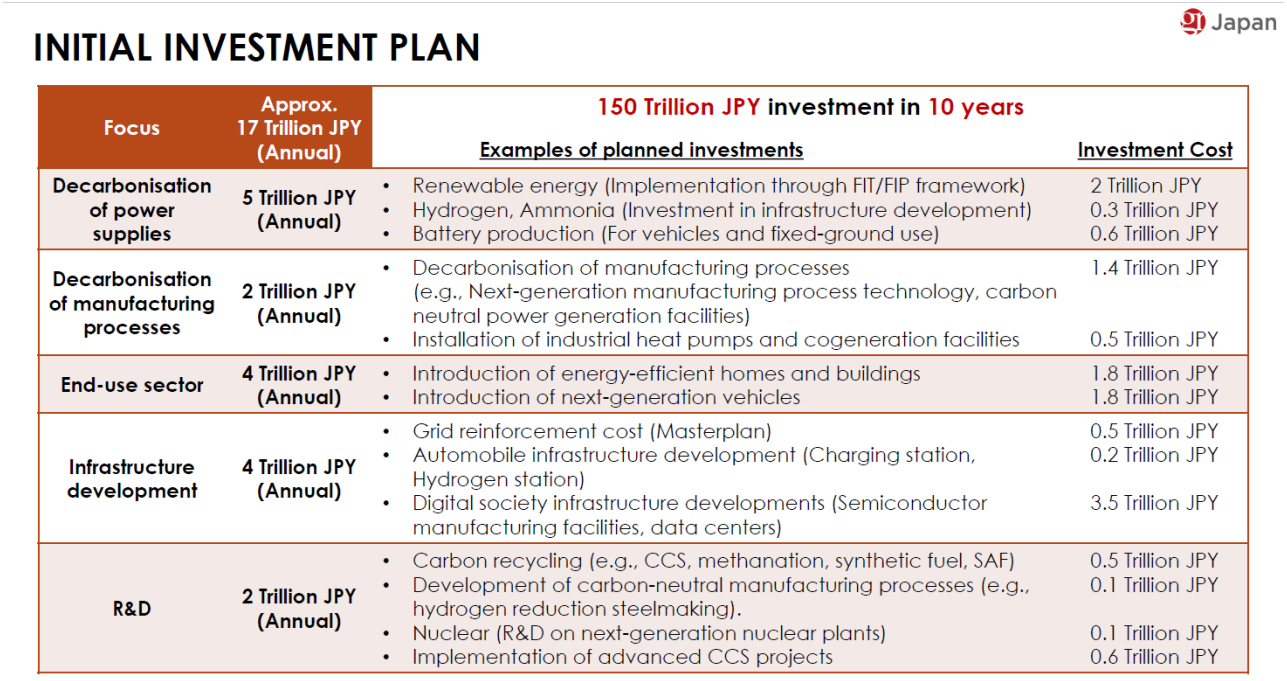


Fig. 5: GX Roadmap for 10 years (source: GR Japan, 2023)

The planned **allocation of private investment** is outlined in fig. 6. It reflects the focus on the **key prioritized areas** including steel, chemicals, pulp and paper, cement, automotive, batteries, aircraft, SAF, ships, lifestyle products, resource recycling, semiconductors, hydrogen, next generation renewable energy (e.g. perovskite solar cells, floating offshore wind turbines), nuclear power and CCS.



Focus	Approx. 17 Trillion JPY (Annual)	150 Trillion JPY investment in 10 years Examples of planned investments	Investment Cost
Decarbonisation of power supplies	5 Trillion JPY (Annual)	• Renewable energy (Implementation through FIT/FIP framework) • Hydrogen, Ammonia (Investment in infrastructure development) • Battery production (For vehicles and fixed-ground use)	2 Trillion JPY 0.3 Trillion JPY 0.6 Trillion JPY
Decarbonisation of manufacturing processes	2 Trillion JPY (Annual)	• Decarbonisation of manufacturing processes (e.g., Next-generation manufacturing process technology, carbon neutral power generation facilities) • Installation of industrial heat pumps and cogeneration facilities	1.4 Trillion JPY 0.5 Trillion JPY
End-use sector	4 Trillion JPY (Annual)	• Introduction of energy-efficient homes and buildings • Introduction of next-generation vehicles	1.8 Trillion JPY 1.8 Trillion JPY
Infrastructure development	4 Trillion JPY (Annual)	• Grid reinforcement cost (Masterplan) • Automobile infrastructure development (Charging station, Hydrogen station) • Digital society infrastructure developments (Semiconductor manufacturing facilities, data centers)	0.5 Trillion JPY 0.2 Trillion JPY 3.5 Trillion JPY
R&D	2 Trillion JPY (Annual)	• Carbon recycling (e.g., CCS, methanation, synthetic fuel, SAF) • Development of carbon-neutral manufacturing processes (e.g., hydrogen reduction steelmaking). • Nuclear (R&D on next-generation nuclear plants) • Implementation of advanced CCS projects	0.5 Trillion JPY 0.1 Trillion JPY 0.1 Trillion JPY 0.6 Trillion JPY

Fig. 6: GX initial investment plan (GR Japan, 2023)

i. GX Bonds and Green Finance

In order to realize large-scale GX public-private joint investment, the government decided to raise funds through the issuance of "GX Economic Transition Bonds" to support upfront investment of 20 trillion yen.

The first public offering of GX Economic Transition Bonds, which will be called "Climate Transition Bonds", took place in February 2024, raising up to 1.6 trillion yen. The Climate Transition Bonds have already been certified by an external evaluation agency, and the funds raised will be distributed to projects that contribute to the shift to renewable energy as the main power source, utilization of nuclear power, and promotion of hydrogen and ammonia introduction, as described below. The redemption source is expected to be the proceeds from the fuel levy (to be introduced in FY2028) and the emission allowance auction system (to be introduced in FY 2032).

Target areas for GX	Business model
Structural Transformation of the Manufacturing Industry	✓ Development and introduction of innovative technologies such as hydrogen-reduced steelmaking, conversion to a carbon-recycling production system, etc.
GX in the transportation sector	✓ Support for introduction of next-generation vehicles ✓ Development of demonstration aircraft for next-generation aircraft, support necessary for the diffusion of zero-emission ships, etc., etc.
Carbon Recycle/CCS	✓ Support for research and development on carbon-recycled fuels, etc.
Promoting Energy Conservation	✓ Installation of insulated windows, etc.
Making renewable energy the main source of electricity	✓ Expanding introduction of next-generation solar cells (perovskite) and floating offshore wind power, etc.
Next Generation Innovative Reactor	✓ Next-generation innovative reactors incorporating new safety mechanisms
Hydrogen/Ammonia	✓ Establish supply chains domestically and internationally ✓ Promote R&D and introduction of hydrogen production from surplus renewable energy, etc.
Electricity and gas market development	✓ Promote zero-emission thermal power plant ✓ Development of submarine DC power transmission, etc.

(Source: METI, 2023)

To realize over 150 trillion yen in public and private joint GX investments over the next 10 years, the Japanese government also aims to unleash the power of private financial institutions and institutional investors in addition to "GX Economic Transition Bonds". To this end, a domestic market for environmentally friendly business-specific finance ("Green Finance") shall be developed and the efforts to deepen international understanding of investments and loans for transitioning carbon-emitting business activities to decarbonized ones (Transition Finance) shall be strengthened. In addition, since there are cases in the GX sectors where the technology and demand are highly uncertain and risks cannot be taken by private finance alone, the government will work to share knowledge between the public and private sectors to establish a financial approach that combines public and private financing (blended finance). *(METI, 2023)*

ii. International Strategies / GX in SMEs

The realization of GX in Asia, which accounts for half of the world's GHGs, is very important for solving global climate change issues. To contribute to the realization of GX in Asia, Japan has set up the "Asian Zero Emission Community (AZEC)" concept, and through the "Asian Energy Transition Initiative (AETI)" will support the formulation of a roadmap toward the realization of decarbonization and provide financing through government agencies such as JBIC, NEXI, and JOGMEC.

Japanese SMEs support about 70% of employment in Japan and account for about 20% of Japan's total GHG emissions. To help SMEs achieve GX, the government plans to support companies in calculating their own emissions and making capital investments that contribute to renewable energy and emission reductions. The government will also strengthen human resource development and support systems for SME support organizations. (*METI, 2023)*

iii. Legislation

The GX Promotion Law and the GX Decarbonized Power Source Law were enacted in May 2023 to realize the GX Basic Policy.

The GX Promotion Law stipulates that the government shall formulate a strategy for the comprehensive and systematic promotion of GX (the "GX Promotion Strategy"), and based on that the strategy also stipulates the issuance of GX Economic Transition Bonds, the collection of fossil fuel levies, and the collection of contributions for the allocation of emission allowances to power generation companies, and also establishes the GX Promotion Agency, which serves as a window for support for GX-related projects.

