



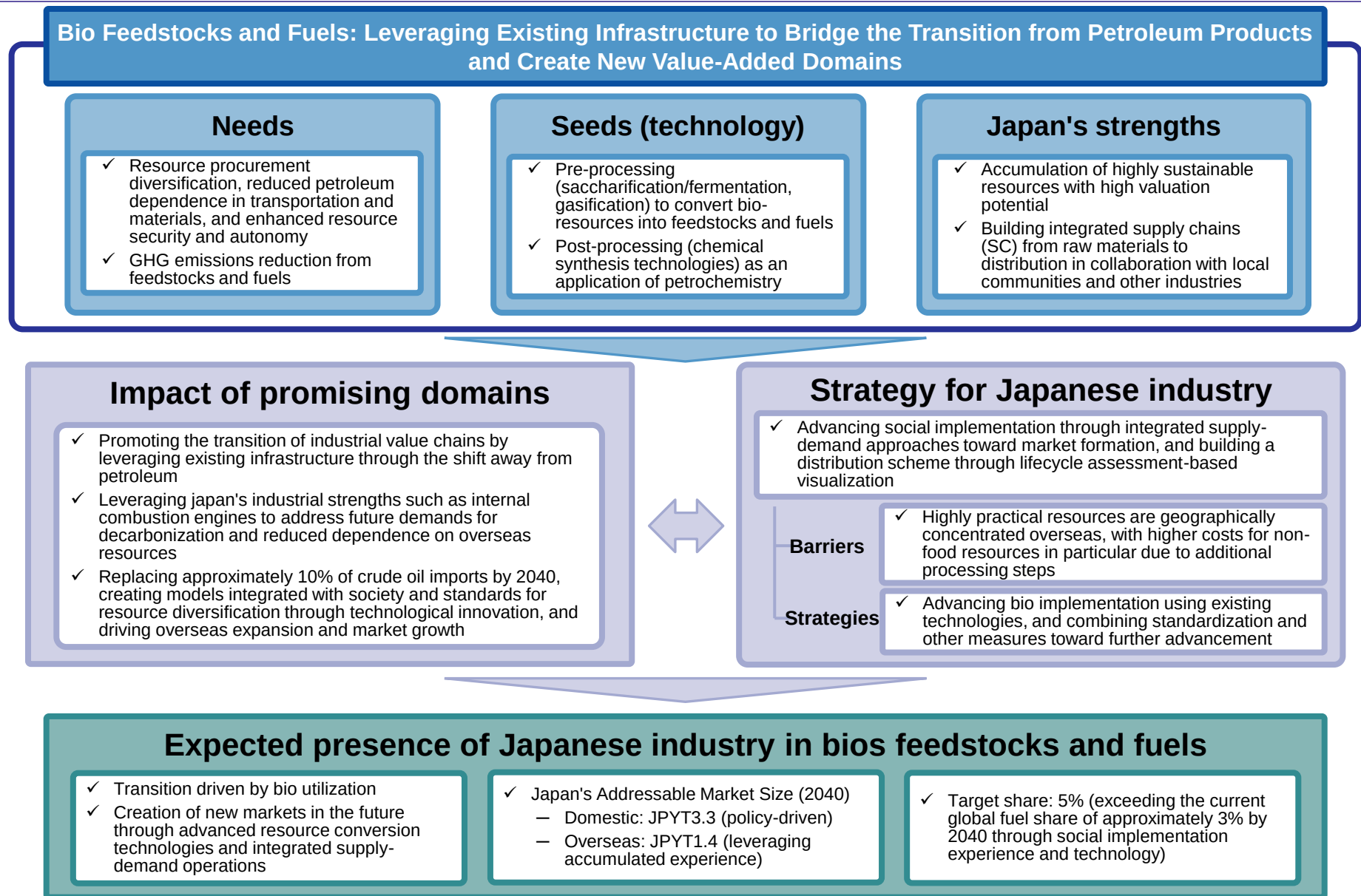
Bio Feedstocks and Fuels

An effective approach to accelerating industrial transition and enhancing autonomy

March, 2026

Industry Research Department
Mizuho Bank

Strategy for capturing the bio feedstocks and fuels market and the expected presence of Japan in 2040



Promoting transition through bio feedstocks and fuels across industrial and social systems toward autonomous industrial growth

■ Background and Issues

- Japan currently relies on overseas fossil resources, including petroleum. Petroleum in particular is an essential resource for non-electrified sectors such as transportation fuels and materials; however, challenges remain in the form of substantial outflows of foreign currency through imports, securing resource and energy security, and driving the transition toward decarbonization.
- GX policy aims to transform the economic and social system as a whole by transitioning social and industrial structures — largely established during the period of high economic growth — to clean energy-centered ones. Furthermore, with the current administration's "Japan Growth Strategy Headquarters" identifying "synthetic biology and bio" and "resource/energy security and GX" as strategic fields, investments that contribute not only to Green but also to Growth and Geopolitics are becoming increasingly important.
- Achieving both objectives requires promoting the supply and utilization of bio feedstocks and fuels derived from biomass resources, advancing the transition of existing infrastructure alongside procurement diversification and local production for local consumption, and formulating growth strategies in coordination with Japan's key industries.

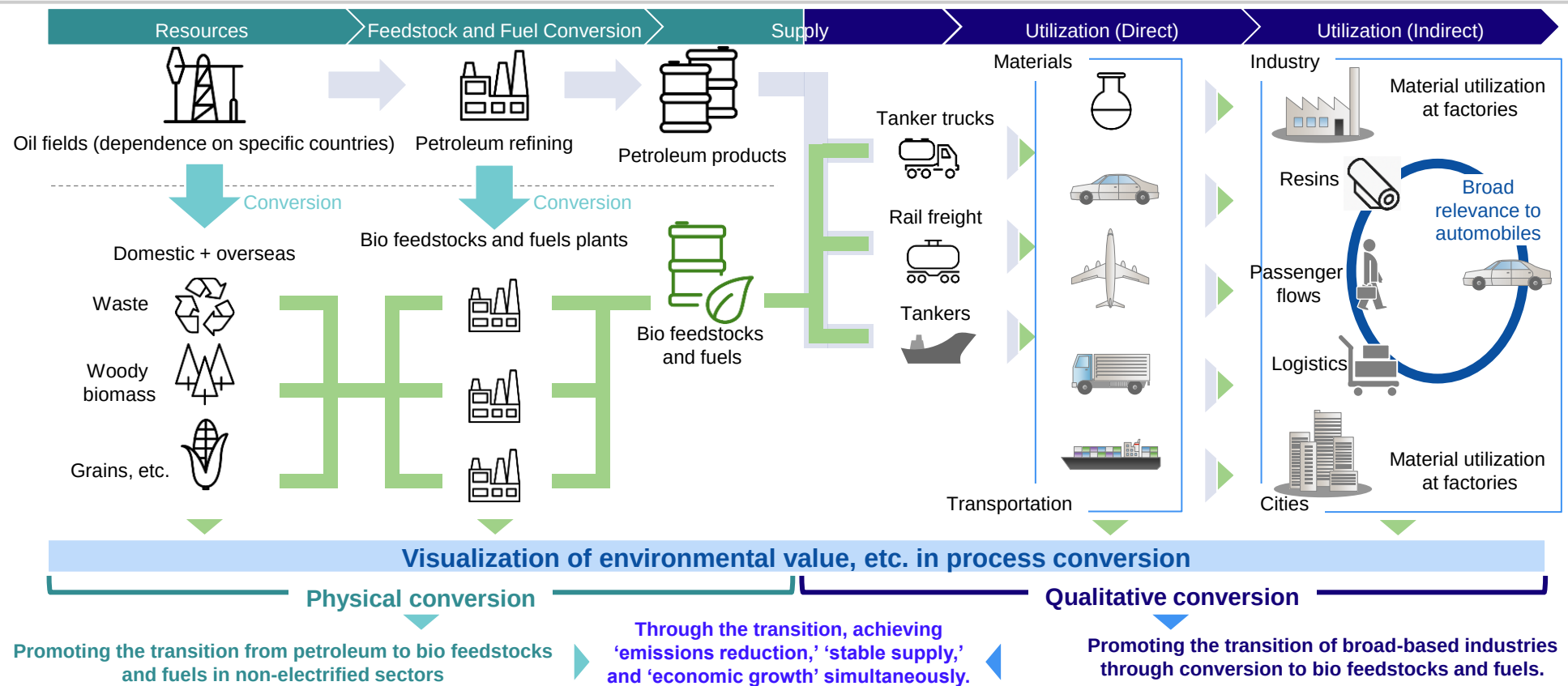
■ Executive Summary

- Bio feedstocks and fuels, which contribute to substituting for petroleum where transition to other primary energy sources is difficult, are identified as a promising area in this report.
- Overseas markets for bio feedstocks and fuels have already reached a certain level of development, whereas Japan remains at an early stage and continues to depend on petroleum imports from specific countries.
- Biomass utilization enables diversification of resource import origins beyond oil-producing countries and allows for the utilization of domestic resources, with the effects extending across industries broadly.
- Japan has accumulated extensive know-how in manufacturing facilities and infrastructure operations through the development of petroleum industry supply chains. Cross-industry technology implementation and advanced processing technology development are also progressing. In terms of resources, Japan is endowed with abundant forest resources and has significant potential for waste utilization.
- At present, however, resources that are readily convertible into feedstocks and fuels are predominantly overseas grains and the like. Going forward, it is also important to simultaneously advance the visualization of added value from forest and waste resource utilization, alongside institutional design that can effectively communicate the benefits generated by industrial-side utilization, as exemplified by transportation equipment.
- Japan has diverse companies with competitive strengths spanning the entire chain from resource procurement through feedstock conversion to utilization, with a proven track record in building resilient cross-industry supply chains.
- Japan possesses a long-standing track record in manufacturing technologies, operations, and evaluation methods related to petroleum products and bio feedstocks and fuels. By codifying these strengths into standards with a view toward standardization, Japan can advance collaboration with partner countries rich in biomass resources to secure initial feedstock supplies. Jointly utilizing resources tied to social challenges such as waste, and advancing market formation in a mutually beneficial manner, also represents a viable option.
- Japan's annual crude oil imports amount to approximately JPYT11; however, implementation of utilization technologies is expected to enable substitution of around 10% with domestic resources. Furthermore, by capitalizing on policy-driven demand creation and standardization opportunities for ethanol, SAF, and other products, the construction of advanced business models with global applicability is anticipated.

