Technology Roadmap for “Transition Finance” in Automobile Sector

March 2023

Ministry of Economy, Trade and Industry

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1. Premise | Necessity for Technology Roadmap for Automobile Sector

- Technology Roadmap for "Transition Finance" (hereinafter, technology roadmap) selects sectors of high importance for transition and those with high emissions with no alternative measures of decarbonization available today (for technological and economic reasons).
- The automobile industry is **a core industry that accounts for about 10% of Japan's employment and about 20% of its exports and leads the Japanese economy**.
  Therefore, it is important to **maintain and reinforce the international competitiveness and lead the world** through **contributing to the world with various options** even with global decarbonization, which is a big change in the environment.
- On the other hand, the automobile sector is **an industrial field with a lot of CO2 emissions and it accounts for 16% of the emissions in Japan,** so **transition toward net-zero in the automobile sector is needed.** Transition **requires large-scale financing** not only to renew, introduce etc. energy-saving equipment for the reduction of carbon emissions and **decarbonization in the manufacturing processes of automobiles and related members**, but also **to develop and implement technologies pursuing diverse options such as development of members of storage batteries, motors, etc. and stable supply of decarbonized fuel including clean hydrogen and biofuels/synthetic fuels**. So, we clarified domestic and international technologies and drew the pathways up to 2050.
- Technology innovation and structural change of business for decarbonization will become advantages of companies. To attract the world's ESG investments which grew to ¥3,500 trillion ($35 trillion: by GSIA) as of 2020, high-emitting industries are required to disclose their strategies with the understanding of investors' perspectives.
- Based on such circumstances of energy, characteristics of the automobile industry, etc. in Japan, the Technology Roadmap was developed through discussions held with technology and finance experts and representatives, etc. of operators of the automobile sector.

1. Premise | Objectives and Positioning of Technology Roadmap [1]

- The Technology Roadmap is designed to serve as a reference for **the automobile companies in Japan, when investigating measures against climate change using transition finance (Note)** based on "the Basic Guidelines on Climate Transition Finance" (Financial Services Agency, Ministry of Economy, Trade and Industry, Ministry of the Environment, May 2021). In addition, **it is intended to help banks, securities companies and investors to assess the eligibility of the fundraiser's decarbonization strategies and approaches.**
- The final goal of the Technology Roadmap is to achieve 2050 carbon neutrality and the Roadmap provides way to envision low-carbonization/decarbonization technologies that are expected to be deployed by 2050 and when these technologies will be deployed based on information currently available.
- The Technology Roadmap is aligned with Nationally Determined Contribution (NDC) based on the Paris Agreement*1, Green Growth Strategy*2, and R&D and Social Implementation Plan using Green Innovation Fund*3.
- **The technologies to realize carbon neutrality in the automobile sector have not been established.** First, we will **steadily proceed with activities to achieve the goal "Electrified vehicles account for 100% of sales of new passenger vehicles in mid-2030s"** while **promoting research and development of technologies that are yet to be established, including stable supply of CN fuel, toward 2050.** In doing so, **we will convert the issue of mid- and long-term decarbonization to a growth engine of Japan** via public and private investments.
- Looking ahead towards 2030 and 2040, **the transition period, it is important to steadily advance efforts for transition including ones to save and convert energy in addition to R&D**.

*1: https://www.env.go.jp/content/900442544.pdf
*2: https://www.meti.go.jp/press/2021/06/20210618005/20210618005-3.pdf
*3: https://www.meti.go.jp/press/2021/11/20211111004/20211110004-2.pdf
https://www.meti.go.jp/press/2021/03/20220314003/20220314003-2.pdf
https://www.meti.go.jp/press/2021/03/20220314003/20220314003-4.pdf

(Note) "Transition finance refers to a financing means to promote long-term, strategic GHG emissions reduction initiatives that are taken by a company to tackle climate change for the achievement of a decarbonized society" - Basic Guidelines

1. Premise | Objectives and Positioning of Technology Roadmap [2]

- Transition finance includes not only investment in low-carbonization/decarbonization within the company but also **efforts/activities that contribute to the transition of other companies and industries through our products and services**. From this viewpoint, domains related to transition are not only technical ones but also activities for *fair transition* including support for those who will be disadvantaged economically and positive business category transition considering CN.

- On the other hand, though these activities are important elements that contribute to the whole of society and economy toward decarbonization, the range is so extensive that the Technology Roadmap mainly deals with **the roadmap of promising technologies for decarbonization from the manufacturing stage,** which accounts for most emissions from the automobile sector, **the usage stage, and related technologies**.

- The term “automobile,” which is incorporated in the Technology Roadmap, mainly means **passenger vehicles and commercial vehicles such as buses and trucks**.

- Note that the primary goal, which is the achievement of decarbonization in 2050, is common among many countries, but **the pathways to the transition depend on the circumstances of each country** and the activities of transition in Japan should be **proceeded with together with the energy policies including the Strategic Energy Plan**.
  The contents of the Technology Roadmap are consistent with the Japanese energy policies.

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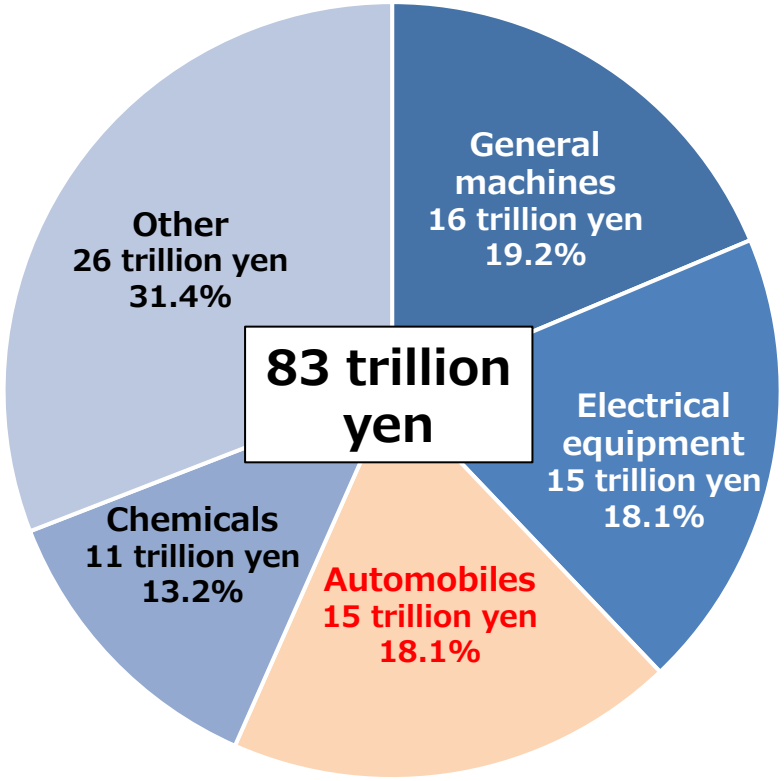
2. Overview of Automobile Industry | Automobile Industry Supports Japanese Economy

- The automobile industry is **a mainstay, and it has been supporting the economy and employment in Japan.**

Value of exports of each of Japan's main products (2021)



(Source) Based on JAMA "The Motor Industry of Japan 2022"

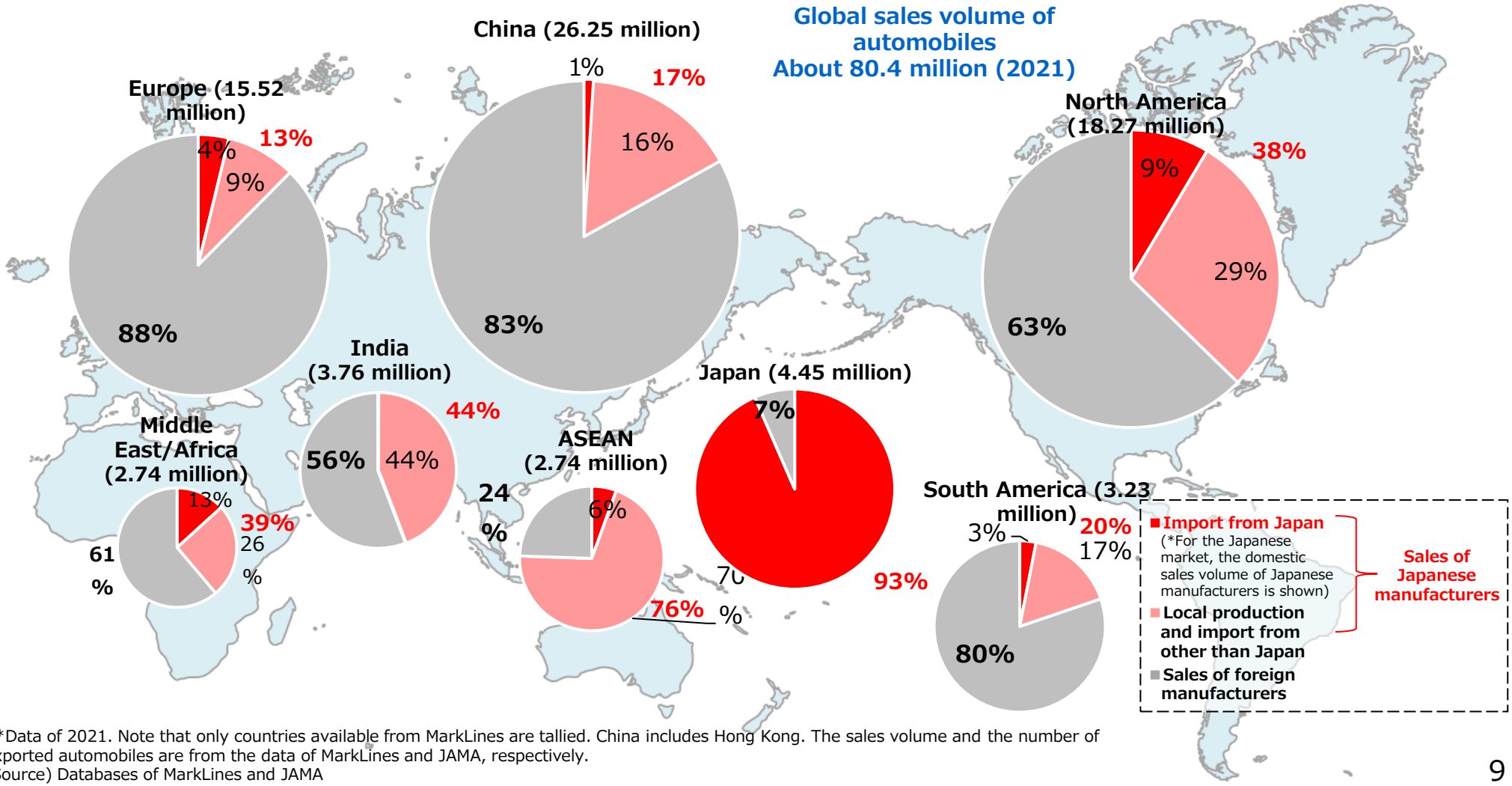
Scale of automobile-related industries

	Total	Percentage
Shipment	About 60 trillion yen	About **20% of manufacturing**
Employment	About 5.5 million	About **10% of all industries**
Capital investment	About 1.2 trillion yen	About **20% of manufacturing**
Research and development	About 3.7 trillion yen	About **30% of manufacturing**

Note) The data on shipment, employment, and others are of 2019, 2021, and 2020, respectively

2. Overview of automobile Industry | Sales Volume of Automobiles in Major Global Markets

- In terms of the sales volume of automobiles in the major global markets, **big markets** are **China** (**about 26 million**), **North America** (**about 18 million**), **and Europe** (**about 15 million**).
- **The sales volume in the Japanese market is about 4.5 million**. **The sales volume in the Asian market including ASEAN and India is about 11 million**.