The GX Decarbonization Power Source Act revised related laws to (1) maximize the introduction and expansion of renewable energy and (2) promote the utilization and decommissioning of nuclear power generation. With regard to (1), the law provides for grants at the start of construction for grid improvements that contribute to the promotion of renewable energy use and establishes a new purchase price system for additional investment in existing photovoltaic power generation facilities. In addition, the new law will strengthen business discipline and temporarily suspend FIT/FIP grants to those who violate related laws and regulations. The new law also sets the operating period of nuclear power reactors at 40 years and allows extension of the operating period up to 60 years on the condition that certain standards are met. (*METI, 2023)*

c. Involved Stakeholders

i. Government related stakeholders

The Green Transformation (GX) process was kicked off by Prime Minister Kishida and is considered a "matter of the boss" issue. The GX Executive Implementation Council as the main executing body was established by the Prime Minister in November 2022. Apart from the Prime Minister, the ministers of Economy (METI), Environment (MOE), Ministry of Finance (MOF) and the Ministry of Foreign Affairs (MOFA), are members of the Council as well as representatives of Keidanren, government-close research institutes such as NIES (National Institute for Environmental Studies) and IEEJ (Institute of Energy Economics, Japan), several universities and major companies including Mitsubishi Energy Solutions Co., Ltd. And Chubu Electric Power Co., Ltd. (Cabinet Secretariat, 2023). An overview of the main stakeholders involved is shown in fig. 7 below.

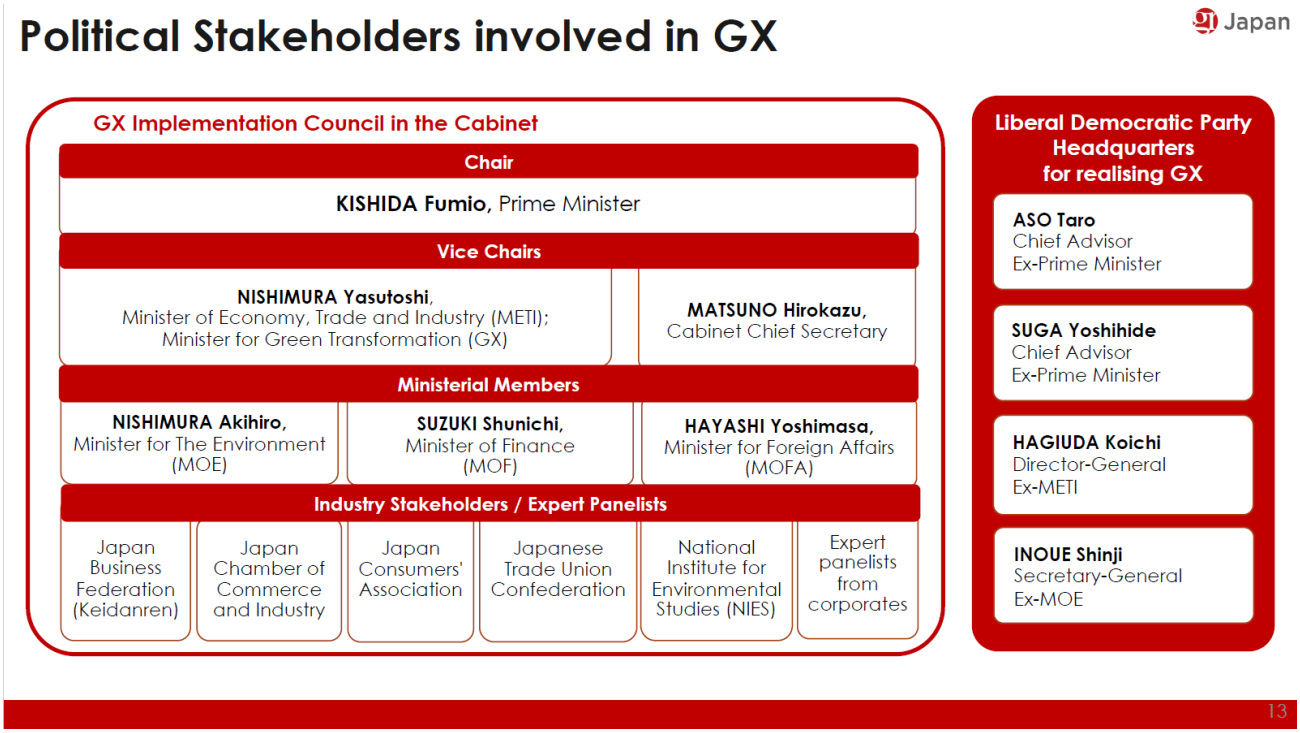


Fig. 7: Political Stakeholders Involved in GX (source: GR Group: "OVERVIEW OF JAPAN'S GREEN TRANSFORMATION (GX)", January 2023)

Another important player when it comes to strategic technology development is the **New Energy and Industrial Technology Development Organization (NEDO)**, a national research and development agency funded by METI back in 1980. NEDO's main task is to create innovation by promoting technological development (including practical demonstration) necessary to achieve a sustainable society. NEDO actively promotes the demonstration of new energy, energy saving and environmental technologies domestically and abroad. From the current NEDO project funds of 38.3 billion euro, 17.2 billion euro (2,754.6 billion yen) are allocated to **"Green Innovation Fund Projects"** which provide support from research and development to the social implementation of innovative technologies for the next 10 years toward realizing carbon neutrality in 2050. (https://www.nedo.go.jp/english/)

ii. GX League

One pillar of the government GX strategy is the "GX League" (https://gx-league.go.jp/en/). Established in April 2022, the GX League is a network of more than 550 Japanese companies (accounting for 40% of Japan's emissions) that are committed to:

- Voluntary emissions reduction with clear targets for 2030 and a roadmap for carbon neutrality by 2050
- Lead decarbonisation of the supply chain
- Support creation of green markets through green procurement.

A Business Working Group has been launched under the league to facilitate market creation and rulemaking on green business, such as developing voluntary certification systems. The GX League will be piloted as Japan's first emissions trading system due to operate as an exchange-based market for the voluntary trading of carbon credits. *(GR Japan, 2023)*

The "GX Dashboard" on the official GX League website serves as a basis for disclosing information about the emissions reduction targets of participating companies and their efforts to reduce emissions in their supply chains. Updates including additional dashboards for companies without submitted Data is taken monthly. In January 2024, METI released the greenhouse gas emissions targets of 372 Japanese companies actively participating in the Green Transformation (GX). The most important reduction targets for 2030 at Hitachi, for example, are a reduction of 93%, although the company has committed to further reduction measures beyond government requirements. Among automakers, Toyota, Nissan and Honda have announced a reduction target of 46%, Mazda 69% and Mitsubishi Motors Corporation 51%. In the steel industry, where emissions reductions are more challenging, Nippon Steel Corporation has committed to a 29% reduction, while Kobe Steel Ltd and JFE Steel Ltd are targeting a 30% reduction. The GX League is currently accepting applications to participate in the Mid-Course starting in 2024**.** *(Kankyo Business, 2024)*

In addition to the large global corporations such as Hitachi, Panasonic, Mitsubishi Electric, Sumitomo, etc., there are numerous companies that dominate as “big players” in their respective market segments, such as:

- Power transmission and distribution companies such as the EPCOs, Electric Power Development Co., Ltd. (J Power), JERA Co., Inc.
- Oil and gas companies such as: B. JXTG Nippon Oil & Energy Corporation, Idemitsu Kosan Co., Ltd., Inpex Corporation, Cosmo Energy Holdings Co., Ltd., Tokyo Gas Co., Ltd., Osaka Gas Co., Ltd., Toho Gas Co., Ltd.
- IT companies such as NTT-Anode Energy, Fujitsu Limited, Hitachi Limited, Mitsubishi Electric Corporation, NEC Corporation, Toshiba Corporation, Panasonic Corporation, Sony.
- Construction companies such as Shimizu Corporation, Takenaka Corporation, Taisei Corporation, Mitsubishi Estate Co., Ltd., Sumitomo Mitsui Construction Co., Ltd., Obayashi Corporation, Kajima Corporation.
- Trading houses like Itochu, Marubeni Corporation, Mitsubishi Corporation, Sojitz Corporation, Sumitomo Corporation. *(AHK Japan, 2023)*

2. GX Policy in Specific Technology Sectors

a. Renewable Energies

One important pillar of Japan's GX Basic Policy is a to establish renewable energies at the centre of Japan's energy supply as a "main source of power" in the near future, stating that "renewable energy will to be introduced as much as possible". *(METI, 2022)*

Japan's current renewable electricity share is only 20%, less than half that of the UK and Germany. The majority of renewable energy generation growth after the Fukushima incident in March 2011 has occurred in solar energy, while hydropower and geothermal power have remained relatively stable as a share of Japan’s energy market, and nuclear has declined dramatically in the aftermath of the Fukushima disaster. Solar and hydropower together generated nearly 60 terawatt hours in 2020, while bioenergy, wind and geothermal energy generation contributed 29, 9, and 3 terawatt hours respectively. *(Shulman Advisory/EU-Japan Centre, Japan, 2022)*