Japan's vision for society and industry through social implementation of bio feedstocks and fuels, leveraging existing strengths and social infrastructure

- Social implementation of bio feedstocks and fuels effectively utilizes existing infrastructure and functions, enabling both the promotion of social and industrial structural transition and growth.
 - On the manufacturing side, changes arise from the shift in resource inputs, whereas on the utilization side, physical changes are limited, enabling responses that leverage existing systems.
 - Social implementation requires visualization so that the changes on the manufacturing side are recognized as benefits by the utilization side, enabling appropriate compensation to be obtained.
 - Growth strategies can be formulated in concert with demand-side industries such as the automotive industry, which has a broad industrial base in Japan and competitive strengths in internal combustion engines.

Image of the transition of existing liquid feedstock and fuel supply chains through bio feedstocks and fuels utilization

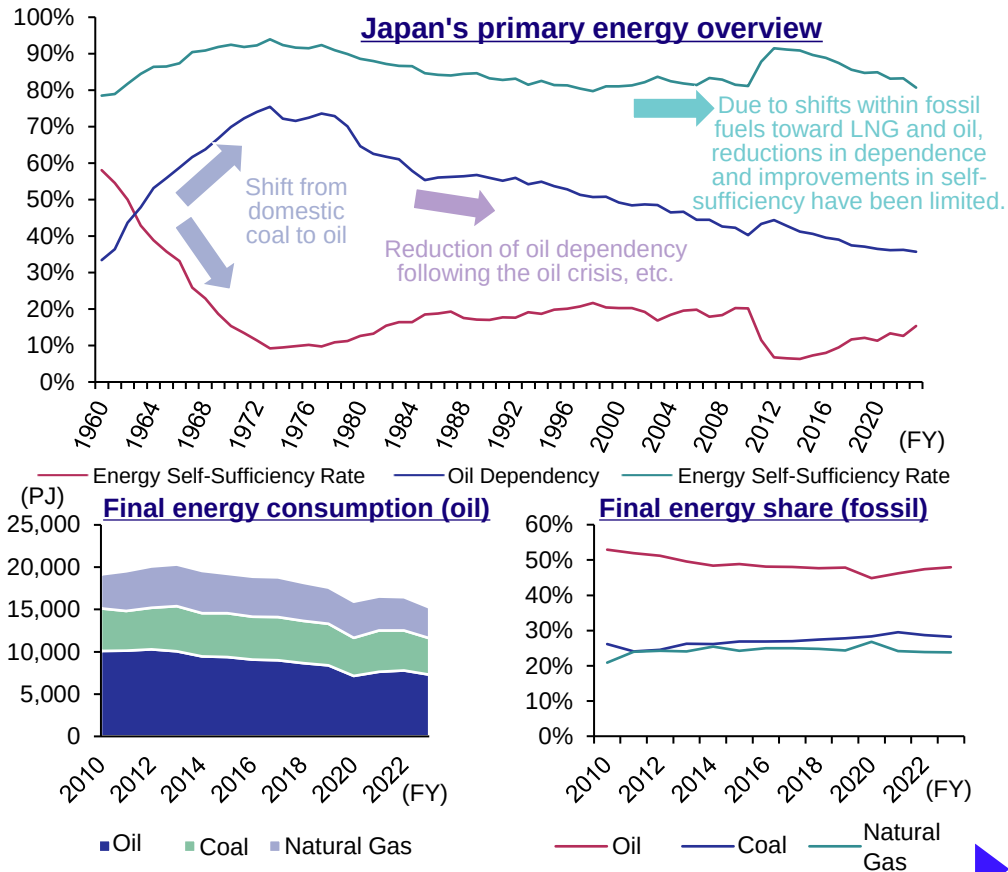


Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on various published materials

Japan's energy supply has been unable to break away from imported fossil fuels, particularly oil, which presents significant energy security risks

- Japan's primary energy self-sufficiency rate has declined since the shift from coal to oil, and remains the lowest among major economies.
- Within fossil fuels, a shift from oil to LNG has progressed in power generation; however, oil, which serves as both a fuel and a feedstock, remains at a high level.
 - Oil is sourced predominantly from the Middle East, with the supply chain at risk of disruption not only due to factors in procurement countries but also through sea lane disruptions.

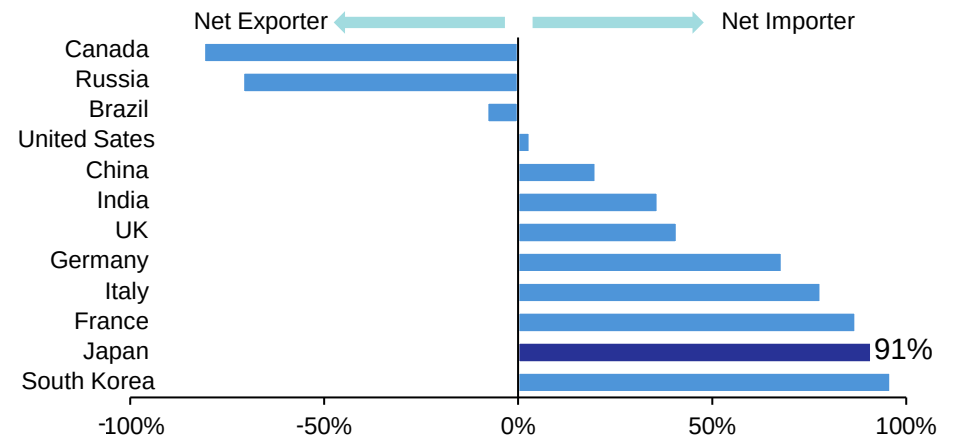
Japan's energy supply challenges



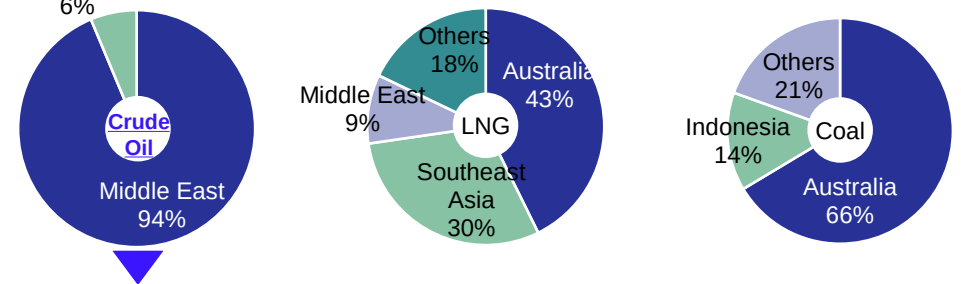
Source: Both figures compiled by Industry Research Department, Mizuho Bank, Ltd. based on Agency for Natural Resources and Energy "Energy Supply and Demand Results (FY2023)"

Overview of Japan's overseas energy dependence

Energy import dependence by country (FY2022, excl. Nuclear)



Japan's fossil fuel import sources (FY2022)



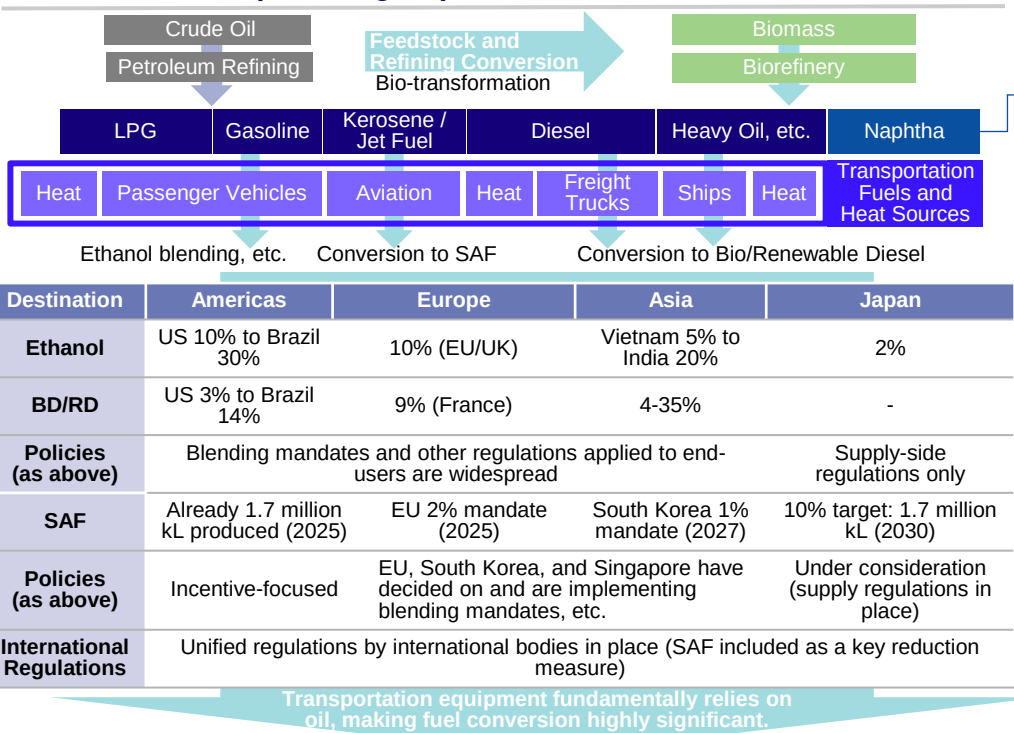
Oil: highly import-dependent with heavy reliance on Middle East procurement, posing supply chain risks.