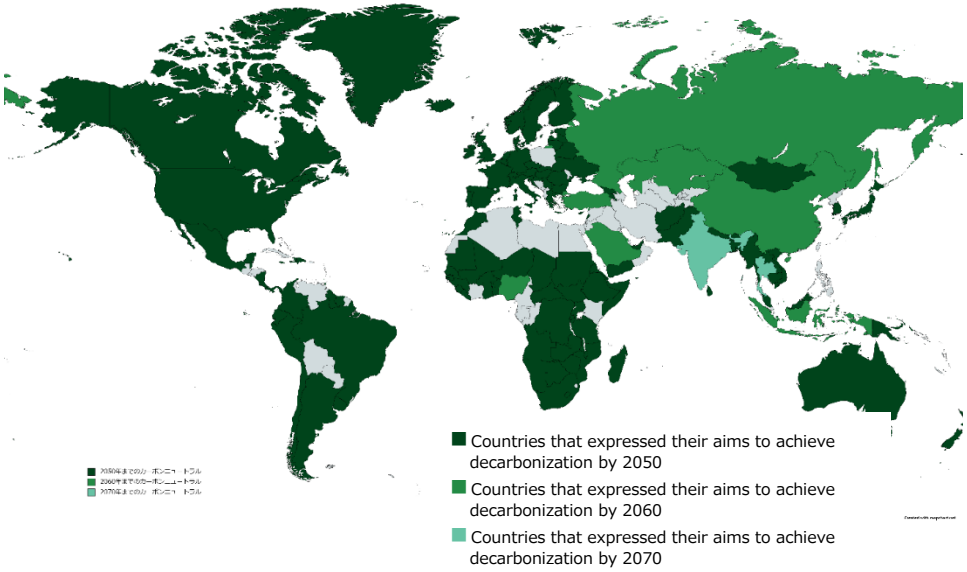


*Data of 2021. Note that only countries available from MarkLines are tallied. China includes Hong Kong. The sales volume and the number of exported automobiles are from the data of MarkLines and JAMA, respectively.
(Source) Databases of MarkLines and JAMA

2. Overview of Automobile Industry | Decarbonization and Automobiles in 2050

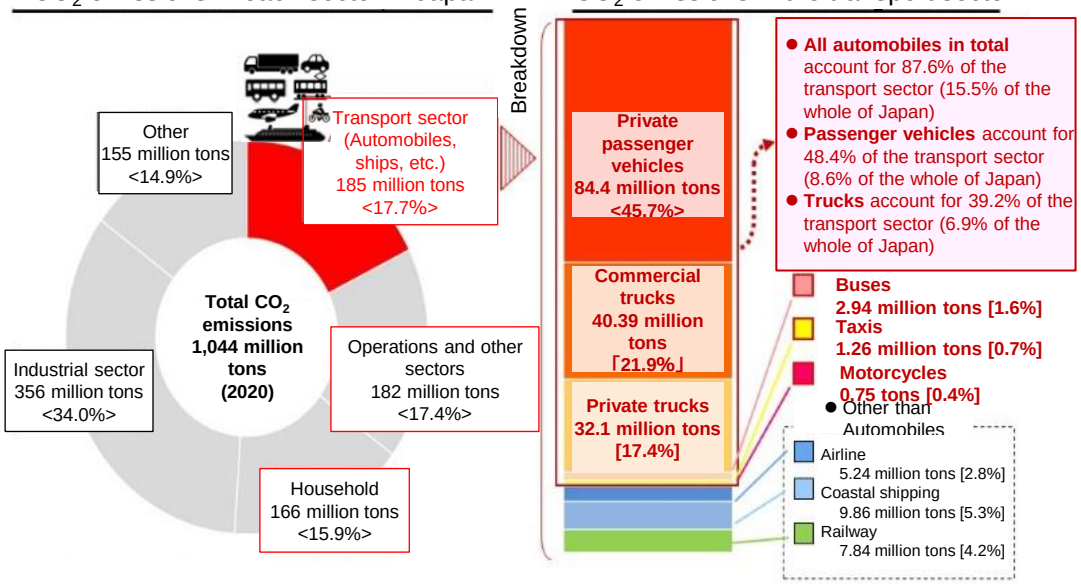
- Each country and each region including Japan expressed **their aims to achieve decarbonization by 2050**.
- In Japan, **the transport and automobile sectors account for 17.7% and 15.5%, respectively, of the CO_2 emissions**, so early responses toward decarbonization are required.

Countries and regions that expressed their aims to achieve decarbonization



1) Prepared by the Ministry of Economy, Trade and Industry, counting [1] member countries of the Climate Ambition Alliance and [2] countries that expressed their aims to achieve CN by 2050 by submitting their long-term strategies to the United Nations or at the Climate Summit, COP26, etc. in April 2021 (as of November 9, 2021)
[1] https://climateaction.unfccc.int/views/cooperative-initiative-details.html?id=95
[2] https://unfccc.int/process/the-paris-agreement/long-term-strategies

CO_2 emissions in the transport sector

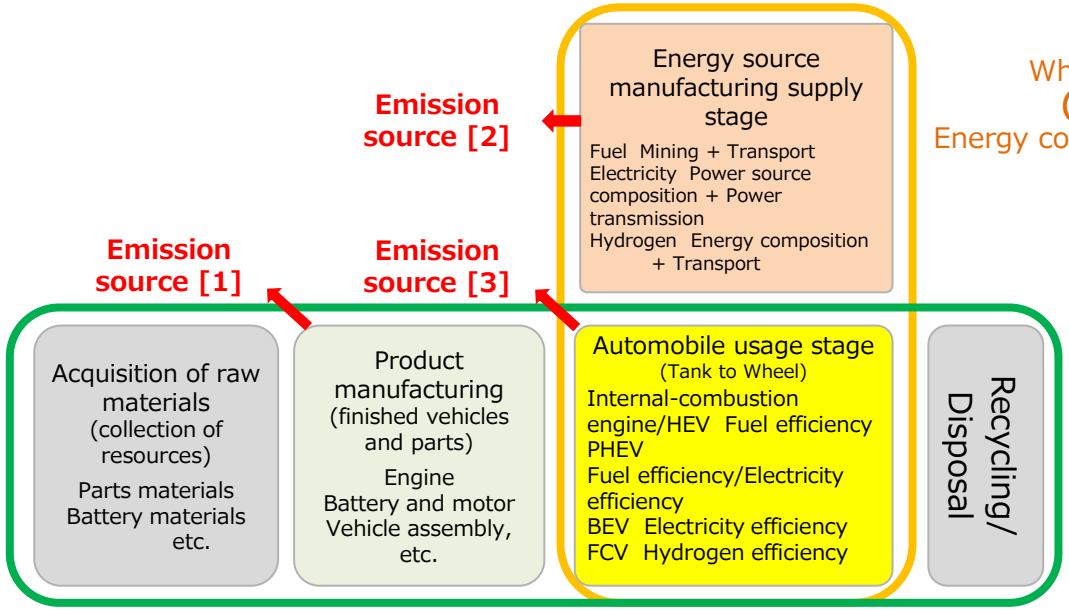


*Due to rounding, the value of the total may not match the sum of the individual constituents.
*The emissions from power generation by electricity operators and heat generation by heat suppliers are allocated to the final demand sector depending on the consumption.
*Prepared by the Environment Policy Division of MLIT from "Final Values of Greenhouse Gas Emissions Data of Japan (1990 to 2020)" by the Greenhouse Gas Inventory Office.
*Motorcycles were included in "Operations and other sectors" up to the final values of 2015 but in the transport sector as an independent item from the final values of 2016.

Domestic CO_2 emissions: 1.44 billion tons
Automobile sector: 15.5%

- <Domestic> Website of the Ministry of Land, Infrastructure, Transport and Tourism "CO_2 Emissions in Transportation Sector" https://www.mlit.go.jp/sogoseisaku/environment/sosei_environment_tk_000007.html