According to the "6h Basic Energy Plan” adopted in October 2021, the share of renewable energies shall be increased to 36-38 percent by 2030 - a significantly more ambitious goal than the 22-24 percent in the previous plan. The focus is on solar energy: photovoltaics should contribute 14-16 percent to the electricity mix in 2030, hydropower with 11 percent and wind energy with 5 percent, hydrogen and ammonia together with 1 percent. By re-starting nuclear power

plants, a share of 20-22% in the country's power mix shall be covered by nuclear power by 2030. *(Renewable Energy Institute, 2022)*

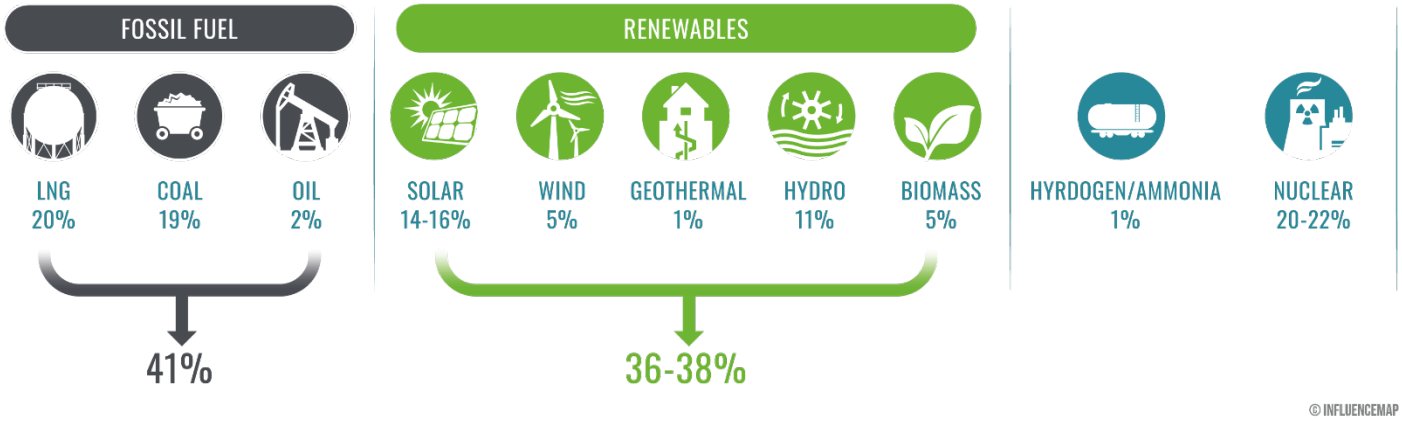


Fig. 8: Japan's 2030 Energy Mix Target (Source: InfluenceMap, https://japan.influencemap.org/policy/Energy-Mix-5345)

i. Photovoltaic

According to the International Renewable Energy Agency (IRENA), Japan has increased its solar capacity significantly in the last 10 years and reached an accumulated capacity pf 78,833 GW in 2022. *(IRENA, 2023)* The rapid rise in solar PV generation has been supported by a generous feed-in tariff (FIT) which started in 2012 at JPY 40/kWh (approx. 0.4 USD/kWh) and was gradually reduced to JPY 12-13/ kWh by 2020. *(Shulman Advisory/EU-Japan Centre, 2022)*

As part of the GX Strategy, Japan aims to reach an installed capacity between 104 and 118 GW solar power by 2030. To reach this goal, around 5 GW capacity need to be installed per year. According to a study from the Japan Ministry of Environment, the total solar energy potential is assessed at around 500 TWh. However, the current plans of the regional electricity companies in Japan only indicate growth to around 80 GW capacity by 2030. It is likely that further government policy incentives could drive more rapid uptake of solar generation. *(GR Japan 2022)*

ii. Wind power

Wind power capacity in Japan has not developed as rapidly as solar generation but showed a stable upward trend in the past years (see fig. 9). There has been a feed-in tariff of around 20 JPY/kWh for onshore wind since 2012, and since 2015 at a level around 35 JPY/kWh for offshore wind, but the higher cost of wind power compared to solar appears to have discouraged investment somewhat. In addition, lengthy environmental impact assessments and local opposition have limited the progress of wind projects (particularly for offshore wind). According to a study from the Japan Ministry of Environment, there is offshore wind potential of 1,500 TWh (equivalent to a capacity of 375 GW capacity at 4,000 operating hours per year), plus a further 450 TWh potential for onshore wind. Despite this very large potential there remain significant challenges to developing offshore wind projects in Japan, notably from challenging water depths and fishing rights, as local fishery cooperatives have the formal right to manage the coastal areas under the system of common fishery rights. *(Oxford Institute for Energy Studies, 2021)*

According to the Japan Wind Power Association (JWPA), the cumulative installed capacity of wind power in Japan by 2023 reached (5,213.4 MW or 2,626 units. The majority is onshore wind power, only 153.5 MW (39 units at 6 sites) account for offshore wind power, of which 5 MW (2 units at 2 sites) are floating type offshore wind farms. *(JWPA, 2024)*

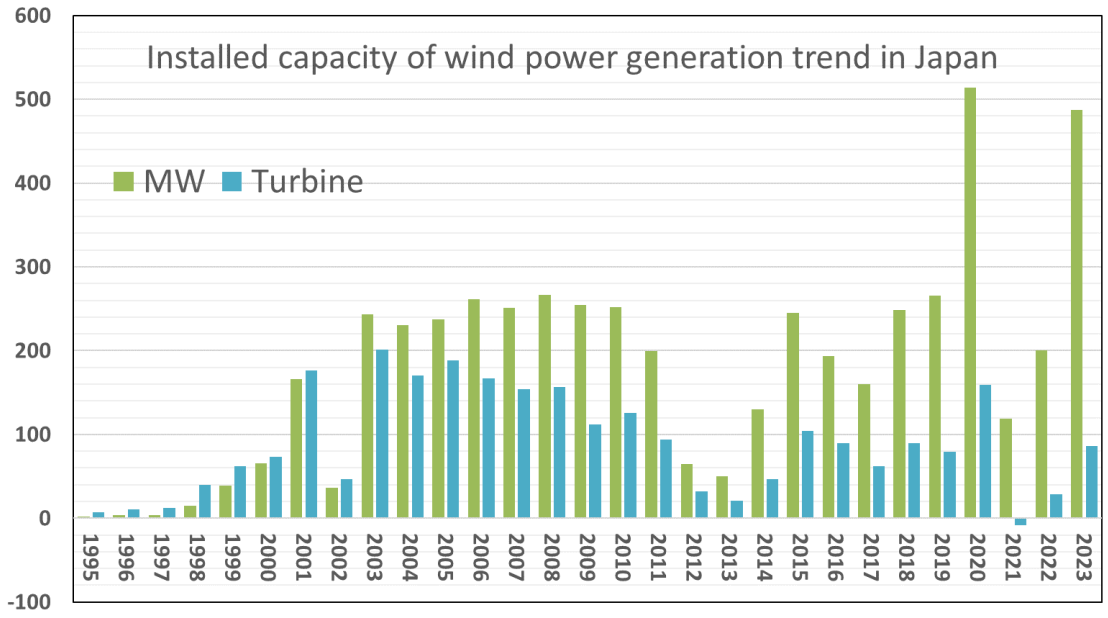


Fig. 9: Development of installed capacity of wind power generation in Japan (Source: JWPA, 2024)

Given the limited space for onshore wind power due to the mountainous topography of Japan, a **focus is set on offshore wind power** in the government's strategy. In order to encourage domestic and foreign investment, the GX Policy Plan has set the target to install 10 GW of Offshore Wind Power by 2030 and 30-45 GW by 2040. https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/01_offshore.pdf

In May 2023, the Japanese government has chosen five sites off the coast of Hokkaido as "promising zones" for developing offshore wind farms, marking the second stage in a three-part selection process. *(Offshore, 2023)*

As the highest wind power potential and also suitable sites for offshore wind power plants are located in Northern Honshu (Akita Pref., Aomori Pref.), followed by Hokkaido and Kyushu, **developing the necessary infrastructure** is a main challenge in order to connect the supply with the demand "hot spots". This includes:

- development of the power grid based on the Power Grid Establishment Masterplan issued by 2022
- Installing a distance submarine HVDC power transmission system from offshore wind power generation site to large consumption areas.

Other targets related to wind power development are:

- Forming competitive and resilient supply chains, i.e. lowering the cost of fixed-bottom offshore wind turbine-generated power to 8 to 9 yen/kWh by 2030-2035
- Improving the business environment by comprehensive review of various regulations
- Accelerating the development of elemental technologies especially for wind turbines and floating turbines in anticipation of demonstrations based on the “technology development roadmap.”