Source: Both figures compiled by Industry Research Department, Mizuho Bank, Ltd. based on Ministry of Finance "Trade Statistics" and other publicly available materials

Bio-conversion of feedstocks and fuels enables decarbonization and resource autonomy through utilization of existing facilities, even within the oil-dependent structure of transportation and materials industries

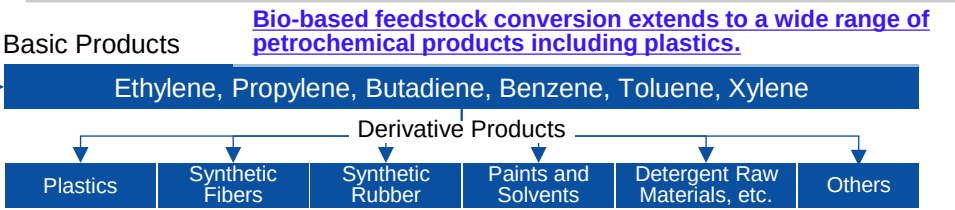
- Petroleum products serve as the energy source for transportation equipment, a key strength of Japanese industry, and the effects of bio-conversion extend across a broad range of industries.
 - Bio-conversion of petroleum products has already begun in select major overseas countries, making it necessary for Japan to advance social implementation at an early stage.
- Oil also serves as a feedstock for a wide variety of products including plastics, and is relevant across a broad range of industries.
 - As the use of bio-based products expands internationally, Japan must also promote their adoption toward decarbonization, resource autonomy, and enhanced industrial competitiveness.

Petroleum-related product groups and the need for fuel bio-conversion

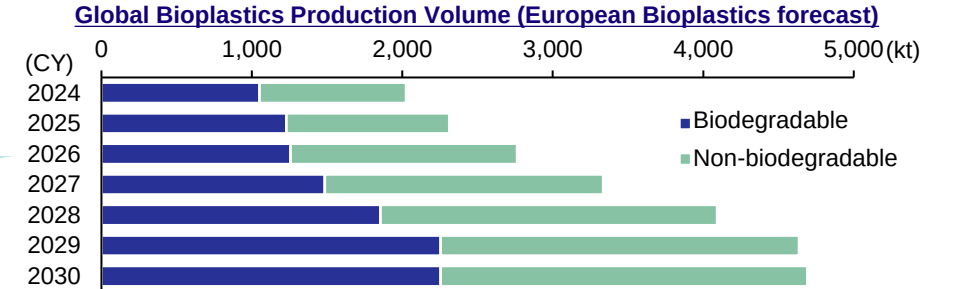


Japanese industry needs to advance fuel conversion for transportation equipment, its core sector, in alignment with upstream bio-conversion, as is the case overseas.

Ripple effects of bio-based feedstock conversion and image of plastics conversion



	Overview of Current Bioplastics-related Policies by Country/Region
Japan	Target introduction of approximately 2 million tons by 2030 (government policy).
Europe	Incorporated into the policy framework as part of the circular economy policy package (EU). Phased increase of the minimum bio-content requirement for single-use bags (France). Preferential measures for single-use products meeting biodegradability, compostability, and similar criteria (Italy).
US	Priority purchasing of bio-based products established in government procurement.
China	National policy documents issued in 2020 stipulated expanded bans on non-biodegradable single-use tableware, strength standards, and restrictions on packaging materials at post offices, among other measures.



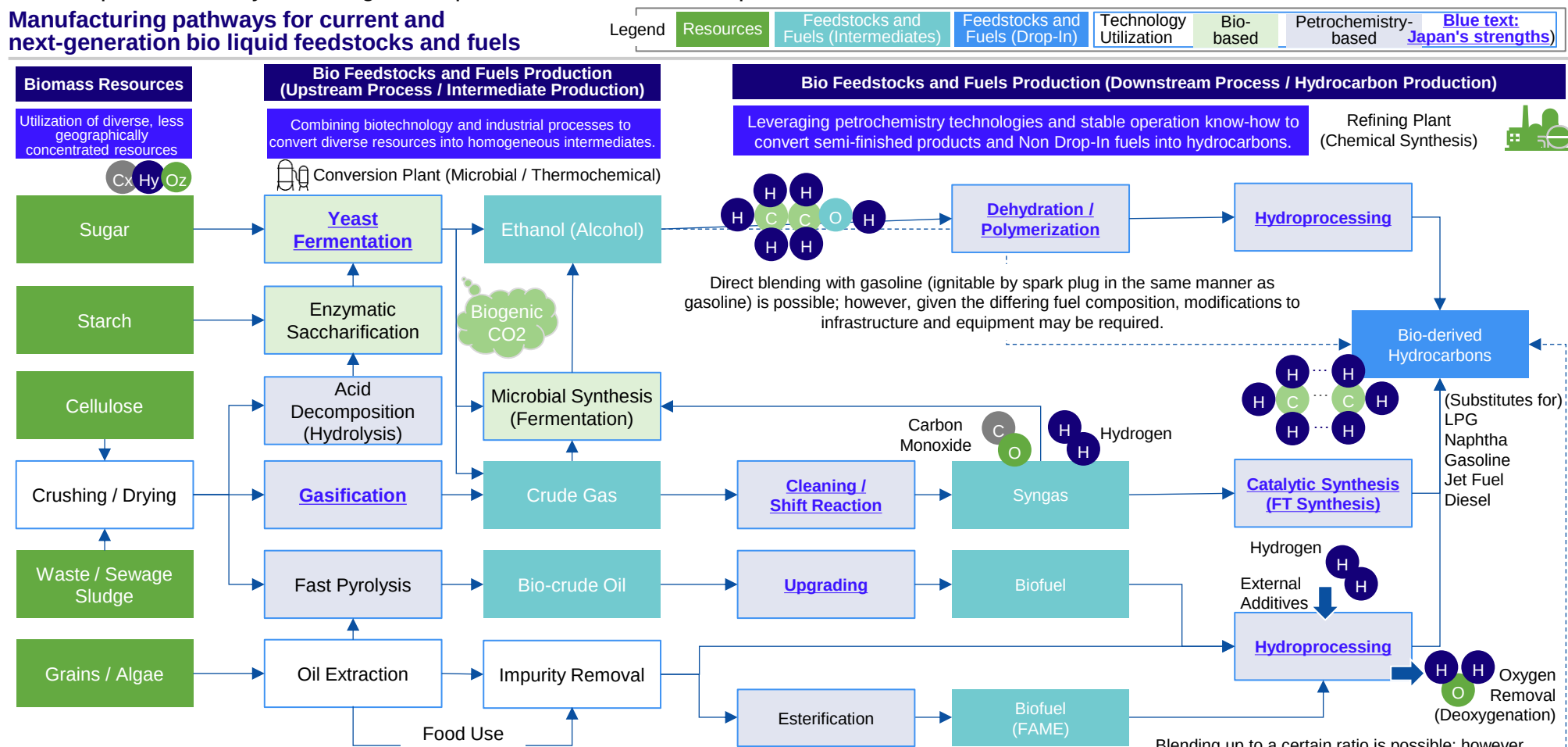
Note: Derivative products and related industries are wide-ranging; representative examples are shown (particularly for materials, the scope extends beyond items listed). BD: Biodiesel fuel; RD: Renewable diesel fuel.

Source: Both figures compiled by Industry Research Department, Mizuho Bank, Ltd. based on European Bioplastics, “Bioplastics Market Development Update 2024,” Japan Petrochemical Industry Association, and other publicly available materials.

Development of diverse processes is advancing, ranging from intermediate production to the manufacturing of oil-substitute products, toward the utilization of biomass resources

- Multiple pathways exist for the production of bio feedstocks and fuels utilizing diverse, less geographically concentrated biomass resources, and many are currently being developed and verified in Japan.
 - In upstream processes, ethanol conversion using relevant technologies is being promoted, backed by policy support for bio-manufacturing as well as cross-industry collaboration.
 - In downstream processes, technologies for refining to a level equivalent to oil products through conversion processes analogous to petrochemistry are being developed and held across multiple fronts.

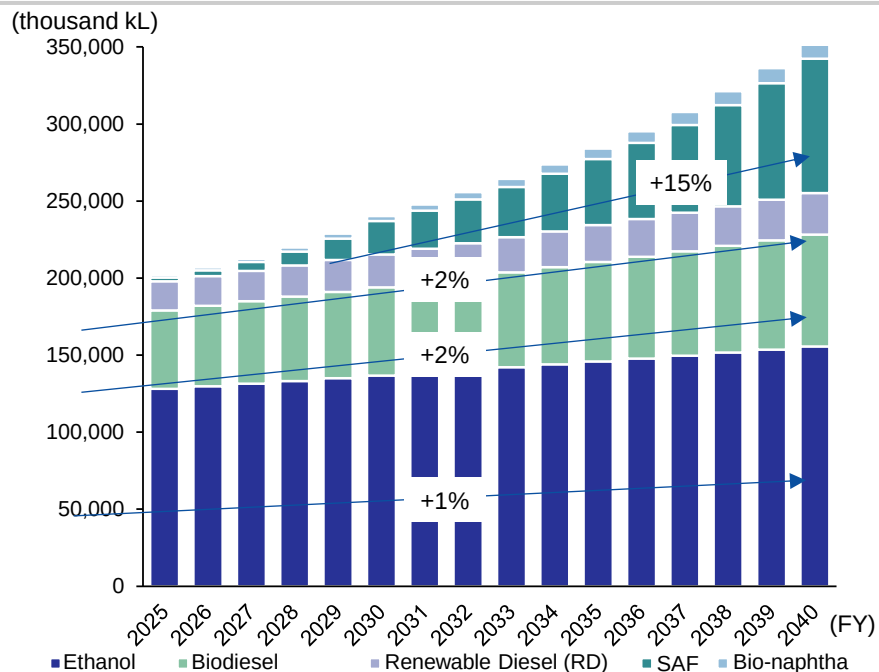
Manufacturing pathways for current and next-generation bio liquid feedstocks and fuels



With domestic energy industrialization also in view, the bio feedstocks and fuels market is emerging through oil substitution

- This paper addresses oil substitution through bio feedstocks and fuels; market projections going forward are as set out below.
 - Overseas, markets for ethanol-gasoline blending and biodiesel are already large-scale compared to Japan, with SAF expected to grow going forward.
 - Domestic biofuels consist predominantly of ETBE (ethanol-derived products) based on the Act Concerning Sophistication of Recycling Business, etc. to Promote Resource Circulation, but SAF-led growth is expected to strengthen going forward.