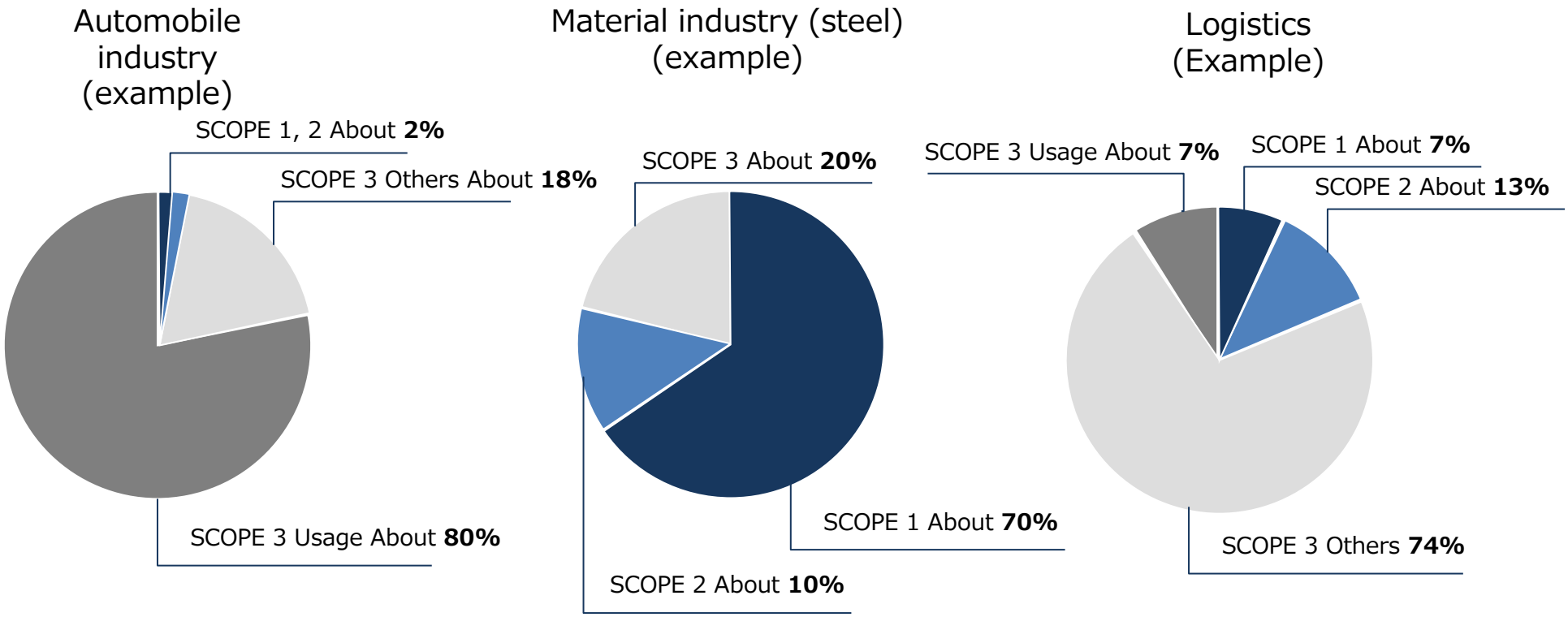
2. Overview of Automobile Industry | Direction toward CN of Automobile Sector



Major emission sources	Overview	Direction toward the reduction of carbon emissions and decarbonization
[1] Product manufacturing	Emissions in manufacturing of essential parts for decarbonization of vehicles	• Performance improvement of storage batteries, motors, etc. • Secondary utilization and recycling of batteries, etc.
	Emissions in use of electricity, etc. in the plant during manufacturing	• Reinforcement of energy-saving measures • Promotion of fuel conversion (gas conversion and decarbonized fuel) • Utilization of green electricity, etc.
[2] Energy sources Manufacturing and supply	Emissions by production of necessary energy for driving, etc.	• Establishment of the supply organization of green electricity and hydrogen • Conversion to carbon-neutral fuel (biofuel and synthetic fuel), etc.
[3] Use	Emissions from tail pipes during driving	• Introduction of fuel efficiency regulation • Prevalence and promotion of electrified vehicles • Energy-saving of in-vehicle computing technologies • Optimization of traffic flow/Streamlining of transport, etc.
Acquisition, recycling, and disposal of raw materials		• Not applicable to the Technology Roadmap

2. Overview of Automobile Industry | CO_2 emissions in the value chain of each industry

- **The automobile industry is characteristic in that emissions from other companies related to business activities (Scope 3)**, specifically **emissions from use of vehicles by users (about 80%), are greater** than direct and indirect emissions from business activities (Scopes 1 and 2).
- **Therefore, measures for OEM, which is the supply side**, (introduction and electrification of energy-saving equipment, support for research and development, etc.) as well as **measures which change the demand of automobile users** are important.



(Source) Prepared by the Automotive Division based on the information disclosed by each company

2. Overview of Automobile Industry | Big Picture of Activities Related to Storage Batteries and Motors for Promotion of Electrification

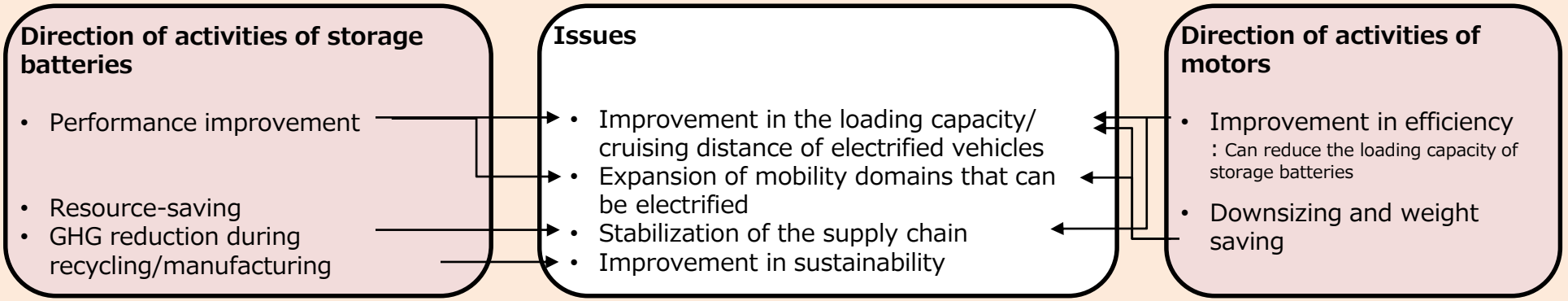
Excerpted from the materials of the working group of the industrial structure conversion field at the green innovation project sub-committee of the fifth industrial structure council

- The issues of electrification are [1] deterioration of the loading capacities of vehicles and cruising distance constraint due to the capacities/weights of electric power trains, [2] presence of mobility domains where electrification is difficult such as light and large vehicles due to [1], and [3] issues related to sustainability such as use of many scarce resources, absence of established recycling systems, and great emissions of GHG during manufacturing.
- In this project, we will promote research and development for performance improvement, resource-saving, and reduction of GHG emissions during recycling/manufacturing for storage batteries and motors, aiming to resolve such issues and reinforce the competitiveness of the related industries in Japan.

Major activities toward decarbonization in the automobile sector

Supply side

- **Reinforcement of electric power train technologies: Activity domains of this project**



- Reinforcement of technologies other than power trains toward decarbonization including that of in-vehicle computing technologies*
- Supply chain/Value chain conversion
- Large-scale investment support

- Rule formation/standardization

Demand side

- Prevalence of electrified vehicles (regulations and promotion measures)
- Transformation of the use of automobiles (construction of the smart mobility society)

2. Overview of Automobile Industry | Necessity for Decarbonization in Production Processes of Automobiles

- In the manufacturing process of vehicles, a lot of CO_2 is emitted in each phase, mainly **the painting process**.
- It is essential to decarbonize the manufacturing process through **the reinforcement of energy-saving measures in plants, greening of electricity used in plants, etc.**

1) Overview of the process of a vehicle factory

Press

Produce panel parts including roofs and doors by cutting and pressing steel plates

Body

Assemble each pressed panel into the shape of the body by welding

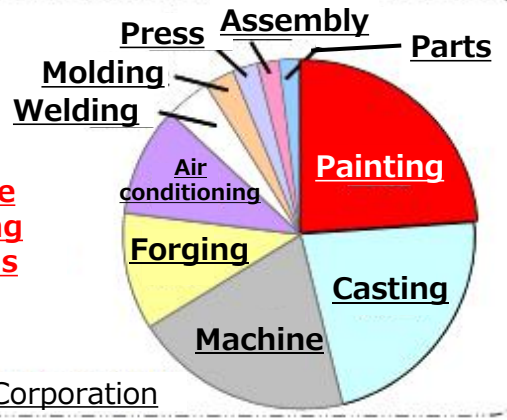
Painting

Burn electrocoat, middle coat, and topcoat onto the cleaned body

Assembly

Install interior and exterior parts such as the engine, transmission, meters, bumper, and driving battery

[Percentage of CO_2 emissions by process]



The self-manufacturing rate, the automation rate, etc. vary among companies, so the CO_2 emissions also varies

From: Material of Toyota Motor Corporation

Source: Japan Automobile Manufacturers Association “Activities of Global Warming Countermeasures in Automobile Manufacturing” (2022/2)

2. Overview of Automobile Industry | Overview of Green Growth Strategy (Automobile/Storage Battery Industry) (Revised in June 2021)

◆ Aim at decarbonization of the whole lifecycle of vehicles in 2050 and reinforcement of competitiveness of the storage battery industry as a new energy infrastructure.

Basic concept

[1] Actively implement a wide range of policies in not only the automobile industry but also energy supply, various industries, life, work, mobility, logistics, regions, and development of local communities.

[2] **Aim to achieve diverse pathways** by optimally combining power trains, energy, fuel, etc. **not limited to specific technologies** in order to establish international competitiveness.

[3] The Japanese automobile industry is a core industry with the world's most advanced total technological capabilities to supply vehicles around the world, so take comprehensive measures focusing on the measures and market conditions of foreign countries.

[4] As there are many related industries in which small and medium-size companies are the majority, aim to construct **an industrial structure for positive activities** toward realizing decarbonization through **responding to electrification, challenging new domains, converting and diversifying business categories, coordinating and merging among companies, etc.**

Goal of electrification *electrified vehicles = EV (electric vehicles), FCV (fuel-cell vehicles), PHEV (plug-in hybrid), HV (hybrid)

- ✓ Make electrified vehicles account 100% of sales of new passenger vehicles by 2035
- ✓ Commercial vehicles:
  - As for small vehicles of 8t or smaller, aim to make electrified vehicles account for 20 to 30% in sales of new vehicles by 2030 and 100% in combination with use of decarbonized fuel such as electricity and synthetic fuel by 2040
  - As for large vehicles over 8t, aim at advanced introduction of 5,000 vehicles in 2020s and set the prevalence goal of electrified vehicles in 2040 by 2030

Goal of the arrangement of infrastructures

- ✓ Install 30,000 public quick chargers and 120,000 normal chargers (realize the same convenience as gasoline vehicles by 2030 at the latest)
- ✓ Arrangement of about 1,000 hydrogen stations by 2030 (promote the arrangement of charging and filling equipment of offices for commercial vehicles)

Decarbonization of fuel

- ✓ For synthetic fuel, expand introduction and reduce costs in 2030s aiming at independent commercialization by 2040