(https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/01_offshore.pdf)

b. Energy Storage

Energy storage technologies are an important pillar for the energy transition worldwide. The intermittent availability of renewable energies poses major challenges for electricity suppliers and network operators. Japan's GX Plan explicitly lists up "battery storage" as a main field of investment.[1] In the course of the planned expansion of renewable powers as described in the previous chapter, batteries for various purposes will be required, be it for residential solar systems or for large-scale batteries that are treated as accessories of substations or power plants under the current Electricity Business Act. Accordingly, the Japanese government has set the target to achieve a **cumulative installation of approximately 24 GWh for the total of home-use and business/industrial-use storage batteries by 2030** and allocated 13 billion Yen in November 2021 to encourage stationary battery development, including grid storage batteries.[2]

(https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/05_automobile.pdf)

Batteries are used both behind the meter, where the market is expected to continue to grow after many PV projects fall out of the FIT program after 20 years, and in front of the meter, where they are used to store excess renewable electricity Energy is used, which is sold during peak times for frequency regulation and as a spinning reserve.

In order to deal with distributed energy resources (DER) and surplus energy from wind power plants or megasolar parks, utility-scale battery storage systems will be needed. DER flexibility technology is being developed from the perspective of reducing network congestion through the use of distributed DER such as storage batteries developed. Japan is considered one of the world leaders in this field, being home to companies such as Toshiba or Panasonic, which is actively marketing "all-in-one" solutions for energy supply at factories, including Fuel cells, batteries and an Energy Management System (EMS). *(Panasonic Group, 2021)*

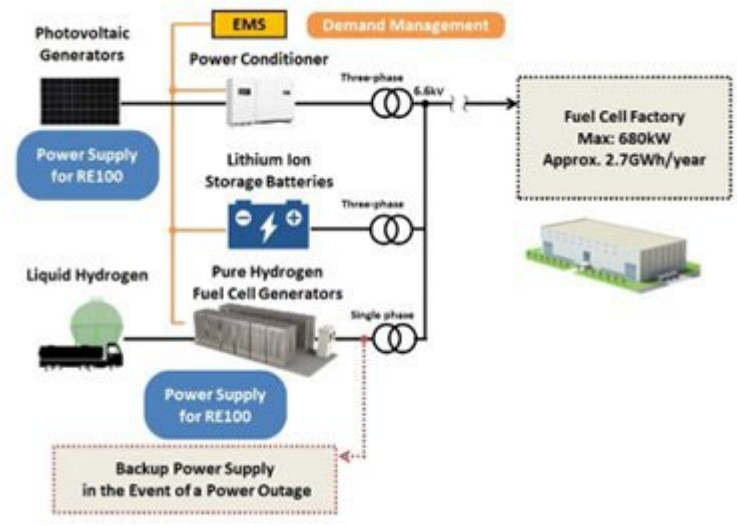


Fig. 10: Configuration of the "RE1002 solution demonstration facility system (Source: Panasonic, 2021)

[1] The prospects for European companies in this area are described in detail in the EU-Japan Centre's report "Clean Technology mapping in Japan: Opportunities for EU Companies - Power & Energy" issued in March 2022.
[2] For mobile batteries, refer to chapter 2 e).

Currently, the general transmission and distribution companies disclose the available capacity of the return power according to the network information guidelines. This information would help operators identify locations where storage batteries can be easily connected. TEPCO and KEPCO have announced “Welcome Zone Maps” in areas where high-voltage electricity can be supplied to factories etc. relatively quickly and inexpensively. Hokkaido Electric Power Network Co. Power Network considers providing pinpoint information on suitable areas for grid storage batteries. *(AHK Japan, 2023)*

At present, **Lithium-ion** (Li-ion) is the current dominant technology on Japan’s battery market. Although the cost is still relatively high, the technology has recently experienced extremely rapid cost declines and technological improvements, which spurs hope that even further cost reduction can be achieved in the future. Thus, a continued market dominance of Li-ion-based energy storage technologies is expected, especially for small-scale energy storage. **Nickel-based batteries** are already used in electric vehicles and in electro-domestic appliances. In order to compete on a more equal footing in the market however, they will need to not only reduce costs, but also improve charge and discharge efficiency. *(Shulman Advisory/EU-Japan Centre, 2022)*

Another battery technology which is expected to play a significant role especially for large-scale storage is the **NAS battery**, a high temperature electrochemical energy storage device which operates at 300°C. The technology is marketed as suitable for medium to long-duration energy storage applications. The market has opened up considerably in recent months, after regulators amended laws to enable more transparency in the energy trading market, the eligibility of battery storage to play into the capacity market, and adjustments in legislation to allow standalone energy storage facilities to connect to the power grid. There are also subsidies available from METI covering a portion of the capital cost of projects selected for the ministry’s programme to support the promotion of energy storage. The Japanese enterprise NGK Insulators, Ltd. has sold more than 5GWh of NAS batteries to projects around the world, including Hungary and Germany, for applications that include renewable energy integration and grid services as well as commercial and industrial and microgrid energy systems. *(Energy Storage News, 2023; EASE News, 2018)*

c. Smart Grids / VPP

The intermittent availability of wind and solar power poses a major challenge to Japan's power grid, which is designed for conventional power generation. Currently, renewable energy sources such as solar and wind energy as well as energy resources such as storage batteries and electric vehicles are not centrally pooled. Not only a lack of electricity, but also an excess supply of electricity can lead to a disruption in the stable energy supply. To prevent this, the Japanese government is not only promoting the development of energy storage technologies (see previous chapter), but also technologies for controlling the amount of electricity generated from renewable sources. In order to secure the country's energy needs and increase the grid capacity for renewable energies, Japan wants to invest more in the development of a decentralized energy system and create a "**next generation grid**". In April 2022, for example, the “aggregator system” was introduced, in which so-called aggregators take over the management of several locally controlled power sources and make them available to network operators or energy trading companies via Virtual Power Plants (VPP). *(AHK Japan, 2023)*

As part of the ‘next generational network’, Japan is also investing in **Regional Energy Management Systems** (REMS). Energy management system (EMS) means a computer-controlled system used by electric utility operators to monitor the real-time performance of the various elements of an electrical system and to control generation and transmission assets. Nippon Koei Group is one of the engineering and consulting companies operating in this area and advised

TEPCO (Tokyo Electric Power Co.) regarding the installation of a next-generation monitoring and control system before the Olympic Games in Tokyo. *(AHK Japan, 2023)*

A system that regulates the balance between electricity supply and demand by managing different energy resources using IoT technology is called a **Virtual Power Plant** (VPP). The energy management of VPPs includes, on the one hand, reducing electricity demand (from the consumer) when there is only a limited supply of electricity and, on the other hand, storing the electricity supply when the output of renewable energy exceeds the grid capacities. Furthermore, it can control the flow of excess electricity from private power producers back into the power company's network (reverse power). In Japan, VPPs are being introduced as pilot and demonstration projects, but have not yet been used commercially as they were not commercially viable until 2022. However, Japan's FIT regime, which is phasing out after 2019 and forces renewable energy producers to sell electricity on the market, is likely to result in more favourable conditions for VPP. METI actively supports VPP demonstration projects. With the introduction of the feed-in premium (FIP) in 2022, transmission and distribution companies will be forced to find flexible sources of generation in the market. As a result, projects incorporating VPP are gradually emerging. There are interesting collaborations in the VPP area, such as: B. Next Kraftwerke and Toshiba Energy Systems & Solutions Corporation.30 The joint venture (JV) between Next Kraftwerke and Toshiba Energy Systems & Solutions Corporation (Toshiba ESS) under the name “Next Kraftwerke Toshiba Corporation” is a VPP service provider Allowing third parties in Japan to set up their own VPP. *(AHK Japan, 2023)*