Global market outlook for bio feedstocks and fuels



[Ethanol/Biodiesel/RD]

Utilization has already advanced to a certain degree in adopting countries; going forward, growth at a similar rate to that seen thus far is projected, driven by electrification and fuel efficiency improvements in the road transportation sector.

[SAF]

Electrification is difficult to advance in aviation, making this a sector where fuel conversion is set to accelerate going forward toward the 2050 carbon neutrality target established by international bodies.

[Bio-naphtha]

Growth toward bioplastics production volume of 10 million tons by 2040.

[Ethanol]

Gasoline blending ratio 2035: 10%
Growth toward 15% by 2040

[RD]

Diesel conversion Growth toward 5% by 2040

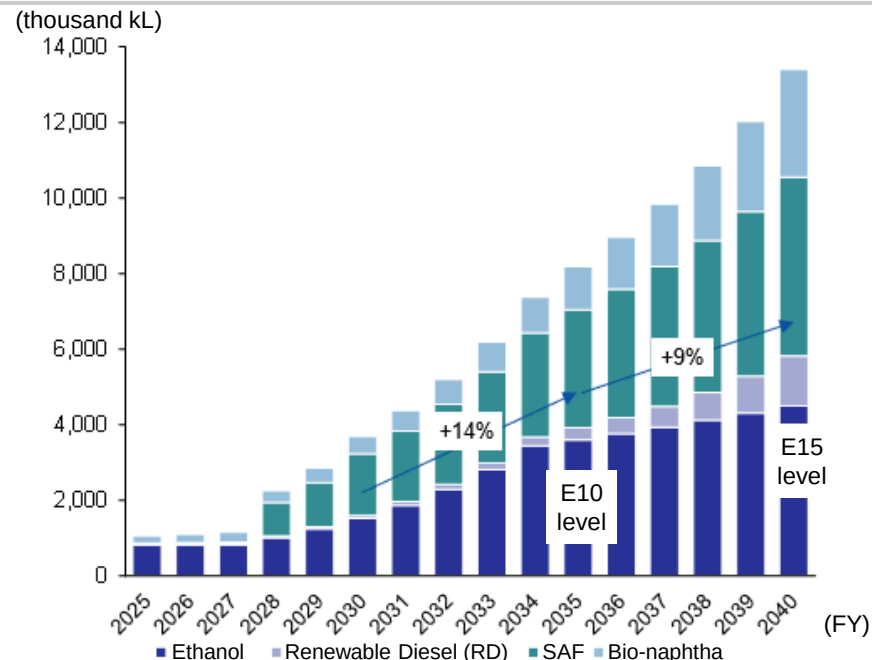
[SAF]

Jet fuel conversion 2030: 10%
Thereafter, growth at the above rate toward the 2050 carbon neutrality international target

[Bio-naphtha]

Bioplastics target Growth toward 2 million tons by 2040

Domestic market outlook for bio feedstocks and fuels



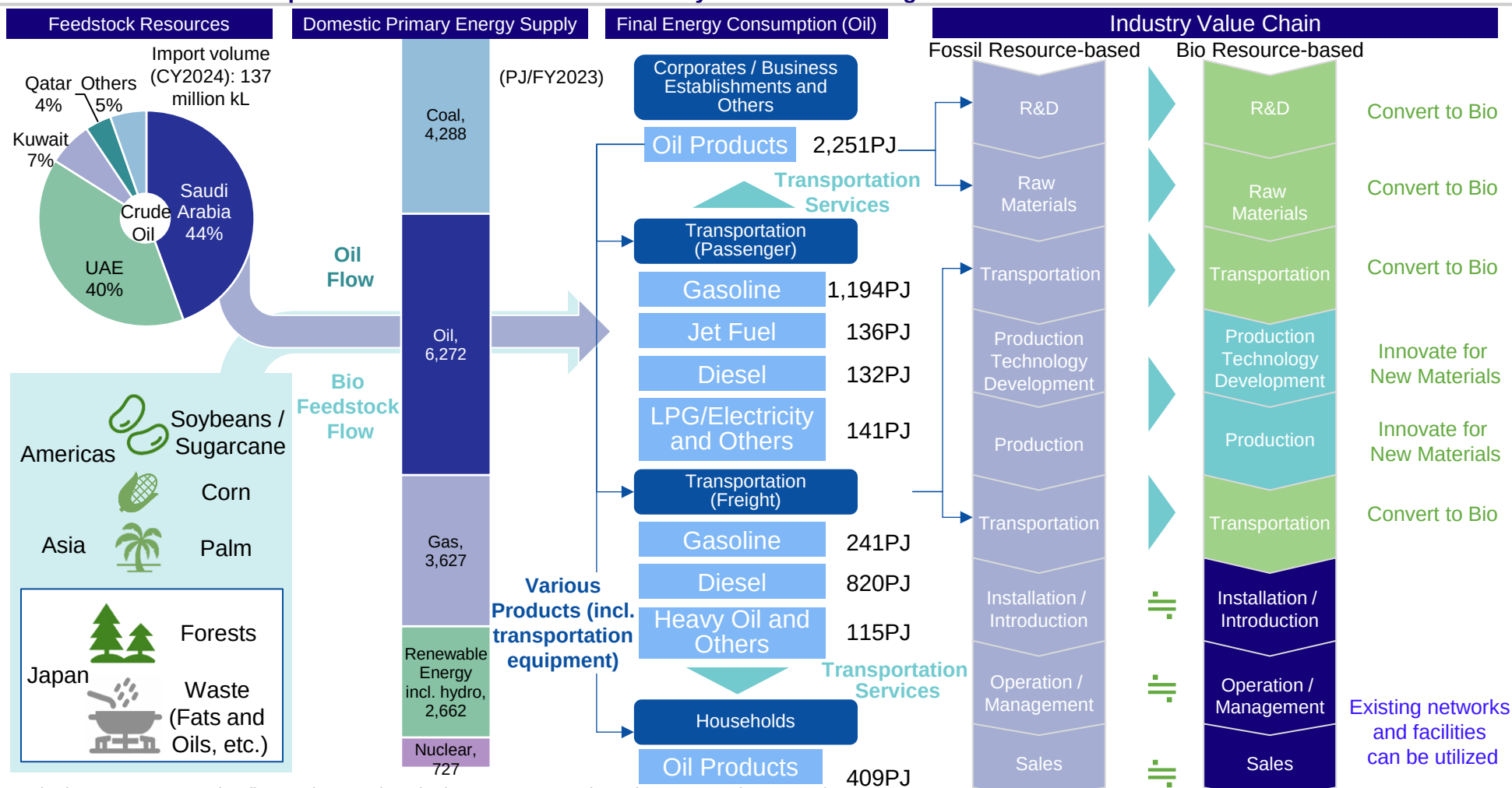
Note: Industry Research Department, Mizuho Bank, Ltd. forecast. Figures shown are CAGR. Current ethanol in Japan refers to ETBE (a gasoline blending component manufactured from ethanol as feedstock); figures are presented on an ethanol-equivalent basis.

Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on IEA Renewables 2025, Global Forest Resources Assessment 2022, and other materials.

Transition to bio feedstocks and fuels leads to transformation across various industries, with existing value chains also able to be utilized

- Japan relies on specific countries for oil, the lifeline of its current feedstocks and fuels, presenting significant risks to resource and energy security.
- Bio feedstocks and fuels serve as substitutes for oil products, contributing to resource diversification including domestic sources, and enabling transition that leverages existing value chains.

Structure of oil utilization in Japan and transformation of the industry value chain through transition to bio feedstocks and fuels



Note: Final energy consumption figures (FY2023) and others represent selected representative examples.

Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on Agency for Natural Resources and Energy "Comprehensive Energy Statistics."

Japan can leverage a collaboration framework with businesses and government bodies capable of fulfilling diverse roles across the entire value chain, from upstream to downstream

- Japan possesses both a framework enabling high-quality feedstock procurement and the capabilities to apply it toward biofuel use; combined with highly competitive demand-side industries centered on automobiles, Japan is positioned to implement integrated strategies spanning the bio feedstocks and fuels value chain.