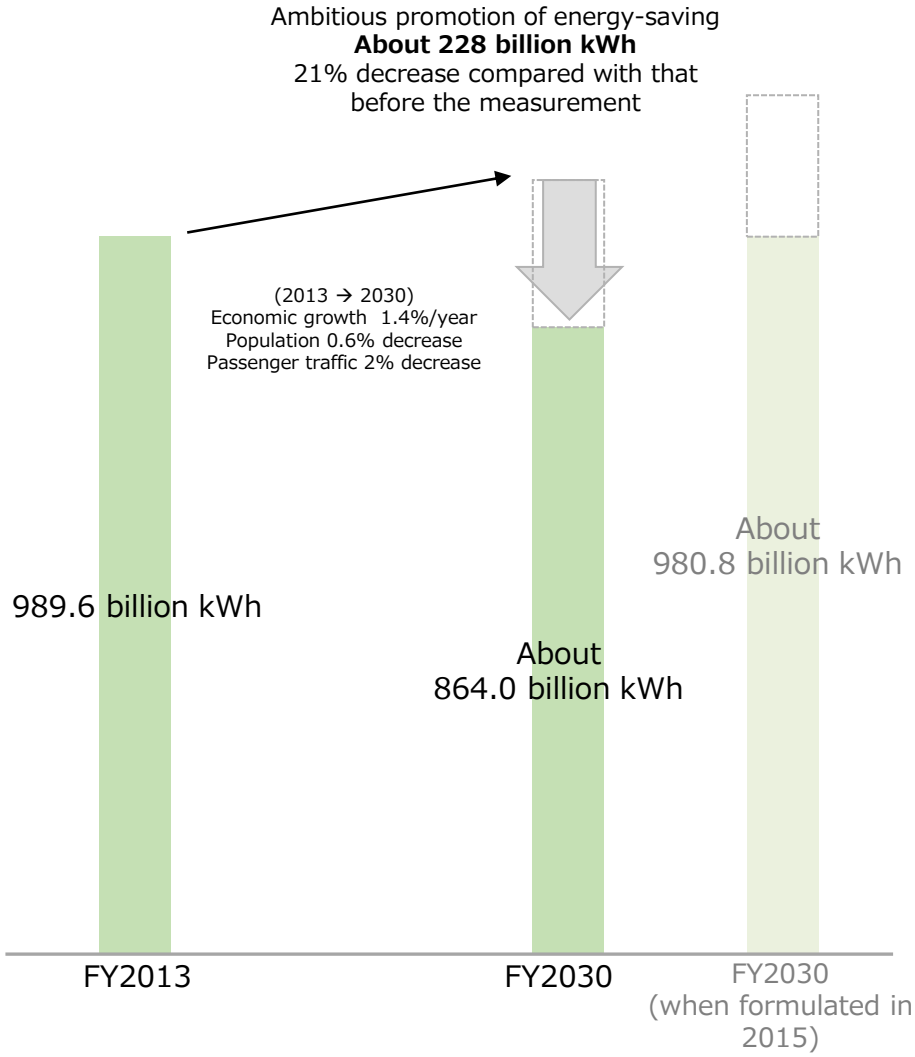
Goal of storage batteries

- ✓ Improve the domestic manufacturing capacity of in-house storage batteries to 100 GWh as soon as possible by 2030, and aim for an in-vehicle battery pack price of 10,000 yen/kwh or less, at which point the electric vehicles becomes as economical as the gasoline-powered vehicles.

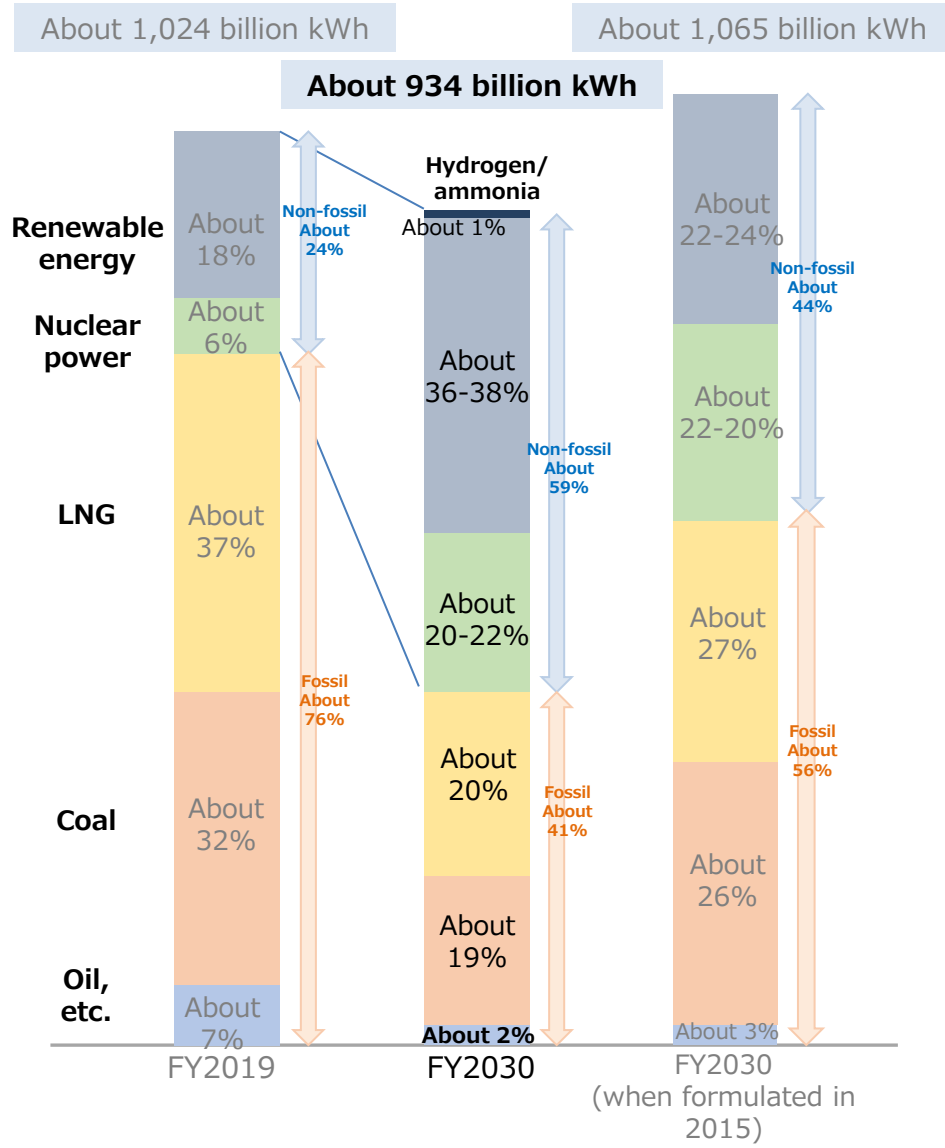
2. Overview of Automobile Industry | Forecast of Electricity Demand and Power Source Composition in 2030

Excerpted from the forecast of energy supply and demand in 2030 (related material) (October 2021)

Electricity demand



Power source composition



2. Overview of Automobile Industry | Electric Automobile Types and Promising Use Cases

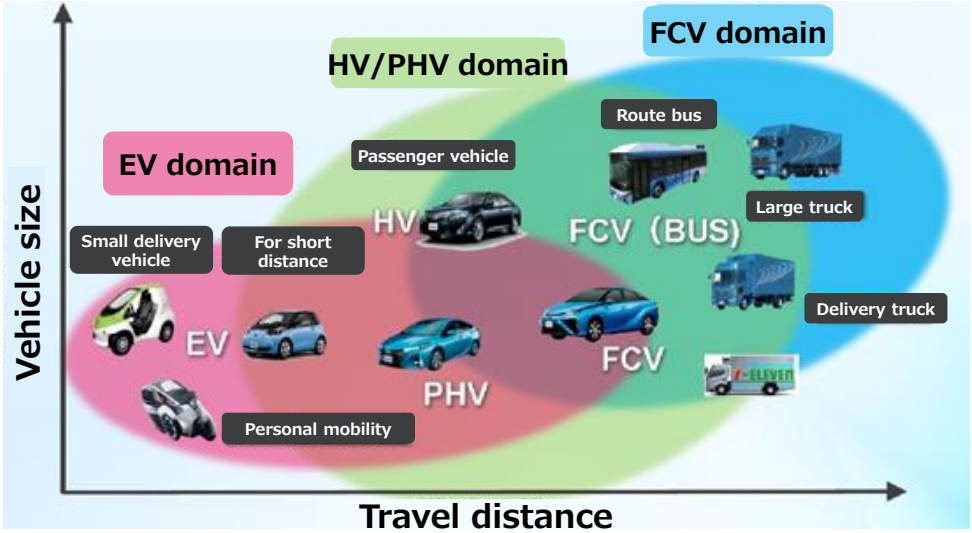
- Each electrified vehicles has **unique strengths and issues**. **Make use of the strengths and industrial infrastructures of Japan** and **promote competitiveness for innovation among technologies by pursuing diverse options** without being limited to specific technologies.

✓ Electric vehicles (**EV**) and plug-in hybrid vehicles (**PHEV**)

✓ Fuel cell vehicles (**FCV**) = Mainly **commercial vehicles**

✓ Decarbonization of fuel (utilization of **synthetic fuels** (**e-fuel**))

Mapping of next-generation vehicles



(Source) Partially modified "Data Collection and Business Potential Verification Outsourcing Evaluation Report on Characteristics of Cruising Distance, etc. of Each Use Case Including EV/FC Bus/Truck in 2020" by the Ministry of the Environment

Types of electrification of commercial vehicles and promising use cases

Vehicle category			Distribution with categories: Last one mile (100 km or less)	Local transport (101–260 km)	Trunk transport (261 km or more)
Truck	Light truck		**BEV** Can cover the necessary daily travel distance by nighttime normal charging		
Truck	Small truck		**B2C: BEV** **B2C: FCV** In use cases with high operating rate such as convenience delivery, EV may not be able to meet the travel distance requirement and it is also difficult to secure charging time	**BEV** **FCV**	**FCV**
Truck	Normal truck	Middle S		**BEV** **FCV**	**FCV**
Truck	Normal truck	Middle L		**BEV** **FCV**	**FCV**
Truck	Normal truck	Large	**FVC** Use cases are rarely fixed and it is necessary to endure short- to long-distance driving EV cannot secure sufficient loading capacity and it is difficult to secure charging points/time		
Bus	Small bus		**BEV**		
Bus	Large bus		**BEV** **FCV**		**FCV**