From 2024, a “**capacity market**” will be re-established to prepare in advance future required electricity supply capacity, and the adaptive capacity will be secured in a lump sum across the country. Therefore, no significant increase or decrease compared to the 2020 results is expected in the period from 2021 to 2023, during which the public offering of balancing energy is to be continued. From 2024, when the capacity market opens, the market is expected to grow significantly. This will also favour the market for VPP technologies. *(AHK Japan, 2023)*

d. Hydrogen

In autumn 2021, **Japan's national hydrogen strategy** was revised to align it with the green growth strategy. The target is to realize a hydrogen market of 3 million tons per year by 2030, up from 2 million tons currently – rising to 20 million tons per year by 2050. With a view on the demand side, the development of 1,000 hydrogen stations for mobility is envisaged until 2030. The plan is also aiming at 800,000 fuel cell vehicles in use by 2030 and 2-3 million by 2040. In 2021 there were just 3,800 fuel cell vehicles in circulation in Japan and 47 fuel stations. By 2030, METI also hopes to have 1,200 fuel cell buses, 10,000 fuel cell forklifts, and 5.3 million residential fuel cell units. Looking at domestic production costs, METI expects that the cost of hydrogen/ammonia-fired power in Japan’s thermal plants will fall to 17 yen/kWh in 2030, and 12 yen/kWh by 2050 - by which time there will be 15-30GW of hydrogen/ammonia-fired capacity in the country. The 2030 target is far more modest, with hydrogen/ammonia mixed in small volumes with fossil fuels generating just 1% of output by then. The Japanese government also plans to establish success cases of ammonia/ hydrogen co-firing by 2024 in order to support the development of supply chains starting 2025, and to achieve lowered costs by 2030. METI’s hydrogen strategy also sets a hydrogen price target. From 100 yen per cubic meter in 2021, METI expects the hydrogen price to fall by two thirds to 30 yen/ Nm3 by 2030, and further to 20 yen/ Nm3 or less by 2050 – which is below the expected cost of natural gas. These numbers are for delivered ex-ship hydrogen if imported, but do not explicitly state that the hydrogen is to be low carbon. *(Shulman Advisory/EU-Japan Centre, 2022)*

In order to strengthen international competitiveness, the GX strategy focusses on technologies in which Japan has strengths and aims to

- accelerate the commercialization of **hydrogen power generation turbines** in Japan and abroad by supporting the early demonstration with actual equipment, with a view to capturing the global market in the future,
- promote research and development to improve the power generation efficiency and durability of **stationary fuel cells** in order to promote market expansion,
- accelerate the commercialization of **FC trucks** through demonstrations.

Hydrogen **transportation and storage** is a major lever to reduce costs. The Japanese government also invests in

- commercialisation of large-scale transportation-related equipment by 2030 by conducting research and development and demonstrations with the use of funds and
- promoting international standardization of hydrogen transportation-related equipment.

Water electrolysis is a key technology for realizing a "Hydrogen Society". Thus, the Japanese government is aiming to expand the global adoption of water electrolysers by lowering their cost through

- development of technology to increase the size of water electrolysers, and aiming to maintain and strengthen international competitiveness by further reducing the cost of the equipment (1/3 to 1/6) and increasing durability and
- lowering entry barriers to overseas markets by preparing an environment where the performance of water electrolysers can be evaluated under the same conditions as in Europe.

https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/02_hydrogen.pdf

In course of the "Green Transformation", Japan has also set the target to expand the supply of **green steel** to 10 million tonnes by 2030. *(GR Japan, 2023)*. Hydrogen will play a substantial role in steel sector decarbonization as hydrogen direct reduction (H-DR) is one of the most promising technologies to decarbonize steel production. *(GJETC, 2022)*

As of 2021, the Green Innovation Fund had already allocated €3.0bn to 11 projects with this aim of helping create a **large-scale hydrogen supply chain**. Major Japanese corporates have also launched initiatives to develop hydrogen-related technologies and begin establishing a hydrogen supply chain. Idemitsu, Iwatani, ENEOS, Tokyo Gas, Air Liquide and others have joined the efforts by forming the "Hydrogen Supply and Utilization Technology Research Association". Meanwhile, Sumitomo, Chiyoda, Toyota, and others are conducting a feasibility study, financed by subsidies from NEDO, New Energy and Industrial Technology Development Organization, into the establishment of hydrogen import facilities and a distribution network in the Chubu (Central Japan) area. ENEOS and Kawasaki city are following suit for the Kawasaki waterfront area. Kawasaki Heavy Industry has developed a liquid hydrogen carrier ship and joined a pilot program with Iwatani Corporation, Shell Japan, and J-Power to pursue development of a liquid hydrogen supply chain. *(Shulman Advisory/EU-Japan Centre, 2022)*

e. Transport & Mobility

With regard to transport and mobility, the GX Strategy includes political targets and measures in the field of electric vehicles (EV), fuel cell vehicles (FCV), sustainable aviation fuel (SAF), and Mobility as a Service (MaaS).

For **electrification of transport**, METI has set the following targets:

- for passenger vehicles: EV share of 100% of new vehicle sales by 2035,

- for commercial vehicles: EV share of 20-30% of new light vehicles sales by 2030 and EV and "decarbonized fuel" vehicles accounting for 100% by 2040,
- for heavy vehicles: advanced introduction of 5,000 vehicles in the 2020s and full electrification by 2030.
- Enhance charging infrastructure by rolling out 150,000 EV chargers (incl. 30,000 fast chargers)

The package of measures to promote electrification also include utilization of fuel efficiency regulations, promotion of electrification of public and company vehicles, support for introduction and promotion of replacement, strengthening of supply chains and value chains, consideration of visualization of CO_2 emissions throughout the life cycle of storage batteries, unification of regulations related to the Road Transport Vehicle Act and the High Pressure Gas Safety Act for fuel cell vehicles, etc.

The rapid development of highly efficient and low-cost **batteries for EV** is a bottleneck for electrification of transport. Thus, the Japanese government has set the target to increase the domestic production capacity for in-vehicle batteries to 100GWh as early as possible by 2030.

(https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/05_automobile.pdf)

For expansion of **hydrogen-fuelled mobility**[3], the government aims to

- install approx. 1,000 hydrogen stations in optimal locations by 2030,
- have 800,000 fuel cell vehicles in use by 2030 and 2-3 million by 2040,
- have 1,200 fuel cell buses in use by 2030.

Hydrogen is also to play an important role for decarbonization of **ship and air transport**, next to other sustainable fuels. The GX plan has set the targets

- to cut CO_2 emissions in shipping industry by 1.8 million tonnes by 2030 through introduction of ammonia/hydrogen-fuelled ships and
- to develop carbon neutral fuels for shipping and aviation sectors by 2050. *(GR Japan, 2023)*

Fig. 11: Hydrogen/bio-fuelled ship "HANARIA" (Source: https://www.mol.co.jp/en/pr/2023/23111.html)

The Japanese government also promotes the development and demonstration of zero-emission ships such as hydrogen-fuelled ships or ammonia-fuelled ships. Two ways to decarbonise are being explored: to gradually convert the use of LNG fuel into carbon-neutral methane or expand the research on the use of hydrogen and ammonia fuel. Through the 'Next Generation Vessel Development' announced in 2022, a hydrogen-fuelled ship is being developed

[3] See also chapter 2 d).

and ammonia-fuelled ship is being commercialized in projects in cooperation with the shipping industry in Japan. *(Nikkei Asia, 2022; RINA, 2022)*

Next to electrification, hydrogen an ammonia, Sustainable Aviation Fuel (SAF) made from food waste, waste oil or plants is one possibility to help reduce CO_2 emissions in aviation. A new regulation by METI introduced in May 2023 makes it mandatory that 10% of aviation fuel for international flights sold by oil wholesalers be SAF from 2030. In addition, Japanese airlines that fly internationally are to be required to state that 10% of the fuel they use for such flights will be SAF. The government plans that 10% of the aviation fuel used in Japan, or about 1.7 million kilolitres per year, will be SAF. SAF alone is not enough for the industry to reach that goal. Domestic production is expected to be key to the government's strategy, as importing SAFs would generate CO2 emissions. JGC Holdings and oil wholesaler Cosmo Oil plan to start up Japan's first commercial SAF production facility in 2025, making up to 30,000 kilolitres of fuel a year. *(Nikkei Asia, 2023; Biofuels International, 2022)*

Although Japan is considered a leading country for excellent public transportation, its rural public transportation system is unsustainable in rural areas and for the aging population. **Mobility-as-a-Service (MaaS**) as a new transportation concept that integrates existing and new mobility services into a single digital platform, providing customized door-to-door transport and offering personalized trip planning and payment options, is also promoted further in Japan in course of the GX Strategy. As part of a national initiative towards advancing MaaS, 16 trial projects have been implemented in Japan, such as on-demand taxi combined with a delivery service, and mobile sales acting as portable small-scaled stores. *(Y. Tran and N. Hashimoto, 2022; Asian Transport Studies (2023)*

f. CCU/CCS

With Carbon Capture and Storage (CCS), carbon dioxide is captured (e.g., from industrial processes) and then stored underground for long-term disposal, while Carbon Capture and Utilization (CCU) means that the captured CO_2 is used as input for chemical processes. Many studies of potential pathways to Net Zero globally put a strong reliance on significantly increased use of carbon capture and storage (CCS). *(Oxford Institute of Energy Studies, 2021)*

Given the target to reach "net zero" of the whole Japanese economy by 2050, and related targets as to convert existing thermal power generation into zero-emission power generation and to cut CO_2 emissions in hard-to-abate sectors such as the steel industry by 30% by 2030, Carbon Capture and Storage (CCS) and Carbon Capture and Use (CCU) technologies play a major role also in Japan. According to the 6th Basic Energy Plan current plan, coal is still expected to contribute 19% of power supply in 2030 (see chapter 1.a). In order to transform existing thermal power generation (by coal) into zero-emission power generation, the Japanese government promotes “clean coal” technologies, including the capture and storage of CO_2. *(Oeko Institute/ECOS, 2022)*