Japan's strengths in each feedstock and fuel segment

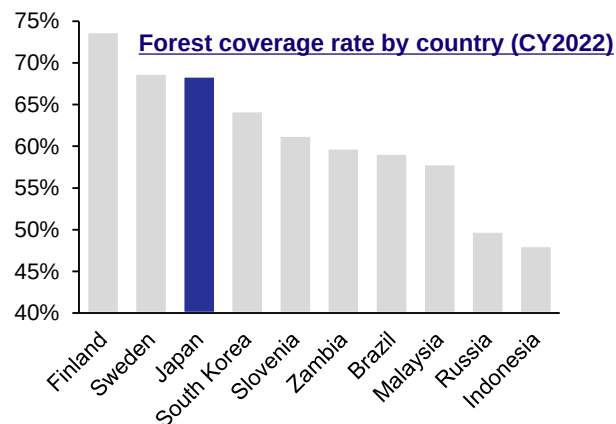
1 Upstream (Resources)	■ <u>A framework enabling efficient collection of select resources with high lifecycle assessment potential.</u> — <u>Woody biomass with abundant resource volumes</u>: Domestic forest resources are densely distributed, with many mature planted forests suitable for harvesting. — <u>Waste with established collection routes</u>: Efficient resource collection is achievable by applying area-wide management practices such as municipal collection and sorting of resources. — High value-added potential: The use of woody biomass and waste delivers a higher contribution to decarbonization over the lifecycle compared to other resources.
2 Midstream (Manufacturing)	■ <u>Capabilities and track record in large-scale plant engineering and stable supply chain construction.</u> — <u>Integrated stable operation</u>: Supply chains are constructed through vertical collaboration centered on midstream functions such as engineering, ensuring stable supply. • In the social implementation of LNG as well, Japan has achieved social implementation ahead of the rest of the world across upstream (resource development), midstream (gas and electric power supply), and downstream (wide-area distribution). — Advanced control and operation: Japan-based companies handle the full scope of complex refining processes, from design through measurement and control, R&D, and evaluation and certification. — <u>Expansion into bio areas</u>: Capabilities and experience cultivated in the petrochemical industry can be applied to constructing bio resource-based industry value chains.
3 Downstream (Utilization)	■ <u>Demand-side industries in bio feedstocks and fuels (automobiles, materials, etc.) command high presence in both market and technological terms.</u> — <u>Collaboration with key industries including automobiles</u>: Working alongside powerful demand-side players (automobiles, materials, logistics), Japan can advance the full cycle of demonstration, standardization, procurement, and design for feedstocks and fuels. — <u>Rule formation involving peripheral industries and government</u>: Advancing coordination with the policy side, starting from the demand side, to promote and lead rule formation. — <u>Joint demand creation</u>: Leading social implementation from policy-driven demand such as ethanol, extending to standardization and related areas, thereby enhancing the added value of existing vehicles as well.

Source: Compiled by Industry Research Department, Mizuho Bank, Ltd.

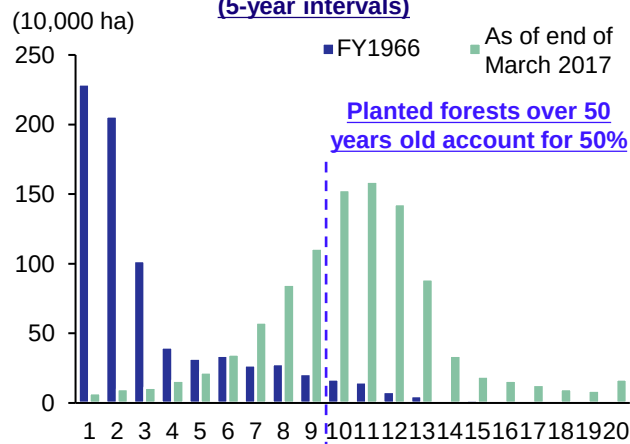
Procurement of woody biomass and waste, which yield higher lifecycle assessments, is relatively accessible in upstream resource sourcing

- In non-food resources highly valued for bio feedstocks and fuels production, Japan is endowed with abundant forest resources and waste materials for which collection networks have been established.
 - Utilizing waste generates revenue through its contribution to solving social challenges such as waste processing; in Japan, high population density creates an environment conducive to efficient collection, while circular utilization remains at an early stage, presenting significant potential for use in bio feedstocks and fuels.

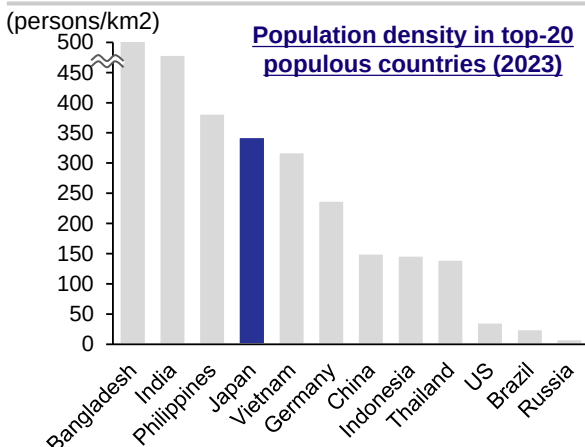
High-density, high-availability quality forest resources



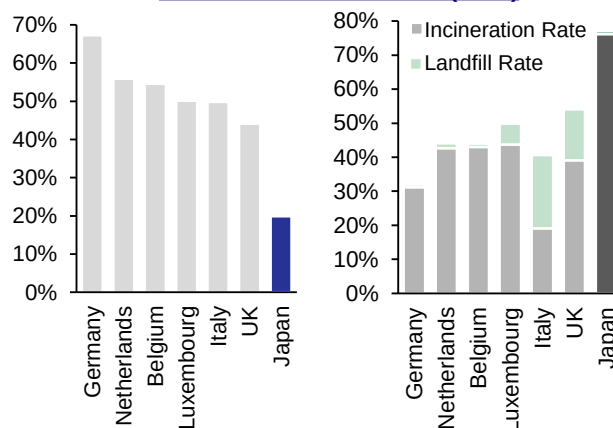
Changes in age class composition of planted forests (5-year intervals)



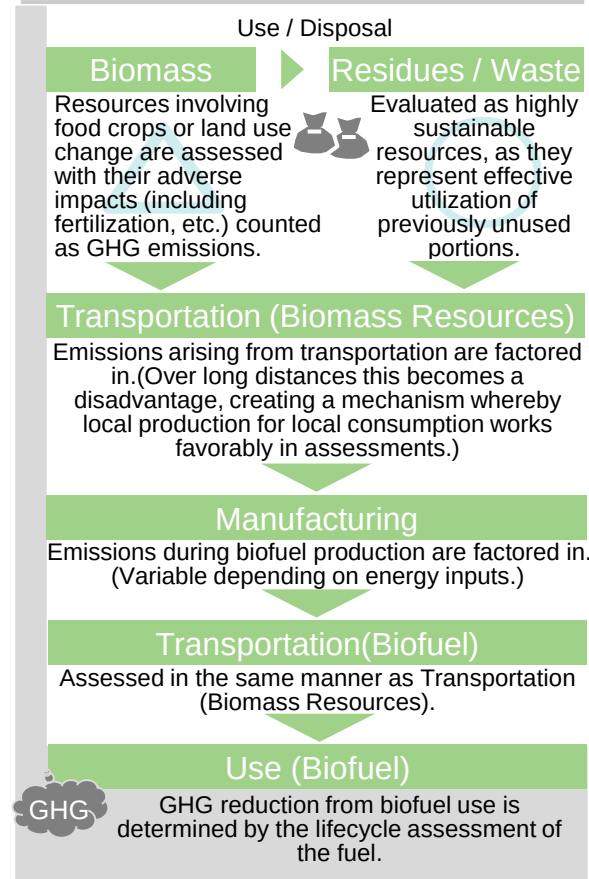
Waste resources amenable to efficient collection with significant utilization potential



Japan-Europe waste recycling rate and waste incineration / landfill rate (2018)



Lifecycle assessment of biofuel



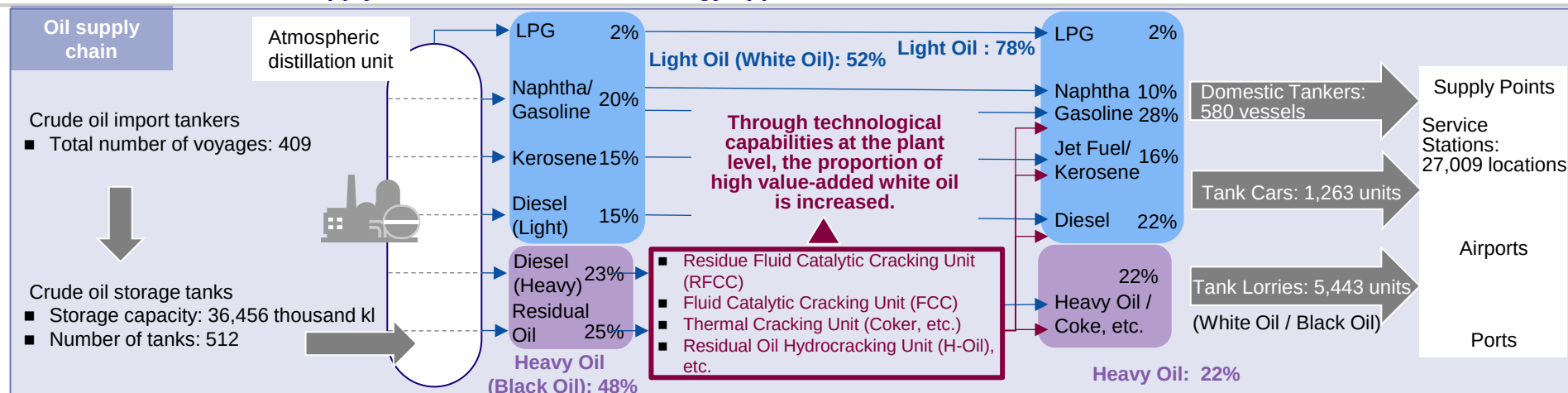
Woody biomass and waste are resources with a high emissions-reduction effect that can be compatible with solving social challenges.

Source: All figures compiled by Industry Research Department, Mizuho Bank, Ltd. based on various publicly available materials including the World Bank, OECD, Eurostat, and Forestry Agency.