2. Overview of Automobile Industry | Electrification Goal of Each Country

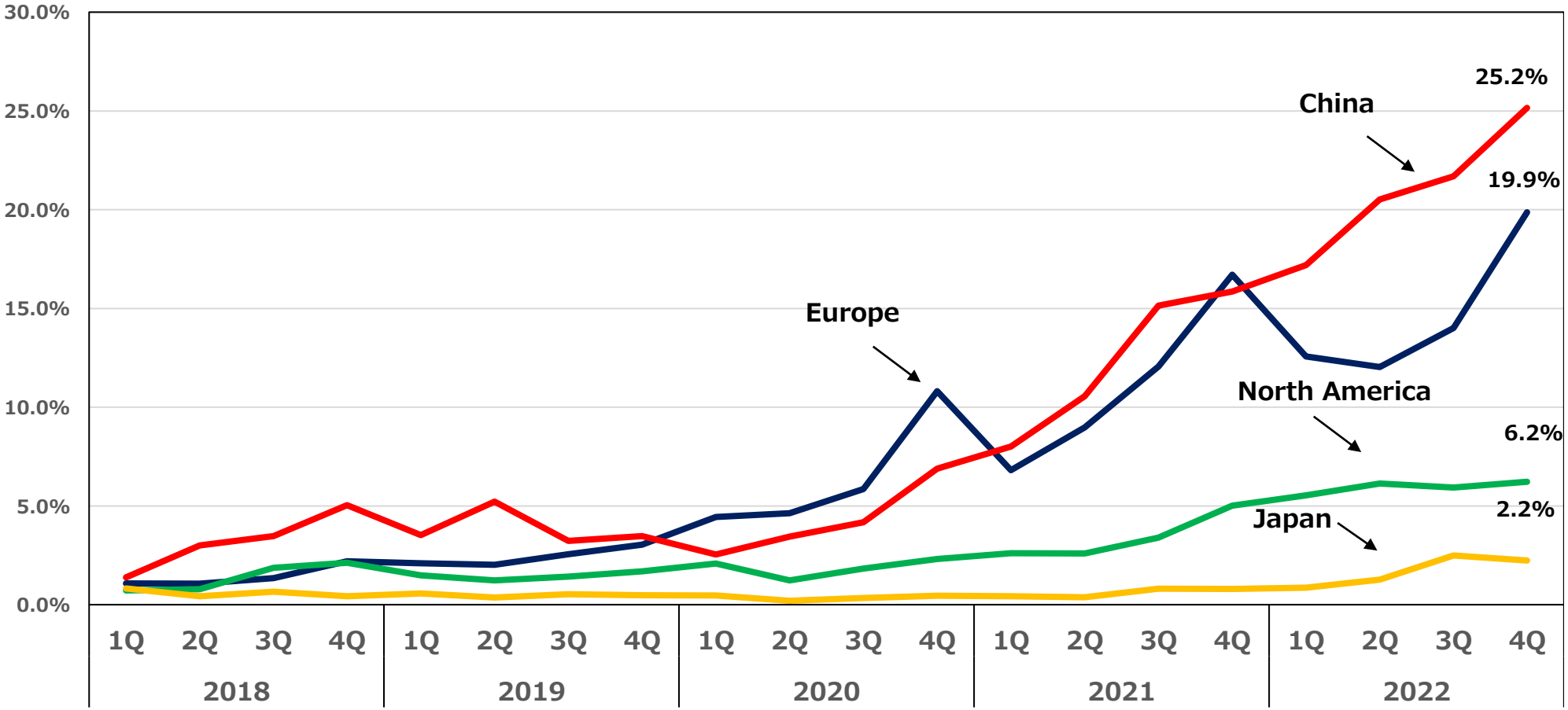
	Target year	Goal	FCV	EV	PHEV	HEV	ICE
Japan	2030	HV: 30 to 40% EV/PHV: 20 to 30% FCV: Up to 3%	Up to 3%	20-30%		30 to 40%	30 to 50%
	2035	Electrified vehicles (EV/PHV/FCV/HV)100%	100%				N/A
EU	2035	EV/FCV: 100% (Note) However, there are regulations of intermediate review, etc.	100%		N/A		
U.S.	2030	EV/PHV/FCV: 50%	50%			50%	
California	2035	EV/PHV/FCV: 100%	100%				
China	2025	EV/PHV/FCV: 20%	20%				
	2035	HEV50% EV/PHV/FCV: 50% (Note) Announced in China-SAE	50%			50%	N/A
UK	2030	Gasoline-powered vehicles: Sales prohibited EV: 50 to 70%		50-70%			N/A
	2035	EV/FCV: 100%	100%		N/A		
France	2040	Internal combustion vehicles: Sales prohibited	100%		N/A		
Geramany	2030	EV: Stock 15 million		Stock 15 million			

Source: Prepared based on information disclosed by the Ministry of Economy, Trade and Industry

2. Overview of Automobile Industry | Transition of BEV Ratio in Major Countries and Regions

- **The global sales volume of BEV in 2022 is about 7.7 million**. It increased especially in **China and Europe**.

Transition of the sales ratio of electrified vehicles in major countries and regions



(Note) North America consists of the U.S. and Canada and Europe consists of a total of 17 countries, namely 14 EU countries (Belgium, Germany, France, Italy, Luxembourg, Netherlands, Denmark, Ireland, Greece, Spain, Portugal, Austria, Finland, Sweden), Norway, Switzerland, and the UK. As for the U.S., SUV is calculated based on small trucks, so the value is the total of passenger vehicles and small trucks.
(Source) Data of MarkLines and JAMA

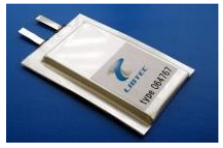
2. Overview of Automobile Industry | Pursuit of Diverse Options through Innovation

- Promote global cutting-edge innovation using the green innovation fund **in order to improve the possibility of each option**.

[1] Next-generation batteries and motors
Upper limit 151 billion yen

Support **the development of high-performance batteries, recycling technologies, etc.** including
[1] **Double the cruising distance**
[2] **Make the cobalt collection rate 95%**

Reduce cost, improve convenience, and mitigate resource risk.


All-solid-state battery


Recycling process

[2] Construction of the hydrogen supply chain
Upper limit 370 billion yen

Support the construction of large-scale supply chains including **overseas transfer, the development of technologies of hydrogen manufacturing by water electrolysis devices**, etc.

Aim to **realize a hydrogen society**, to both **create demand** and **reduce the supply cost** together.

Marine transport (liquid hydrogen carrier)

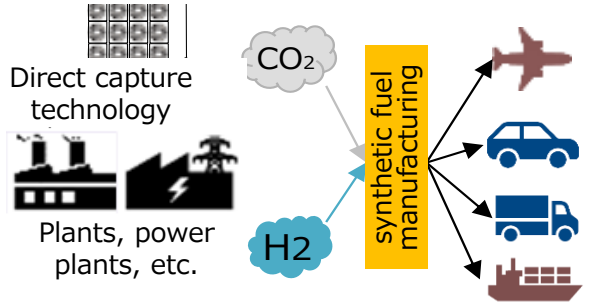
Hydrogen manufacturing (electrolysis device)

[3] Synthetic fuel
Upper limit 57.6 billion yen

Support the development of processes to **convert CO2 and hydrogen to synthetic fuel efficiently at scale**.

Aim to **improve the manufacturing yield and utilization technologies of synthetic fuel**.

Conceptual image of manufacturing and supplying synthetic fuel



* Synthetic fuel: Fuel manufactured by synthesizing CO_2 and hydrogen.

2. Overview of Automobile Industry | Activities for Construction of Electrified Society

[1] Acceleration of the introduction of electrified vehicles

Support purchases to make electrified vehicles account for 100% by 2035 (Up to 850,000 yen)

*electrified vehicles: Electric vehicles, fuel cell vehicles, plug-in hybrid vehicles, and hybrid vehicles

(Source) Website of Nissan

[2] Arrangement of charging and filling infrastructures

Increase charging infrastructures 5 times by 2030 (30,000 → 150,000)

Support the introduction of equipment at scale

(Source) Website of the Next Generation Vehicle Promotion Center

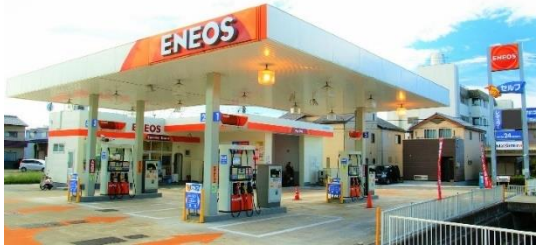
[3] Development of the storage battery industry

Secure the position as a global leader through the storage battery strategy (technology development, securing of the manufacturing infrastructures, human resource development, etc.)

(Source) Website of PPES

[4] Support for structural conversion of suppliers, etc.

<u>Support business category conversion</u> for smooth electrification, **<u>including parts suppliers, automobile dealers and maintenance business operators, and gas stations</u>**



(Source) ENEOS website

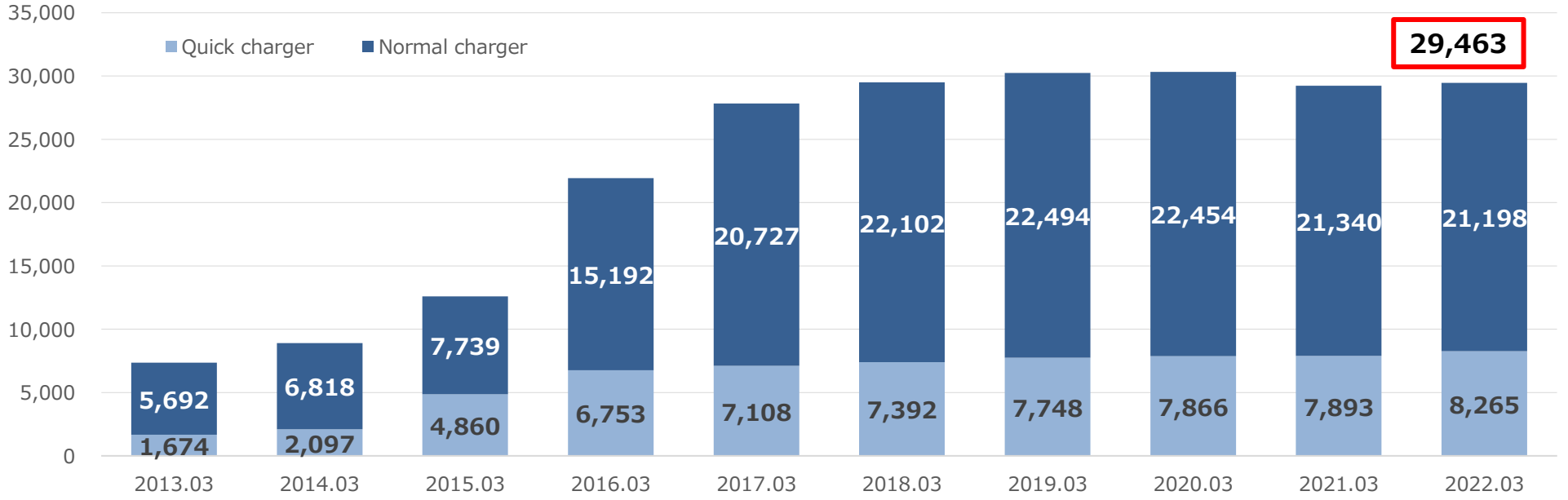
Engine parts

EV and motor parts

2. Overview of Automobile Industry | Current Situation of Charging Infrastructure

- **So far, about 30,000 public chargers have been arranged nationwide.**
- It is necessary to **popularise EV/PHV and arrange charging infrastructures as the two pillars of vehicles in a good balance.**

Transition of the number of chargers installed in Japan



Survey by ZENRIN CO., LTD.