As part of the GX strategy, Japan has set the goal to **build a CCUS value chain and capture 120-240 million tonnes of CO2 by 2050** *(GR Japan, 2023).* The Roadmap for Carbon Recycling Technologies identifies technological challenges and sets targets and time frames for carbon recycling technologies (capture including direct air capture, transport, storage, reuse) to accelerate innovation in this field. According to the roadmap, the options and requirements for introducing CCU technologies in existing coal-fired power plants by 2030 will be examined at first. The next step is to gather practical experience for the application of CCUS from 2040 onwards. At the same time, the costs for the processes are to be drastically reduced to a range of about 200-1,000 JPY/t CO2 (2-9 USD/t CO2). *(Oeko Institute/ECOS, 2022)*

As part of the CE (Circular Economy) strategy, technologies for combustion control in order to facilitate the recovery of CO_2 from waste treatment facilities are to be developed (see chapter 2.h). Besides the CO_2 separation technology,

storing the captured CO_2 is another challenge. Considerable research has been carried out regarding CCS in Japan, including a 3-year demonstration project at Tomakomai in the northern island of Hokkaido. *(Oeko Institute/ECOS, 2022)* Several other carbon capture projects are being investigated around Japan, and consideration is also being given to potential export of CO2 by ship for storage overseas, potentially in locations such as Australia or the Middle East. *(Oxford Institute of Energy Studies, 2021)*

g. Housing & Construction

Particularly in the building sector, the potential for greenhouse gas (GHG) emission reduction is significant through improved insulation or switching from fossil fuel-based heating systems to heat pumps running on renewable electricity. *(GJETC, 2023)* In Japan, CO_2 emissions from residential sector in Japan continued to rise in spite of the progress of heat insulation and airtight in houses and the spread of efficient housing equipment. *(Building Research Institute, 2024)*

The Green Transformation (GX) plan also includes measures to foster the energy performance of buildings. The aim is that all **new-built houses will be "zero emission houses" by 2030**. To reach this goal, the Japanese government is considering to introduce further regulatory measures in order to improve the compliance rate with energy-efficiency standards for housing or make them mandatory instead of voluntary. For existing housing stock, the investment in real estate projects that contribute to the expansion of **energy-saving renovation and improvement of energy-saving performance** is going to be promoted.

(https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/12_housing.pdf)

In addition, Concepts such as the **LCCM** (Life Cycle Carbon Minus)[4] and **ZEH/ ZEB** (net-zero energy houses/ buildings) are promoted with the aim of absorbing 5.6 million tons of CO2 by 2030. The Japanese government will allocate 1.8 trillion JPY of the GX Economy Transition Bonds to the introduction of energy-efficient homes and buildings over the next 10 years. *(GR Japan 2023)* Complying with this goal, private companies such as real estate giant Mitsui Fudosan announced to achieve ZEB/ZEH level environmental performance in all new constructions in Japan and to improve the environmental performance of existing facilities by installing PV panels, use LED lighting or reduce the impact by air conditioners in hotels and commercial facilities. *(Mitsui Fudosan, 2021)*

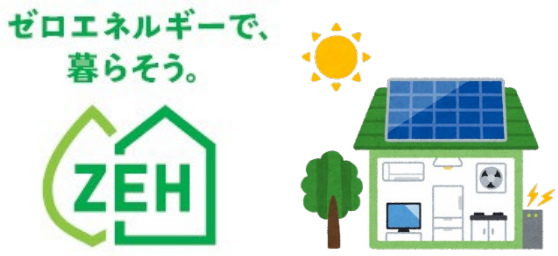


Fig. 12: ZEH Zero Energy House Log and Image (Source: Sapporo City, https://www.city.sapporo.jp.e.ain.hp.transer.com/kankyo/energy/zeh/zeh_toppage.html)

With regard to "embedded carbon" in the building materials used, the GX strategy aims to expand the supply of **carbon neutral cement** to 2 million tonnes by 2030 and to promote wooden construction of non-residential and mid- to high-

[4] The concept of a LCCM (Life Cycle Carbon Minus) house means that a long lifetime, low CO_2 emissions during construction, use and disposal, as well as energy output by solar power generation, etc., results in a negative life-cycle CO2 emission balance of a house. *(Building Research Institute, 2024)*

rise buildings and new materials such as CLT (cross-laminated timber). *(GR Japan 2023; see also: https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/12_housing.pdf)*

"Smart Houses" and **"Smart Buildings"** are also promoted since many years in Japan. Technologies needed include intelligent low-voltage electricity meters, intelligent high-voltage electricity meters, electricity meters of the distributed power generator, water heaters with heat pumps, home air conditioning systems, solar power generation in private households, instantaneous water heaters, lighting, storage batteries, chargers/dischargers for Electric vehicles, electric vehicle chargers, fuel cells, hybrid water heaters, commercial air conditioning and lighting systems. *(AHK Japan, 2023)*

h. Circular Economy

The broad field of Circular Economy (CE) is also within the scope of Japan's GX Strategy. Over the next 10 years, 2 to 4 trillion JPY of the Economy Transition Bonds will be allocated for CE related measures and technology development. This includes also Investment in infrastructures, new business models and startups, innovative technologies, etc. *(GR Japan 2023)*

In March 2023, the government announced the "Strategy of Resource-Autonomous Circular Economy for Growth". The main pillars are Reduce, Renewable, Reuse, Recycle, and Recover. CE aspects to be taken into account at each stage of the product lifecycle (design, manufacturing, recycling, collection).

In the field of **"Reduce" and "Renewable",** the highly functional bio-based materials are to be promoted through technology development and demonstration. Based on the "Roadmap for the Introduction of Bioplastics, approx. 2 million tons of bioplastics are to be introduced by 2030.

For improved **"Reuse" and "Recycle",** high-performance materials and recycling technologies shall be developed and introduced. Recovery routes and the recycling market shall be expanded. Furthermore, technologies for combustion control in order to facilitate the recovery of CO_2 from waste treatment facilities are to be developed.

In the field of "**Recovery"**, technology development to ensure high-efficiency energy recovery from low-quality waste is on the agenda, as well as the improvement and cost reduction of heat storage and transportation technologies for supplying heat from incineration facilities to distant utilization facilities.

(https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/13_circular_economy.pdf)

Japan is the second-largest consumer of single-use plastic packaging in the world after the USA and is eager to increase the low recycling rate of just 10%. Government regulations such as the Resource Curation Strategy for Plastics in 2019 and the Plastic Resource Circulation Act in 2022 are becoming stricter every year, which means opportunities for market expansion and business growth for European companies. In fact, Japan has declared that it will encourage recycling over incineration of waste plastics and is implementing the European Green Deal policy and the New Circular Economy Action Plan. Looking ahead to 2035, the domestic market for recycled plastics and materials is expected to reach 504 billion yen, while the market for recycled plastics alone is expected to hit 355.3 billion yen, more than doubling its current size. *(ECOS/EU-Japan Centre, 2023)*

In transition from a linear economy to a circular economy, new business models are emerging and expected, and supporting measures and regulatory reforms are required accordingly (ex. PaaS/MaaS) Startups (see Fig. 10).

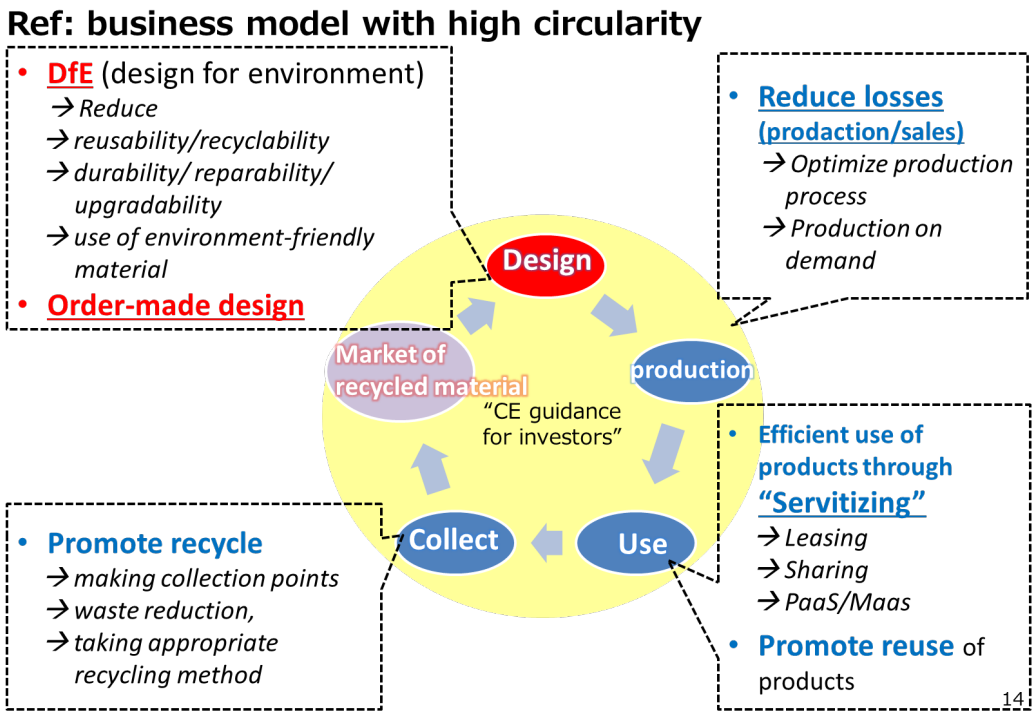


Fig. 13: Business Model with High Circularity (Source: METI, 2024)