In the midstream, stable supply network construction and technological capabilities enable high value-added production, while a collaboration framework with demand-side players is established downstream

- Japan's oil industry has established a stable supply chain spanning from crude oil procurement to product supply, while also possessing technologies for high value-added product manufacturing.
 - Domestic operators responsible for technology, operations, and evaluation — spanning from engineering through process optimization to visualization — collaborate seamlessly.
- In the transition to bio, Japan can provide capabilities to complete stable operations from plant to end customer, enabling market formation in collaboration with demand-side players.

Current oil-based feedstock supply chain and various technology applications



1 Stable supply chain construction

- A framework spanning national and industry boundaries, enabling stable supply and high value-added production.

(Example of response to new developments) For gas and heat, Japan has accumulated experience from constructing LNG supply chains ahead of other countries.

2 Engineering and process optimization capabilities

- Skilled specialist personnel
- Refining technology development with catalyst manufacturers
- Technical implementation, stable operation infrastructure construction, maintenance and inspection by EPC contractors

(Key areas of application)

- R&D
- Equipment design, procurement and construction
- Construction, maintenance and renewal
- Control and monitoring

3 Monitoring and operation optimization technologies

- Industrial measurement and control equipment incorporating advanced measurement technologies.

(Key areas of application)

- Refining equipment: Temperature transmission / Gas analysis
- Central control: Plant status monitoring
- Piping: Flow rate / Density / Pressure

4 Certification and quantification

- Presence of international certification bodies
- Collaboration with major IT companies

These strengths are also deployed in the bio domain.

5 Collaboration among Japan-based companies

- Collaboration with demand-side industries led by the automotive sector
- Advancement of rulemaking in coordination with the government



Existing capabilities are leveraged in the bio feedstocks and fuels domain, which shares similarities with oil.



Control capabilities cultivated in liquid feedstock and fuel manufacturing are applied to processes such as cultivation in bio operations.

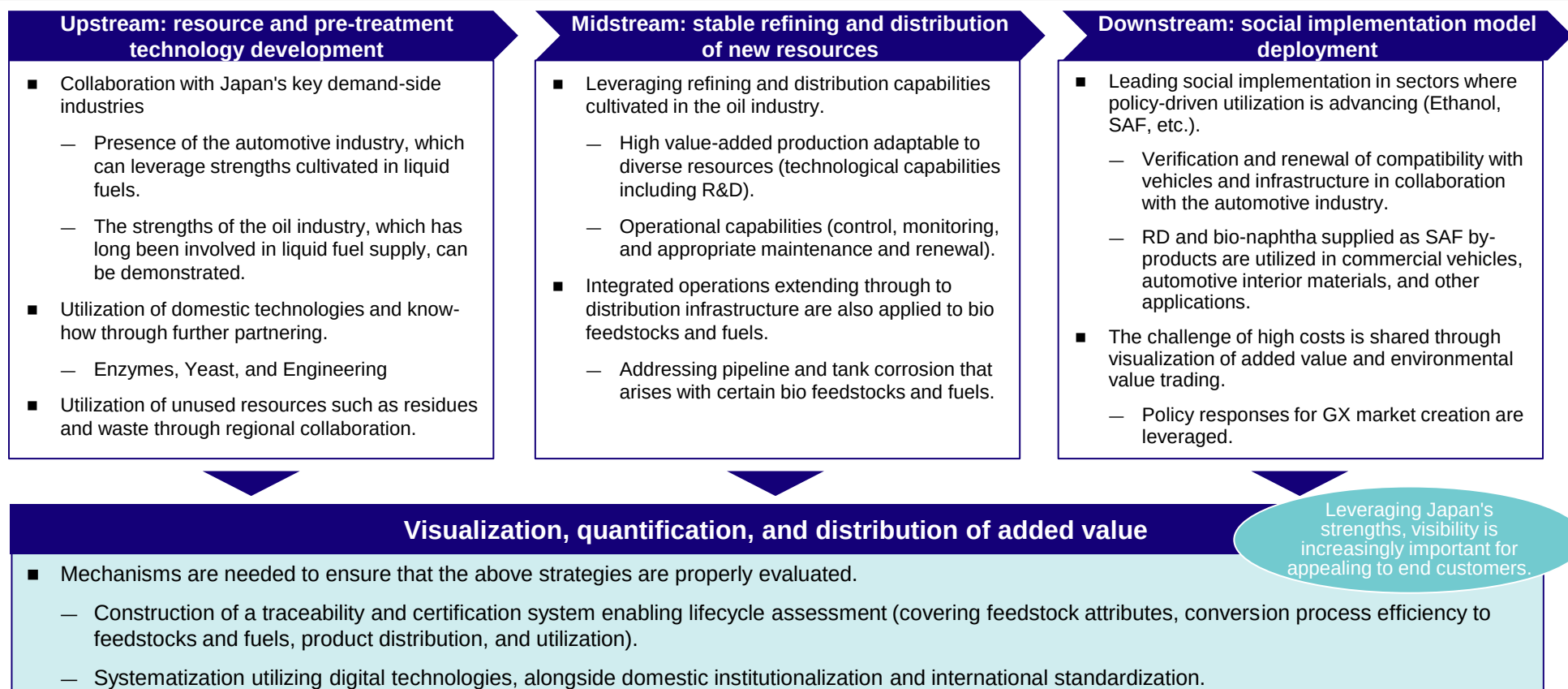
Lifecycle assessment is utilized in the bio domain to enhance environmental value.

Note: Figures are as of FY2024 or end of March 2025. Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on various publicly available materials from oil industry associations and other sources.

Advancing simultaneously and in parallel across industries on each element of feedstocks, processes, products, and value

- Advancing bio feedstocks and fuels requires addressing differences from oil in terms of resource characteristics, refining and distribution, demand structure, and visibility.
- For supply chain construction, it is important for stakeholders to collaborate and pool their respective strengths, rather than pursuing piecemeal responses.
 - Upstream, demand-side industries and regions are drawn in to secure resources; midstream, the existing capabilities of the oil industry are leveraged.
 - Downstream, it is important to advance market formation by leveraging policy support in leading sectors, while also making the value of the supply chain as a whole visible.

Strategies for Japanese industry to capture the bio feedstocks and fuels market

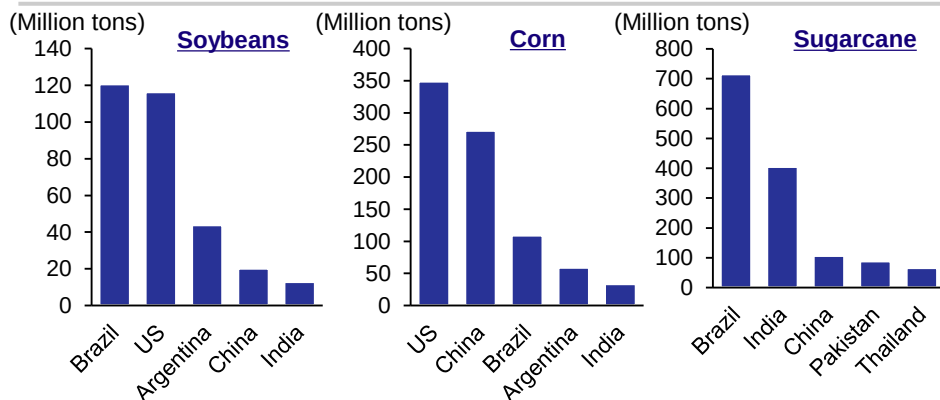


Source: Compiled by Industry Research Department, Mizuho Bank, Ltd.

Production of bio feedstocks and fuels faces hurdles of high costs due to overseas concentration and import dependence for edible feedstocks, and increased processing steps for non-edible feedstocks

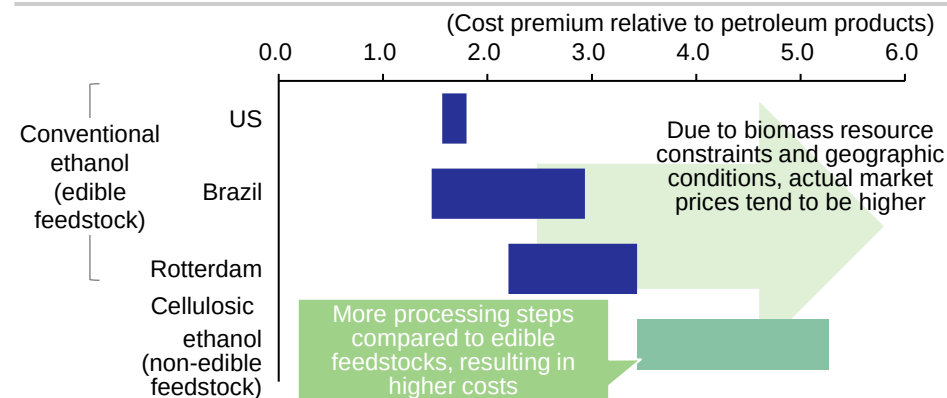
- Edible feedstocks such as fats/oils and sugar-based resources favorable for producing bio feedstocks and fuels are concentrated in the Americas and other regions, leaving Japan dependent on overseas procurement.
- The cost of producing bio feedstocks and fuels is higher than petroleum even when using edible feedstocks; when utilizing non-edible feedstocks such as residues (cellulose, etc.) and waste materials, additional processing steps are required, resulting in an even higher cost structure.