Cumulative sales volume and number of public chargers of EV/PHV in each country (Result of 2021)

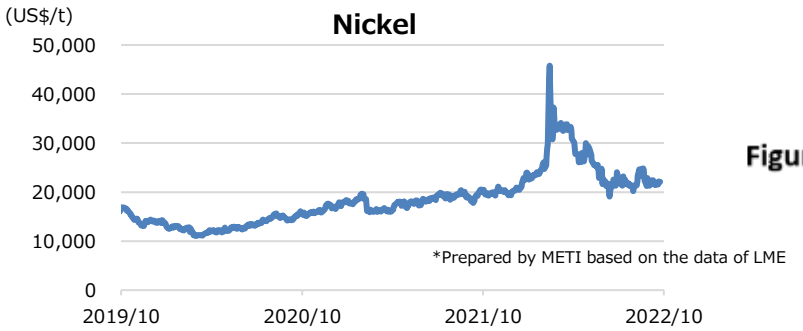
	Japan	China	U.S.	Germany	UK	France	Netherlands	Sweden	Norway
Cumulative sales volume of EV/PHV	334,000	7,843,000	2,064,000	1,315,000	746,000	725,000	385,000	300,000	637,000
Number of public chargers	29,000	1,147,000	114,000	51,000	37,000	54,000	85,000	14,000	19,000
Number of public chargers per EV/PHV	0.09	0.15	0.06	0.04	0.05	0.07	0.22	0.05	0.03

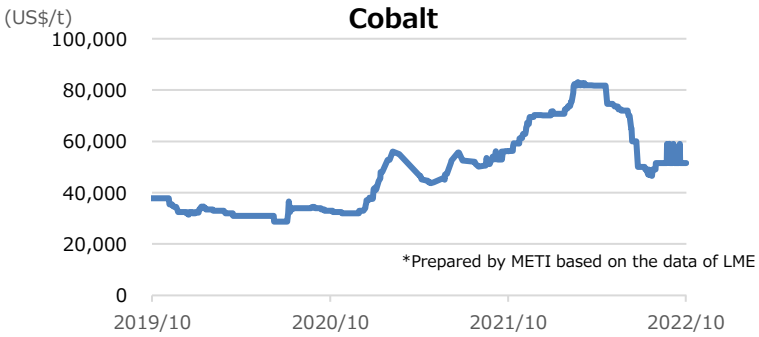
Source: IEA Global EV Outlook 2022

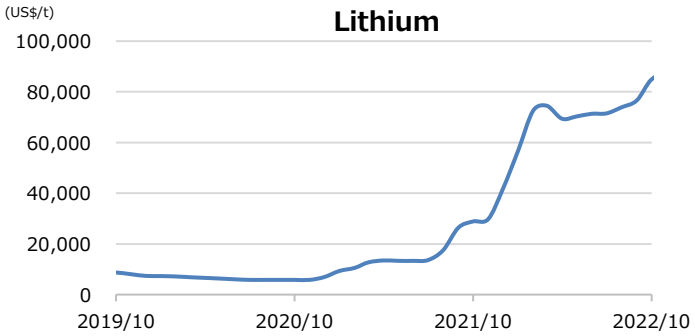
2. Overview of Automobile Industry | Resource Prices and Storage Battery Price

- With **changes in resource prices including lithium**, **the storage battery price rose in 2022 for the first time** since 2010.

○ **Price trend of the battery metal in the past three years**



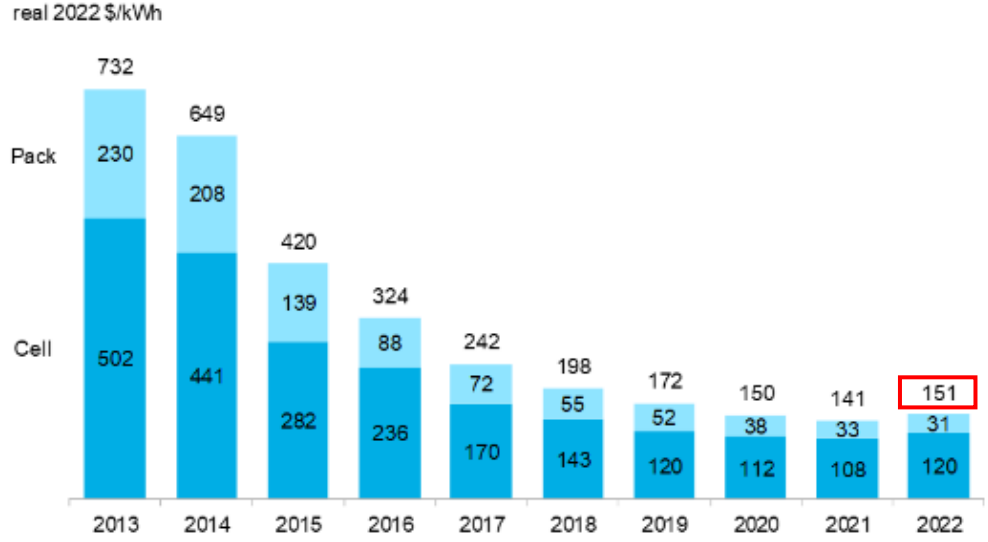




*Prepared based on the TRADING ECONOMICS data of the Chinese market price of lithium carbonate by METI

○ **Transition of the weighted mean price of storage batteries**

Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2022

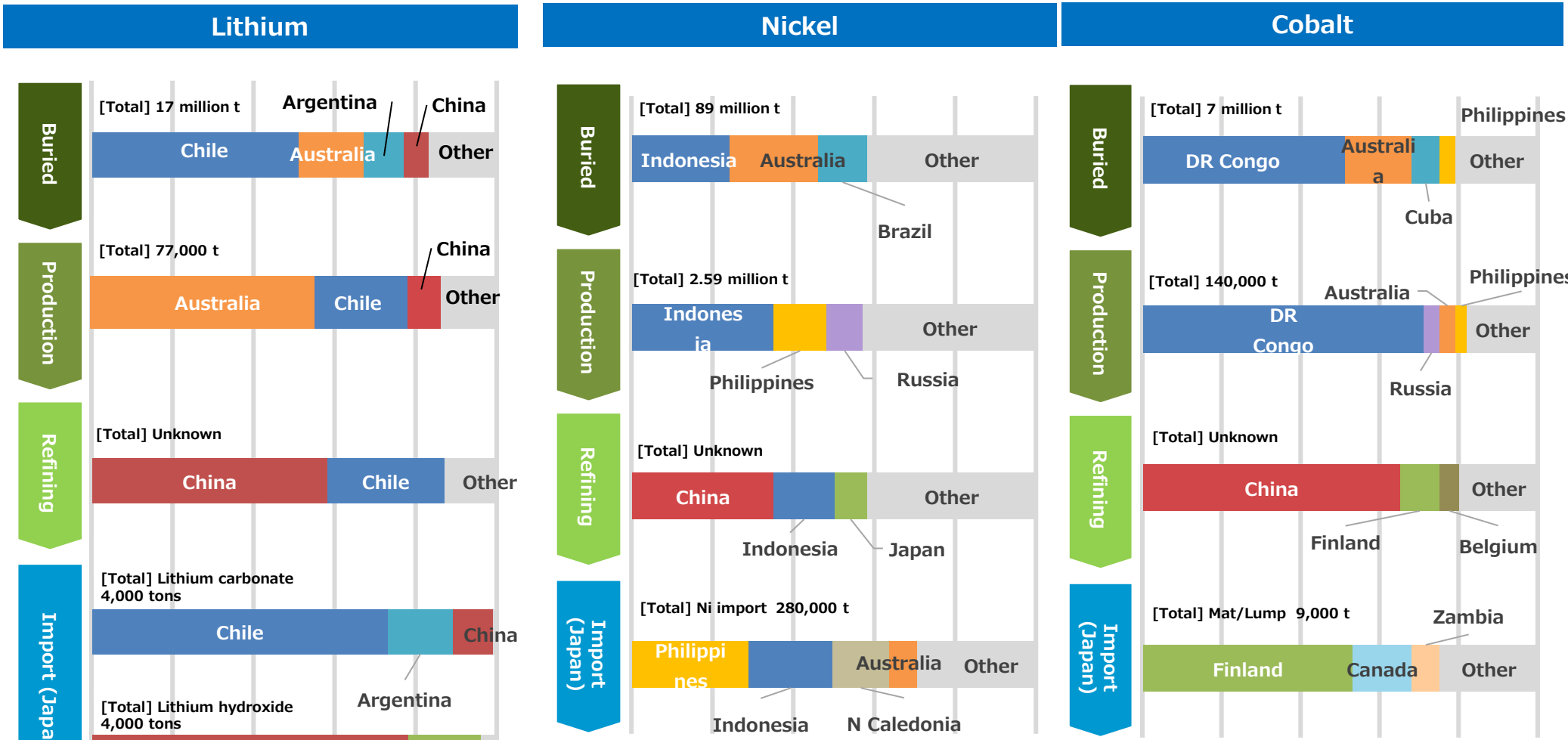


Source: BloombergNEF. All values in real 2022 dollars. Weighted average survey value includes 178 data points from passenger cars, buses, commercial vehicles and stationary storage.