METI expects the market for CE related technologies to grow from JPY 50 trillion in 2020 to JPY 80 trillion in 2030 and JPY 120 trillion in 2050. With a view to the growing CE related market worldwide, METI engages in the proliferation of Circular Economy policies and initiatives. The EU is seen as a major market for CE technologies. By engaging in international committees including G7 and G20, Japan is eager to make her strategy **compliant to government policies in the foreign markets, especially in the EU**. The EU Ecodesign for Sustainable Products Regulation is one example. *(METI, 2024)*

i. Farming & Food Production

To address the serious challenges of climate change and the aging society in Japan at the same time, the Japanese government is forced to advance agricultural policy reforms and increase investment to support the development of smart agriculture. In particular, the diffusion of ICT and smart farming technologies in companies is intended to enable the technological optimization of production and management in agricultural systems, thus promoting the development of a more resilient and sustainable agricultural sector. *(ECOS/EU Japan Centre, 2021)*

In course with GX Strategy, a technology-based strategy was formulated to transform the agriculture and food systems for a sustainable future. In May 2021, the "Strategy for Sustainable Food Systems, MeaDRI (Measures for achievement of Decarbonization and Resilience with Innovation)" was announced by the government in order to enhance productivity potentials and ensure sustainability of food, agriculture, forestry and fisheries sectors through innovation. It is a roadmap for technological development and supports the dissemination of innovative technologies and sets targets for innovative technologies and production systems. *(ECOS/EU Japan Centre, 2021)*

Fig. 14: Smart Agriculture (Source: Kubota, https://www.kubota.com/innovation/smartagri/)

In order to achieve zero CO_2 emissions from the agriculture, forestry, and fisheries industry by 2050, the strategy sets the following goals:

- a complete shift to horticultural facilities that do not use fossil fuels by 2050 through the development of heat pumps
- establishing technology for next-generation organic agriculture by 2040, and increasing in organic farming to 25% (1 million hectares) of farmland by 2050
- establishing technologies for the electrification and hydrogenation of agricultural and forestry machinery and fishing boats by 2040
- establishing a cyclical use of “harvesting, using, and planting” for planted forests, and promoting reforestation using F1 plus trees and increased use of wood
- establishing technology for constructing high-rise wooden buildings by 2040 through the development of wooden building materials and standardization of construction methods
- establishing a method to measure the amount of CO2 absorbed and stored by blue carbon, and aiming to reflect it in the UN Framework Convention on Climate Change and others

(https://www.meti.go.jp/english/policy/energy_environment/global_warming/ggs2050/pdf/09_agri_r.pdf)

The government will promote measures in line with the 2050 target "CO_2 zero emission originating from fossil fuels in agriculture, forestry and fisheries". Specifically, in addition to newly considering the introduction target of renewable energy in the agricultural, mountain and fishing village areas toward the goal of realizing carbon neutrality in 2050, it will introduce a logo mark to visualize the efforts of renewable energy that contributes to the revitalization of agricultural, mountain and fishing villages. Additionally, to support the decarbonization of agricultural, mountain and fishing village areas, it will promote local production and local consumption of renewable energy, such as small hydropower generation, introduction of local production and local consumption type biogas power generation facilities, promotion of utilization of bio liquid fertilizer (digestive juice, which is a by-product of biogas power generation), and more, as well as review the regulations as necessary for the construction of a production area-consumable energy system. Furthermore, while promoting wooden construction of high-rise buildings, development of new materials such as lignin derivatives and CNF to replace plastic, and efficient use of woody biomass energy (heat utilization, etc.), it aims to build a cascade use of forest resources in multiple stages, as well as to introduce a forest cloud system that conforms to standard specifications, and to develop and disseminate automated machines and ICT production control systems that are consistent with the cloud system. *(METI, 2022)*

3. Implications of GX investment policies for European SMEs

a. Potentials

As a leading adopter of Green Transformation (GX) technologies, Japan is expected to capture a substantial share of the world's "green economic" and technological growth in the coming years. This implies various opportunities and potential for business and technological cooperation for EU-based companies, especially in the field of technologies and innovations related to energy, mobility, circular economy, construction & housing, and agriculture & food.

i. Energy, Storage, Hydrogen, VPP, CCS

The 6th Strategic Energy plan (see chapter 2.a) is another shift towards increasing inclusion, diversification, and geographic diffusion of renewable energy generation technologies. This has been supported by pricing schemes, as well as the rise of supporting infrastructure on the Japanese market. In addition to the strategic energy plans, legislation has also established, and continuously amended Feed-in-Tariffs and Feed-in-Premiums in order to establish a market for renewable energy generation, while also establishing targeted zones for offshore wind. Energy-market reforms and infrastructural growth are indicative of future demand growth. The high population density in major urban areas such as Tokyo and Kansai are indicative of potential for substantial demand-growth for residential-scale and office-scale technologies in both the energy-generation and energy-storage markets, especially considering the rise of smart-grid infrastructure.

Given the current GX policy targets regarding the promotion of renewable energies (especially offshore wind and PV), hydrogen infrastructure, energy storage, development of smart grids and VPP (virtual power plants), and the introduction of CCS (carbon capture and storage), innovative solutions are required in fields where EU-based companies have outstanding expertise and experience.

An important aspect for smart grids is energy storage. Since batteries are part of Japan's industrial policy and the share of renewable energy is expected to increase, Japan is likely to remain an important market in the future. With increasing use of solar PV, decreasing FIT funding and high electricity tariffs, the economics of storage could continue to improve.

This provides opportunities to EU SMEs to strategically take advantage of the current trends in Japan that have even been accelerated and strengthened by the GX strategy, ranging from generation, to storage, to associated services. There is a diverse range of market-entrance possibilities, ranging from participation in the R&D landscape, to participation in the establishment or support for new energy technologies, to provision of energy generation and storage using a diverse range of technologies in diverse use-contexts and various scale-levels.

There are several areas where Japan's domestic sector is not yet ready to meet the goals of the GX plan, and these areas present the best opportunities for overseas companies. Specifically, EU companies offering expertise in the following related technology fields should have excellent opportunities in the market:

- innovative, next-generation battery cells
- innovative, next-generation fuel cells
- innovative, next-generation PV technology, e.g. flexible panels, or Perovskite solar cells
- technologies for efficient use of woody biomass energy

- smart grid related technologies and systems, e.g. smart metering, real-time monitoring systems (tracking systems), demand response systems
- technologies for CAPEX and OPEX reduction for electrolysers
- ammonia production units
- energy management systems that optimize the hydrogen production using intermittent renewable power sources
- hydrogen transportation technologies
- elemental technologies for wind turbines and floating turbines
- carbon capture and storage (CCS) related technologies.

ii. Mobility

With regard to transport and mobility, the GX Strategy includes political targets and measures in the field of electric vehicles (EV), fuel cell vehicles (FCV), sustainable air fuel (SAF), and Mobility as a Service (MaaS). This opens up business opportunities for EU companies offering expertise in the following related technology fields:

- light-weight material for EV, aircrafts, and ships
- innovative, next-generation EV batteries
- innovation for bio-based fuels and SAF (sustainable aviation fuels)
- electric vehicle chargers
- MaaS (Mobility as a Service) solutions

iii. Housing & Construction

The Green Transformation (GX) plan also includes measures to foster the energy performance of buildings. The aim is that all new-built houses are to be "zero emission houses" by 2030. Furthermore, expansion of energy-saving renovation and improvement of energy-saving performance is going to be promoted. EU companies offering expertise in the following related technology fields should have excellent opportunities in the market:

- insulation material
- insulating windows
- innovative sustainable building material with low carbon footprint in regard to the whole life cycle (production, use, disposal/re-use)
- innovations for carbon-neutral cement production of alternatives to cement
- innovative wooden building materials
- wooden construction of high-rise buildings
- intelligent low-voltage and high-voltage electricity meters
- water heaters with heat pumps
- efficient and sustainable home air conditioning systems
- innovative energy-efficient lighting systems

iv. Circular Economy

The promotion the broad field of Circular Economy (CE) is also within the scope of Japan's GX Strategy. EU companies offering expertise in the following related technology fields should have excellent opportunities in the market:

- highly functional biobased materials such as bioplastics

- Advanced technologies and mechanisms for waste sorting, e.g. identification and sorting technologies for the mechanical recycling of black plastics
- high-performance materials and recycling technologies
- development of new materials such as lignin derivatives and CNF to replace plastic
- technologies for recovery of CO2 from waste treatment facilities
- technology for waste heat recovery
- improvement and cost reduction of heat storage and transportation technologies.

v. Agriculture & Food

In course with GX Strategy, a technology-based strategy was formulated to transform the agriculture and food systems for a sustainable future. This opens up business opportunities for EU companies offering expertise in the following related technology fields:

- ICT and smart farming technologies such as robots for agricultural use, technologies for precision farming, Artificial Intelligence, drones for agricultural use
- smart farming services
- technologies and solutions to realize the shift from fossil fuels in horticultural facilities, e.g. heat pumps, agrivoltaics, technologies for the electrification and hydrogenation of agricultural and forestry machinery
- technologies for next-generation organic agriculture

4. Challenges

There are some specific challenges and regulatory issues foreign companies are facing when entering the GX related market sectors described in this report.