Edible feedstock production volume concentrated in the Americas and other regions (2022)



Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on Statistics Bureau of Japan, World Statistics 2025

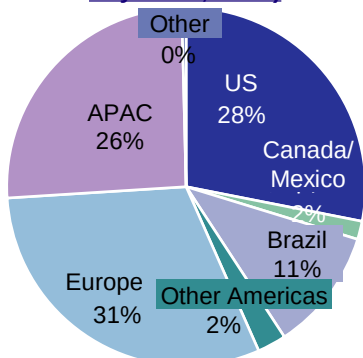
Bioethanol supply cost (literature values)



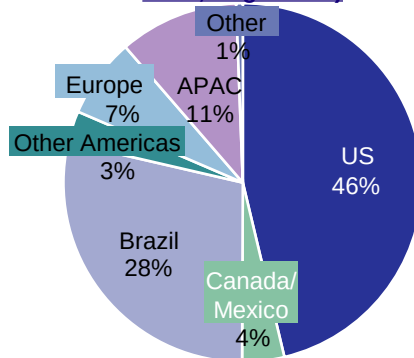
Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on IEA Bioenergy, *Advanced Biofuels – Potential for Cost Reduction*

Supply share of major biofuels by country/region

Biodiesel (Primary biomass feedstocks: Soybeans, Palm)

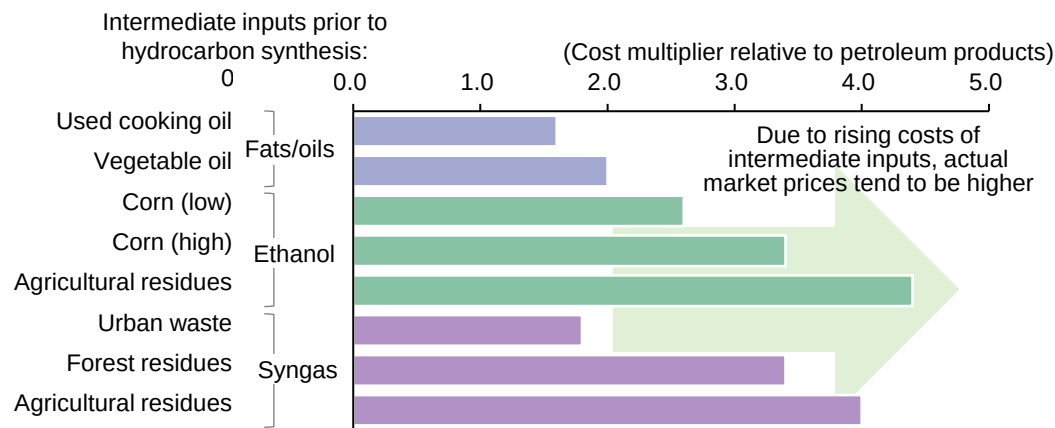


Bioethanol (Primary biomass feedstocks: Corn, Sugarcane)



Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on Energy Institute, *Statistical Review of World Energy 2024*

Supply cost of hydrocarbon-type biofuels by feedstock and production technology (literature values; SAF as example)

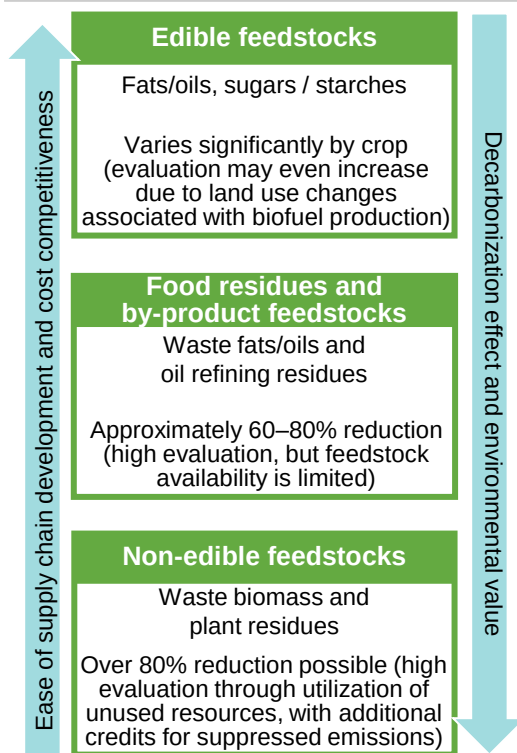


Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on ICAO, *SAF rules of thumb*

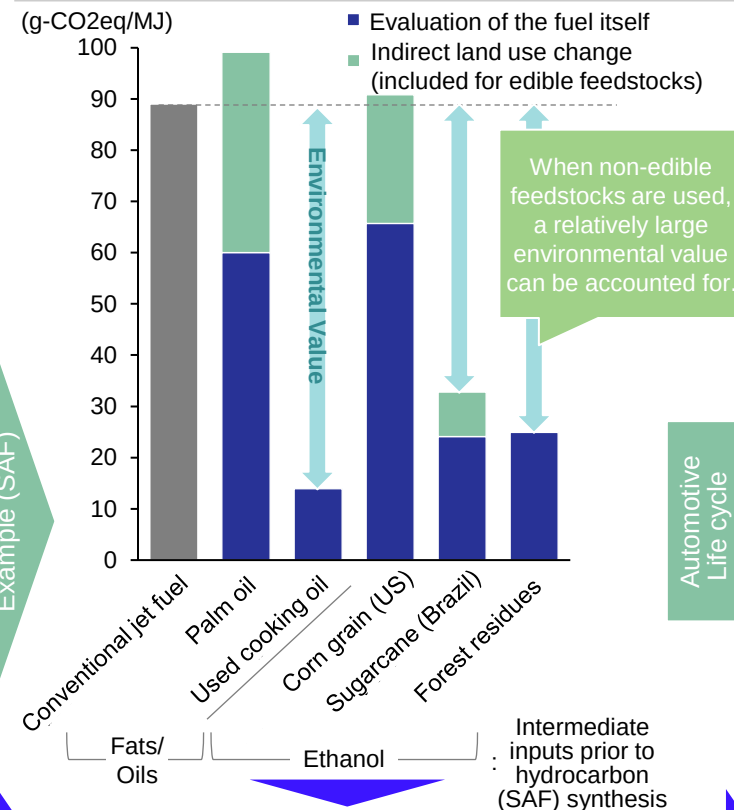
Advancing evaluation rules for non-edible feedstocks, a Japanese strength, in collaboration with the automotive industry, while maintaining and improving the competitiveness of internal combustion engines

- Development of bio feedstocks and fuels capable of delivering high environmental value, with the automotive industry — broadly connected to industry and society — collaborating and driving the process alongside rule formation.
 - Utilizing domestically available non-edible feedstocks for the production of bio feedstocks and fuels can claim higher environmental value than edible feedstocks.
 - Formulating appropriate evaluation rules contributes to the effective utilization of local resources and improved competitiveness of internal combustion engines; public-private deliberation is one possible approach.

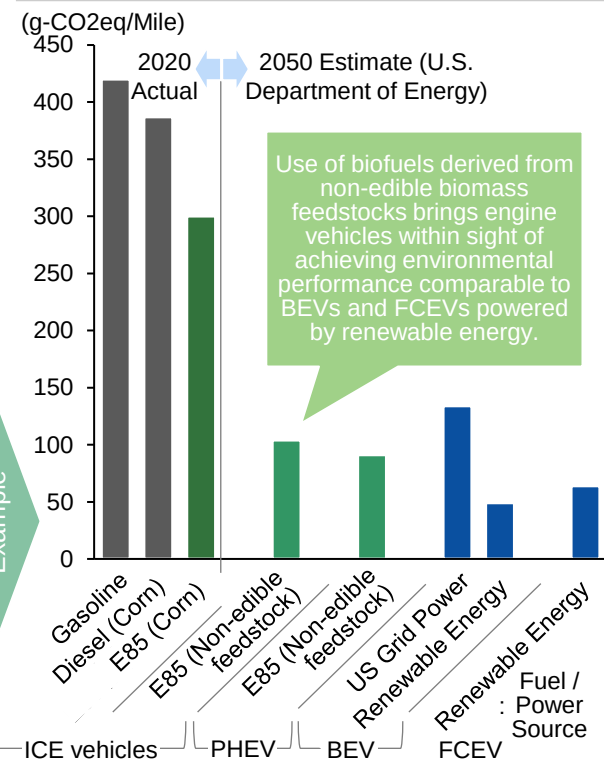
Characteristics and evaluation positioning by biomass feedstock type



Life cycle assessment by biomass feedstock attribute (SAF as example)



Automotive life cycle emissions (compact SUV as example)