Source: BloombergNEF
https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/

2. Overview of Automobile Industry | Supply Chain of Battery Metal

- The origin of most of the raw materials of storage batteries **is concentrated in specific countries (Australia, South America, Democratic Republic of Congo, Indonesia, etc.) in terms of both reserve and production volume**. In addition, **midstream refining processes are concentrated in China, in which the manufacturing cost is low**.
- **It is important to protect the upstream interests** while **supporting the midstream interests.**



Source: USGS 2020, IEA, Trade Statistics

2. Overview of Automobile Industry | Use of Hydrogen in Transport Sector

Excerpted from the material of the first mobility hydrogen public and private council

- Driving of not only passenger vehicles but also **storage battery trucks will start in 2022 using the GI fund**. **Proceed with optimal allocation and enlargement of hydrogen stations considering human traffic and logistics** with a view to popularising FC commercial vehicles.
- Some companies started activities to meet the local hydrogen demand of things other than vehicles through pipelines, etc. from hydrogen ST. From now on, **hydrogen stations may be used for diverse purposes as supply bases for local hydrogen demand**.
- Hydrogen and ammonia (fuel cell and engine) are also expected to be used for ships, planes, etc. in the future.

Arrangement of the FCV/hydrogen ST

7,418 vehicles in operation

178 locations (including those under maintenance)

Prevalence of FC commercial vehicles/multi-purpose use of hydrogen ST

Prevalence of FC commercial vehicles (green growth strategy)

✓ Small commercial vehicles of 8 tons or less
- ◆ Electrified vehicles account for 20 to 30% of the sales of new vehicles by 2030
- ◆ Electrified vehicles, synthetic fuel vehicles, etc. together account for 100% of the sales of new vehicles by 2040

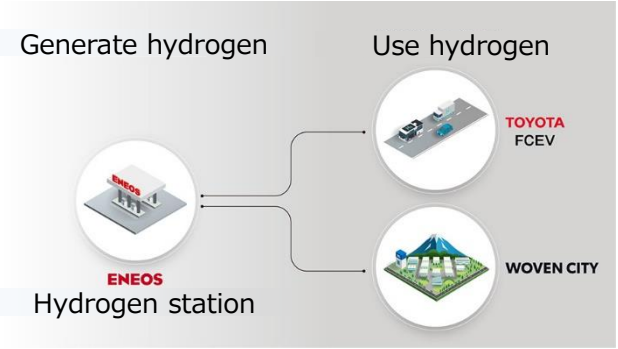
✓ Large commercial vehicles over 8 tons
- ◆ Advanced introduction of 5,000 vehicles in 2020s
- ◆ Setting of the goal for the prevalence of electrified vehicles in 2040 by 2030

FC small truck (image)

FC large truck (image)

Multi-purpose use of hydrogen ST

✓ Example of hydrogen ST near Woven City (right figure)
- ◆ Supply hydrogen from hydrogen ST to passenger and commercial vehicles, etc. as well as **to Woven City through pipelines**
- ◆ Install FC generators for outage within hydrogen stations



Ships, etc.

Small/Short distance
→ **Fuel cell ship**

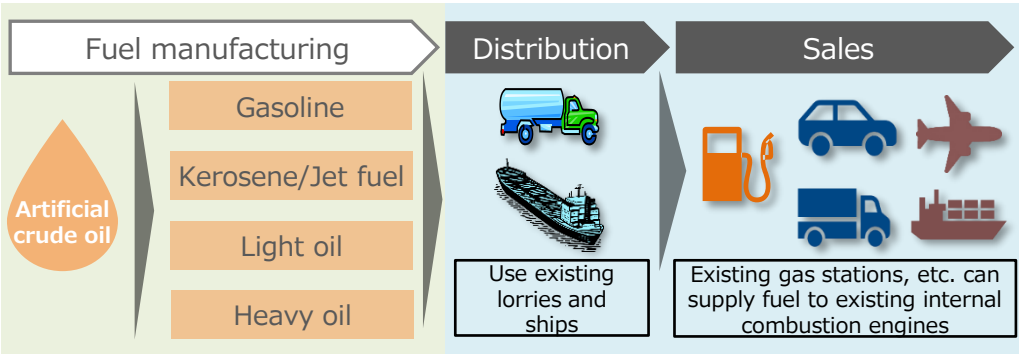
Large/Long distance
→ **Hydrogen gas fuel ship**

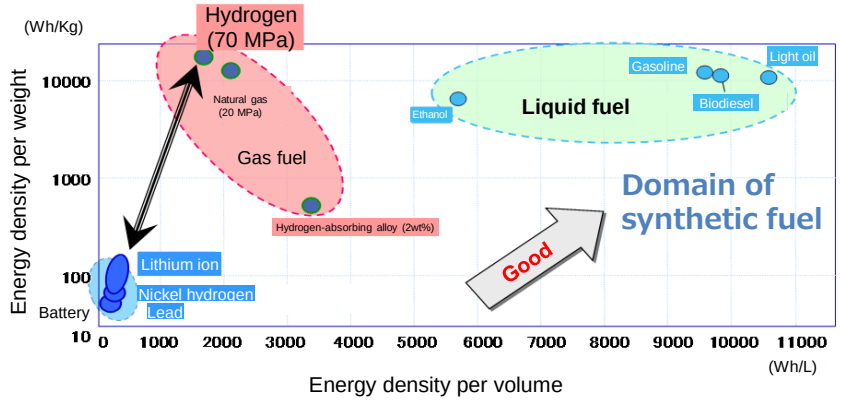
(Source) Asahi Holdings, Inc., Seino Transportation Co., Ltd., NEXT Logistics Japan, Ltd., Yamato Transport Co., Ltd., Hino Motors, Ltd., etc.

2. Overview of Automobile Industry | Synthetic fuel

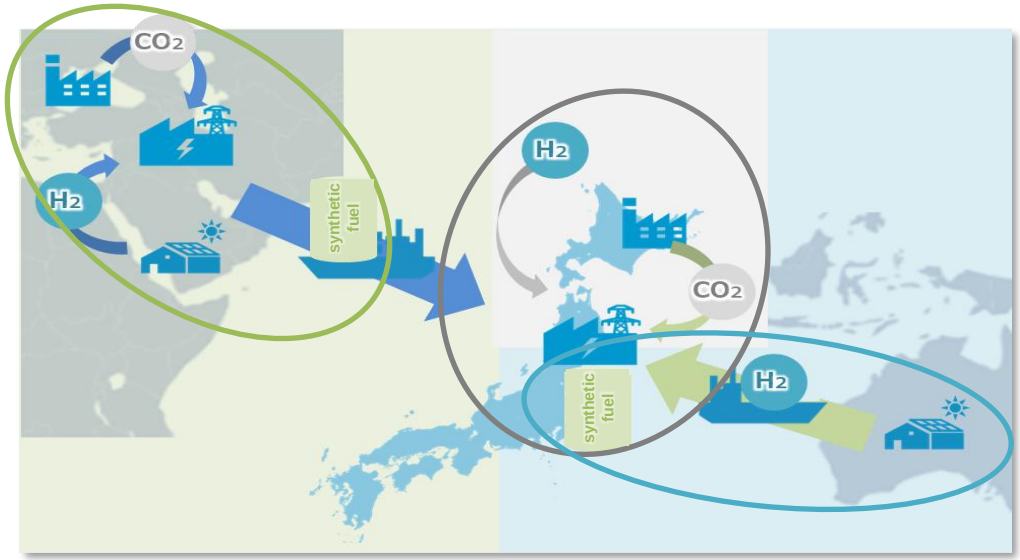
- Synthetic fuel is **artificial crude oil manufactured by synthesizing CO2 and hydrogen**.
- The advantages include [1] **is applicable to the existing fuel infrastructures, mobility, etc.** and [2] **has an energy density as high as that of fossil fuel**.
- Moreover, manufacturing by **FT synthesis** makes it possible to **use the refining capacity of domestic refineries**.
- On the other hand, the issue is the **manufacturing cost**. Though it depends heavily on the hydrogen price, it is as high as **about 300 to 700 yen/L** in the current estimate.
- The urgent task is to **reduce the manufacturing cost by improving efficiency and enlarging the scale of manufacturing processes** and **expand introduction** to a commercial scale.

Advantages





Issues



When the whole manufacturing process is completed overseas and the product is imported

Manufacturing cost : About 300 yen/L

When the whole process from procurement of raw materials to manufacturing is completed in Japan