Japan's Electricity Business Act (amended in 2019) establishes the general framework for Japan's electricity, power, and transmission industry, as well as legal definitions for electricity generation, trading, and distribution firms, as well as for renewable energy and renewable-energy-based electricity generating and retailing firms. Any producer of renewable energy whose output capacity exceeds 10MW, is required to register with METI and comply with grid-stability regulation. The Renewable Energy Act defines and enumerates the key technologies used in the renewable energy landscape, and legally establishes the Feed-in-Tariff.

Under the **Renewable Energy Act**, utility companies are obliged to enter into a power purchase agreement with a Generator who applies having obtained the required certification, unless certain exceptions apply. For the grid connection agreement, each utility company has posted on its website the standard terms for its the power purchase agreements, which may be negotiated on a project-specific basis. *(Shulman Advisory/EU-Japan Centre, 2022)*

GX policy in Japan is closely related to industrial policy, and the policy goals often include targets for Japanese companies on the global market. This makes it sometimes difficult for foreign companies to enter the specific technology markets.

The **public tendering** and awarding process in Japan also poses particular challenges for foreign companies. The deadline for submitting offers is often quite short and in some cases can only be three weeks. In addition, in most cases communication takes place exclusively in Japanese. As a rule, questions should also be asked in Japanese, as public contracting authorities often only have very basic knowledge of English. Collaboration with a suitable Japanese

partner or a trustworthy local Japanese representative is essential for participation in the tender process. In some industries, a partnership or local representative office is mandatory.

Manufacturers of commercial goods in Japan must take into account **regulations** regarding safety of use and technical standards. The Japan External Trade Organization (JETRO) provides information on its website about relevant laws and regulations related to import processes, quarantine periods and technical requirements.

The **Japanese Industrial Standards** (JIS) are a set of standards that are maintained by the Japanese Industrial Standards Committee JISC, which is assigned to METI. The JIS covers industrially manufactured and mineral products. The products are classified and assigned to different technical areas. Although JIS certification is not mandatory, it may be recommended in some cases. Japan strives to harmonize its standards with international (ISO) standards, but Japanese industrial standards still often differ from ISO standards. The JISC regularly publishes information about the level of harmonization between JIS and international standards. For many new fields of technology, also in the fields of hydrogen, smart grids, or circular economy, standards are being developed and still non-existent.

There are some further challenges in the Japanese business world such as:

- Language is still a major barrier to entry into the Japanese market for foreign companies. Although English signs or announcements are increasingly present in everyday life in Japan, Japanese is still by far the most important business language. Large companies that are internationally and globally oriented also have staff with very good English skills, but this is rarely the case in SMEs. The spread of English is encouraged, but efficient communication, especially during initial contact, is often easier and sometimes only possible in Japanese or with the help of professional interpreters. Detailed information on specific topics such as standards, regulations and approval procedures, as well as websites of SMEs and authorities, are sometimes only accessible in Japanese.
- High customer orientation and a good corporate image are prerequisites for successful business in Japan. Rather than a pure technology provider, it is recommended to take the position as secure solution provider together with important customers. To do so it will be an urgent task to establish a trust relationship with customers introducing suitable technologies for the customer’s needs.
- Japanese customers are uncompromising when it comes to quality - even cosmetic faults and irrelevant to the function of the product. Japanese companies are quick to question the entire production and logistics process. An additional delivery check ex works or on arrival in Japan to ensure "Japanese quality" is recommendable.
- In a country where "the customer is God", a high level of service is considered normal. In this view, a deal is not considered closed after delivery, as Japanese customers usually expect free service and after-sales support.
- Relationships are the basis of business in Japan. It is important to show the right level of respect and to always be polite and diplomatic. Patience is essential when dealing with business relationships, and adherence to local etiquette regarding gift buying is important. A close customer-supplier relationship needs to be established before the actual business can begin. Japanese are not risk-averse and prefer continuity and stability. Mutual trust is the key, but it takes time.
- Since decisions in Japanese companies are often the result of extensive consultations with many people from different departments throughout the organization, the decision-making process is particularly lengthy, and several meetings are needed to reach an agreement.

5. Recommendations

Especially for technology providers in the field of GX technologies, it can be an advantage to continually keep an eye on current tenders. Public tenders shall be duly published in the government newspaper “Kanpo” and regional publications. Since constant monitoring requires resources and time, it makes sense to commission special offices. Tenders are not only used to win individual orders but can also be used for marketing and PR strategies. Participation in public projects is received positively, so that the chances of being awarded further projects increase. It should also be noted that in some industries licenses and business reports are required to submit an offer. In order to participate in the Kanpo tenders, the company must be listed as “qualified”. This can e.g. B. via the Japanese branch. In addition, so-called “procurement seminars” are organized annually in English for the respective fiscal year. A translation of “Kanpo” is e.g. B. possible via the Japan External Trade Organization (JETRO). Another point of contact is the EU-funded online portal “EU Business in Japan”, which provides support in Japan for companies registered in the EU. Using the corresponding search function, Japanese-language databases can be searched for specific keywords. The results are then translated back into English, which is why you should expect a wait of two to three weeks. Another platform is operated in cooperation between METI and the EU-Japan Centre for Industrial Cooperation. The tender database is in English - the translation from Japanese to English is automatic. Furthermore, in cooperation with the Tokyo city government and various business associations, the “Business Chance Navi” page was set up, which currently provides project information in Japanese. *(AHK Japan 2023)*

When European technology providers enter the Japanese market, it is essential that they tailor their approach to the specific needs and requirements of the Japanese market. To be successful in the Japanese market, European companies should pay close attention to the following factors:

- **Collaboration** is a key element. Companies actively collaborate with government agencies, research institutions, and other stakeholders to share knowledge, expertise, and best practices. These collaborative efforts promote continuous improvement, technological innovation, and the development of efficient processes. The collective expertise of various stakeholders helps Japanese companies stay at the forefront of industry advancements. The collaboration pattern is various. Some are cooperating with universities and companies, or governments and associations.
- **Time and human resources** are required: Entering the Japanese market requires significant financial, time and human resource investments. A thoughtful long-term approach is necessary to achieve success and make a positive impact in this demanding market.
- Utilize **supporting organizations** such as embassies, chambers of commerce, JETRO and the EU Japan Centre for Industrial Cooperation to access valuable market information and market entry assistance.
- Customers are expecting **high quality and an intensive after-sales-service**, which should best be carried out by a specialized Japanese service company. Existing customers need to be visited regularly, not only for business purposes but also to be visible and to maintain the relationship. It is important to continue to be seen as demonstrating a serious willingness to operate in the Japanese market and to deepen the relationship with Japanese partners. Ensure that both **products and associated services, such as sales, after-sales support and maintenance, are of an exceptionally high standard**, as the Japanese market demands top quality.
- **Select reliable partners**: Carefully select reliable partners to work with, as they can have a significant impact on the success of market entry.
- Build strong **customer relationships**: Focus on building and maintaining excellent customer relationships. Regular visits, including courtesy visits, are essential to build trust and visibility.

- Build **local networks**: Work on building local networks and personal relationships as these play a vital role in business development and success.
- Attending important **trade fairs**: Participating in prominent trade shows is essential for gaining exposure and networking.
- **Detail and image**: Japanese consumers value attention to detail, so invest in areas such as professional interpretation services to ensure clear communication and a positive image.
- **Highlight EU origin**: Capitalize on the excellent reputation of European environmental technologies and proudly display EU origin, especially for companies from Germany, the Netherlands, and the Nordic countries.
- **Interpreters:** Never skimp on a highly qualified interpreter, as this person represents the company and needs to understand and convey more than just words.

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