Generating high environmental value through utilization of unused resources

Developing rule frameworks and systems for life cycle assessment

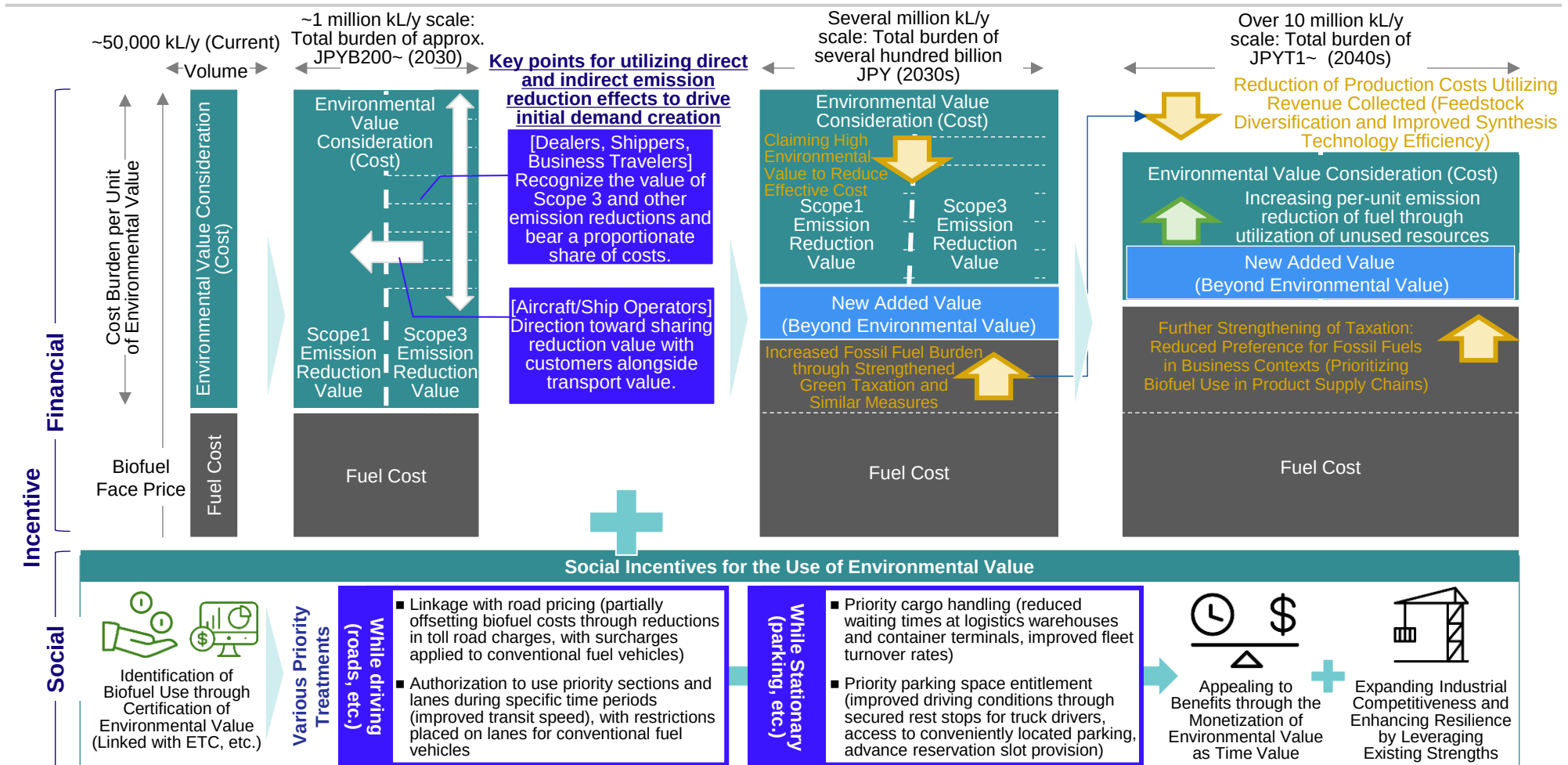
Contributing to sustained competitiveness of ICE vehicles through life cycle assessment and utilization of non-edible feedstocks

Note: PHEV (Plug-in Hybrid Electric Vehicle), BEV (Battery Electric Vehicle), FCEV (Fuel Cell Electric Vehicle)

Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on ICAO, *CORSIA Default Life Cycle Emissions Values for CORSIA Eligible Fuels* (June 2022); U.S. Department of Energy, Office of Vehicle Technologies, *Hydrogen and Fuel Cell Technologies & Bioenergy Technologies* (November 2020); and other publicly available materials

Strategies for societal acceptance of cost increases associated with use of bio feedstocks and fuels

- As cost increases are unavoidable for bio feedstocks and fuels due to the nature of their feedstocks and complex production processes, measures to secure societal acceptance of new benefits are critical for practical implementation.
 - Options include not only cost sharing with stakeholders and narrowing the price gap versus petroleum products through carbon pricing, but also measures enabling consumers to tangibly experience a range of social benefits — such as discounted toll road charges and allocated parking spaces — as a pathway to expanded adoption.

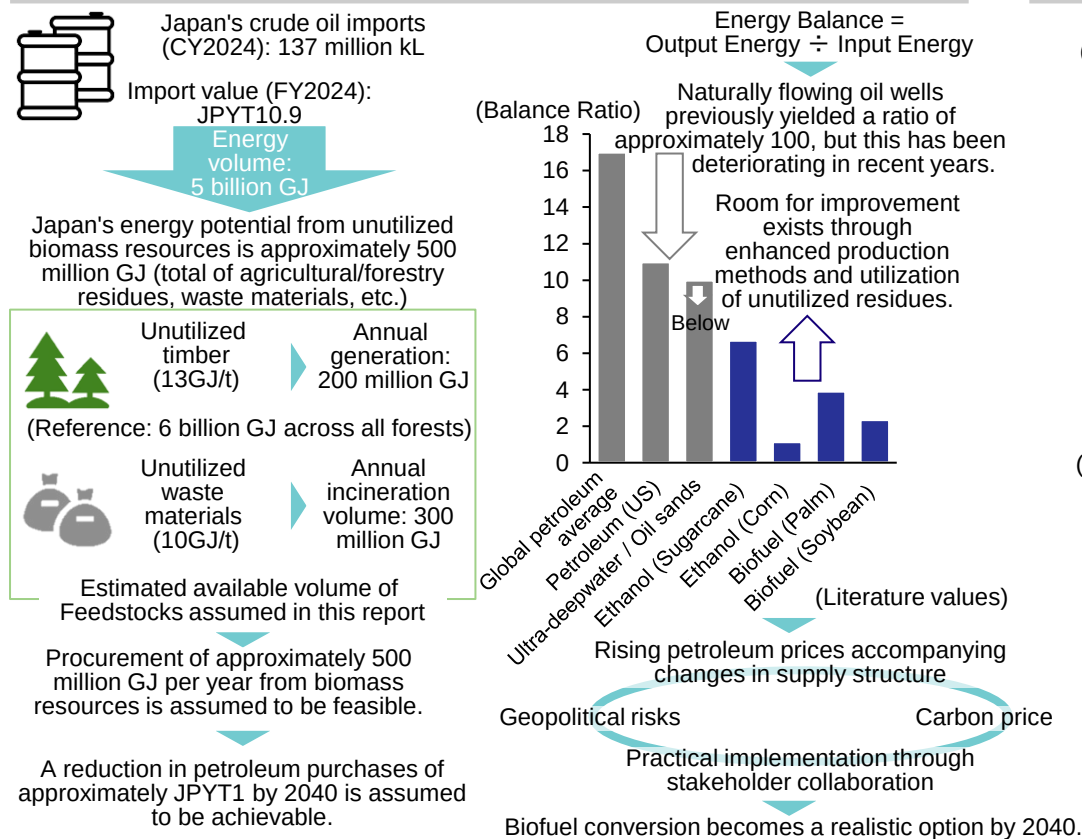


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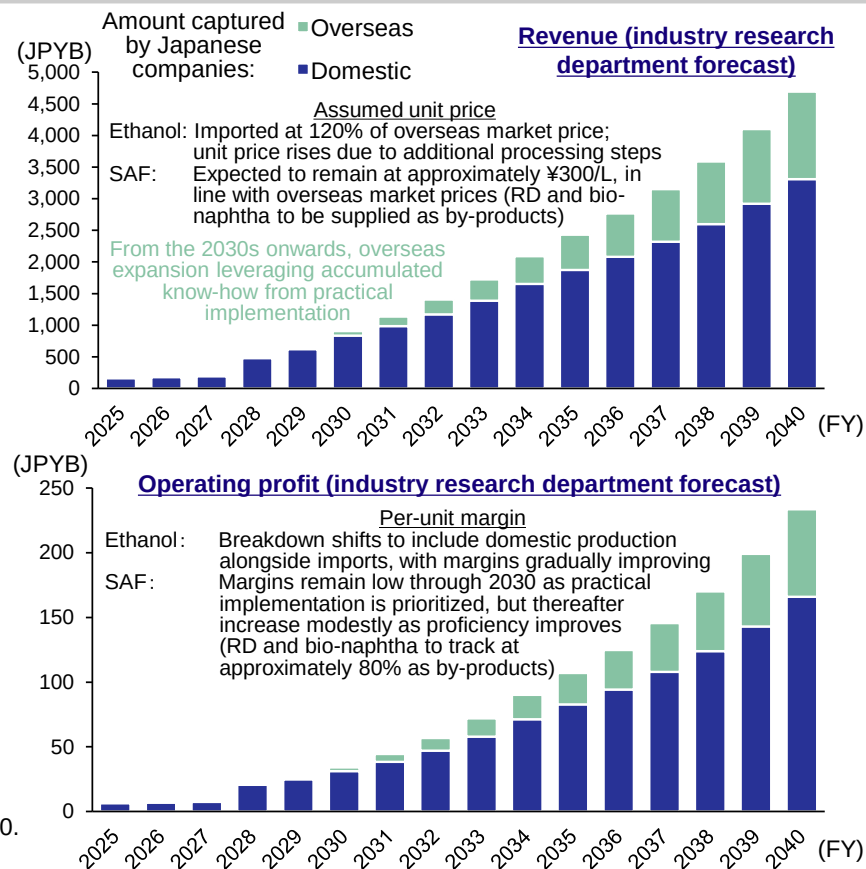
Revenue expansion in bio feedstock and fuel-related businesses expected through broader future feedstock utilization, relative cost competitiveness improvements, and overseas expansion

- Should biotechnology development and feedstock development become full-scale, Japan could potentially substitute approximately 10% of its petroleum consumption with domestically produced biomass.
- While cost increases arising from the price gap with petroleum products represent a challenge for the adoption of bio feedstocks and fuels, practical implementation is expected to advance as this gap narrows on a relative basis.
 - While a combination with imports is realistic in the near term, Japan is expected to lead in market creation through advances in technology and policy responses, with overseas expansion also in view.

Supply volume and pricing potential for bio feedstock and fuel market expansion in Japan



Revenue and operating profit of Japan-related bio feedstock and fuel businesses (sales of manufactured and imported volumes)



Note: Forecast by Industry Research Department, Mizuho Bank, Ltd.

Source: Compiled by Industry Research Department, Mizuho Bank, Ltd. based on David J Murphy, *The implications of the declining energy return on investment of oil production*, The Royal Society (2014); Julio Cesar Marques, *Biofuel in the Automotive Sector: Viability of Sugarcane Ethanol* (2014); NEDO, *Renewable Energy Technology White Paper* (2nd ed.); and various publicly available materials from the Ministry of the Environment and other sources

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