Manufacturing cost : About 700 yen/L

When hydrogen is imported and the manufacturing process is completed in Japan

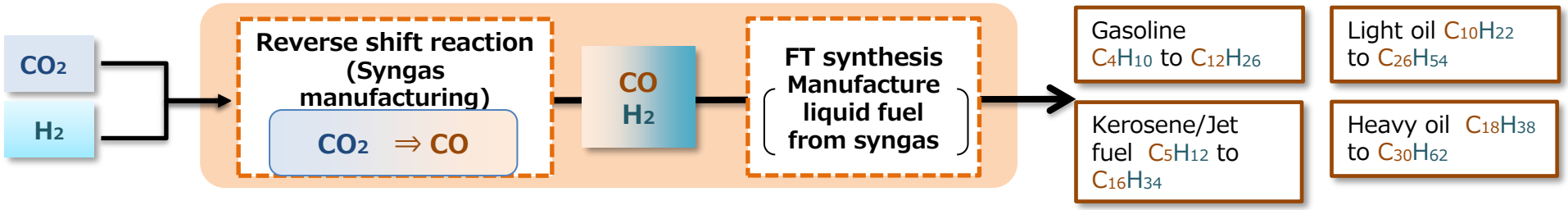
Manufacturing cost : About 350 yen/L

2. Overview of Automobile Industry | Activities for Early Practical Realization And Commercialization of Synthetic fuel

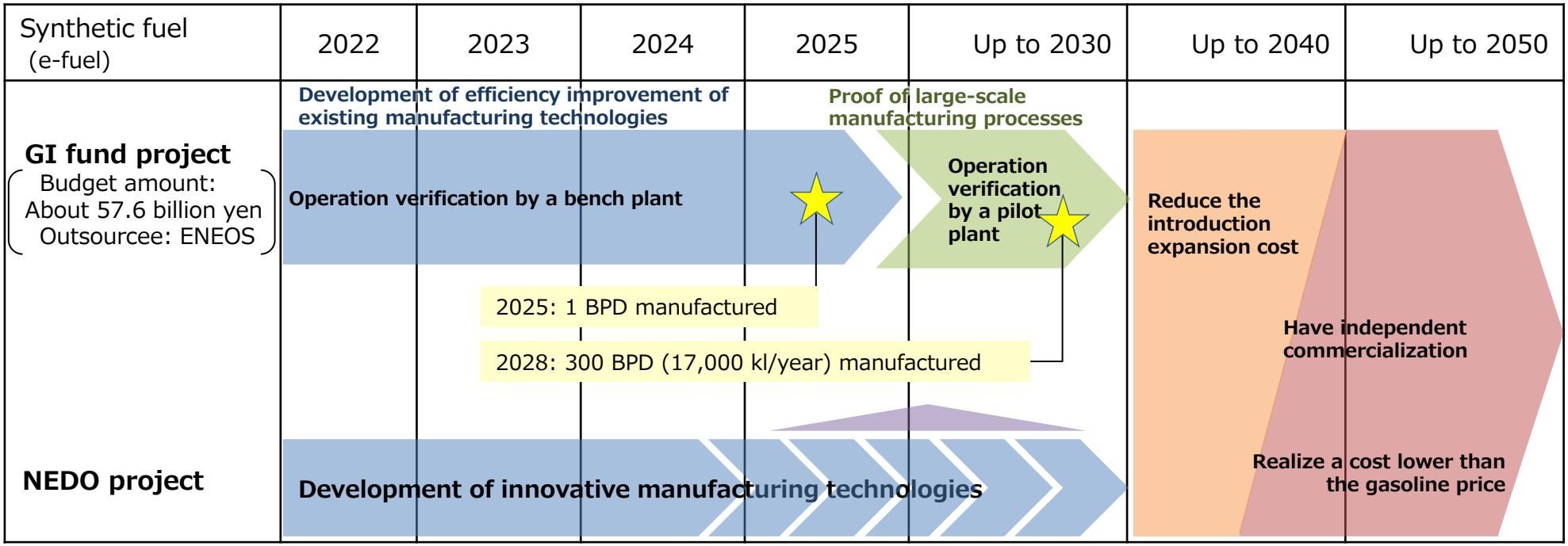
- Support **the development of large-scale and high-efficiency manufacturing processes** with the GI fund, etc. We aim to prove large-scale manufacturing processes by 2030.

Excerpted from the material of the first public and private council toward the promotion of the introduction of synthetic fuel (e-fuel))

Contents of research and development in the GI fund project



Promotion goal of synthetic fuel



(Source: Partially modified from the green growth strategy)

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3. Technology Pathways to Decarbonization | [1] Low-carbon/Decarbonization Technologies “Product Manufacturing”

Product manufacturing

Decarbonization of products

Decarbonization of manufacturing processes

Technology name	Overview	Emission factor*1	Year of implementation*2	Main references*3
Development of storage batteries, motors, etc.	✓ Development of high-performance storage batteries ✓ Development of high-performance and resource-saving materials ✓ Development of small and high-efficient motor systems	Up to 100% reduction	Partial introduction	• Green growth strategy • GI fund - Social implementation plan*4
Secondary utilization and recycling of batteries	✓ Promotion of reuse and recycling of storage batteries	Up to 100% reduction	2030s	• GI fund - Social implementation plan
Reinforcement of energy-saving measures	✓ Effective use of heat, introduction of advanced control and high-efficiency equipment, improvement in the efficiency of the power system, decarbonization of the painting process, great improvement and advancement of the process, etc.	-	Introduced	• Strategic Energy Plan • CN action plan
Promotion of fuel conversion	✓ Conversion from petroleum fuel to natural gas, etc.	-	Introduced	• Strategic Energy Plan
Conversion to decarbonized fuel	✓ Conversion from fossil fuel to decarbonized fuel such as CO_2-free hydrogen	Up to 100% reduction	2030s	• Strategic Energy Plan • GI fund - Social implementation plan
Promotion of utilization and development of renewable energy and zero-emission power sources	✓ Greening of electricity in manufacturing processes, etc.	Up to 100% reduction	Introduced	• Strategic Energy Plan • Green growth strategy
CCS/CCU/DAC	✓ Collection of CO_2 generated in a plant ✓ Produce fuel, material (carbonate), etc. from collected CO_2 ✓ CCS introduction	Up to 100% reduction	2030s	• Strategic Energy Plan • Green growth strategy • GI fund - Social implementation plan

*1: Emission factors are calculated based on the emission factors of existing technologies and the reduction range of the target technologies. The emission reduction range is the range of reduction in the relevant process.
*2: Regarding the Social Implementation Plan, see the start year of the introduction expansion and cost reduction phase.
*3: Underline the references of the years of implementation.
*4: Research and development and social implementation plans in the green innovation fund.

3. Technology Pathways to Decarbonization |
[1] Low-carbon/Decarbonization Technologies “Manufacturing/Supply of Energy Sources”

Energy source manufacturing supply

Arrangement of charging and filling infrastructures

Manufacturing and supply of carbon neutral fuel

Technology name	Overview	Emission factor*1	Year of implementation*2	Main references*3
Arrangement of charging infrastructures	✓ Arrange the necessary charging infrastructure network for electrified vehicles, etc.	-	Introduced (150,000 public chargers in 2030)	• Strategic Energy Plan • Green growth strategy
Arrangement of hydrogen stations	✓ Hydrogen fill-up necessary for fuel battery vehicles, etc. Arrange the infrastructure network	-	Introduced (1,000 stations in 2030)	• Strategic Energy Plan • Green growth strategy
Hydrogen	✓ Efficiency improvement of manufacturing and transport technologies ✓ Dehydrogenation and storage using refinery equipment ✓ Domestic supply and in-house use (for power generation, automobile fuel, raw materials, etc.)	Up to 100% reduction	Partially introduced	• GI fund - Social implementation plan*4 • Green growth strategy • Strategic Energy Plan
Biofuels (Bioethanol, biodiesel, etc.)	✓ Manufacture liquid fuel, etc. from plants, wastes, etc.	Up to 100% reduction	Partially introduced	• GI fund - Social implementation plan*4 • Green growth strategy • Commitment to a Low Carbon Society • Strategic Energy Plan • IEA-ETP2020
Synthetic fuels	✓ Manufacture liquid fuel from hydrogen and CO_2	Up to 100% reduction	2040s	• GI fund - Social implementation plan • Green growth strategy • Strategic Energy Plan • IEA-ETP2020

*1: Emission factors are calculated based on the emission factors of existing technologies and the reduction range of the target technologies. The emission reduction range is the range of reduction in the relevant process.
*2: Regarding the Social Implementation Plan, see the start year of the introduction expansion and cost reduction phase.
*3: Underline the references of the years of implementation.
*4: Research and development and social implementation plans in the green innovation fund.

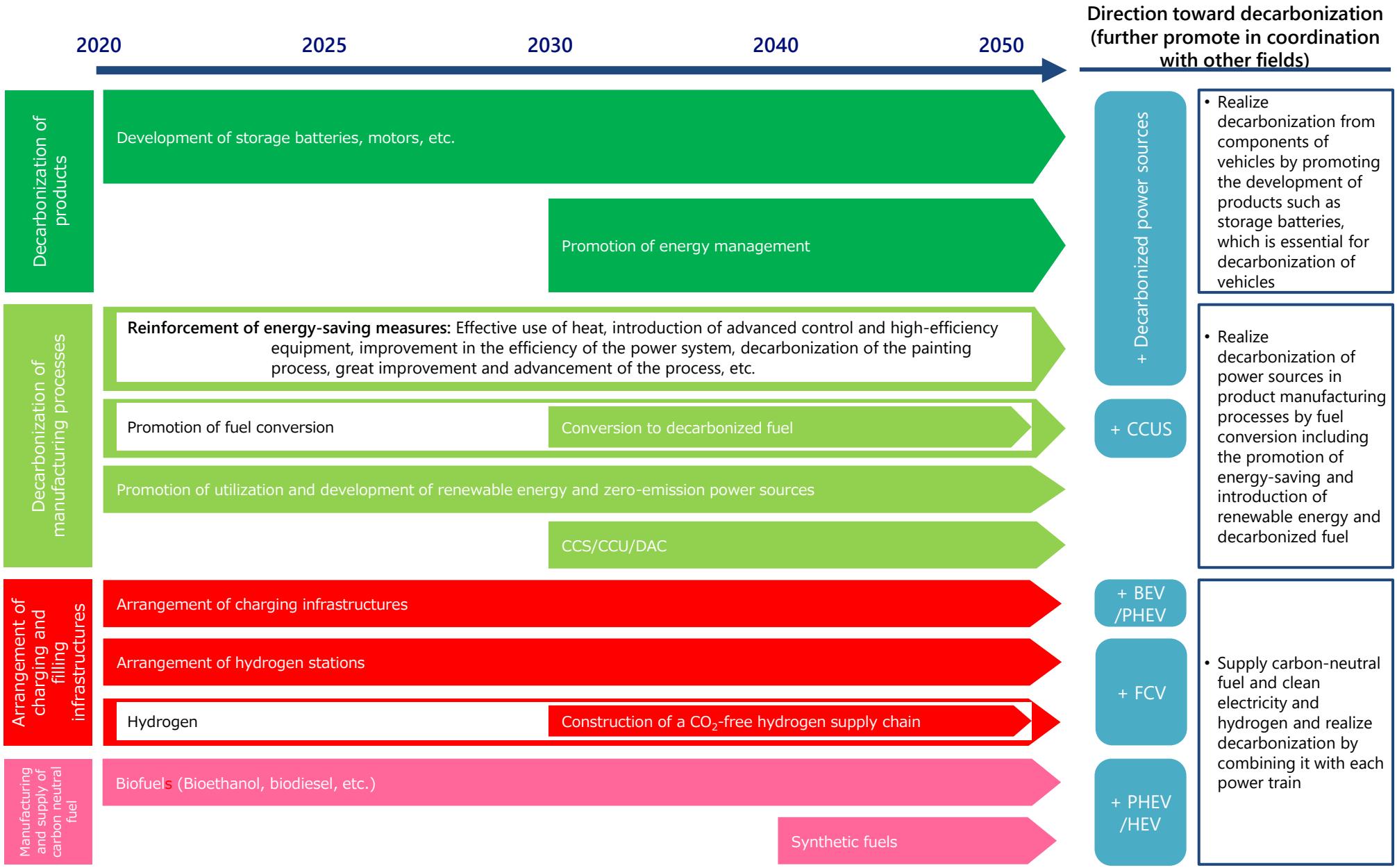
3. Technology Pathways to Decarbonization | [1] Low-carbon/Decarbonization Technologies “Use”

Use

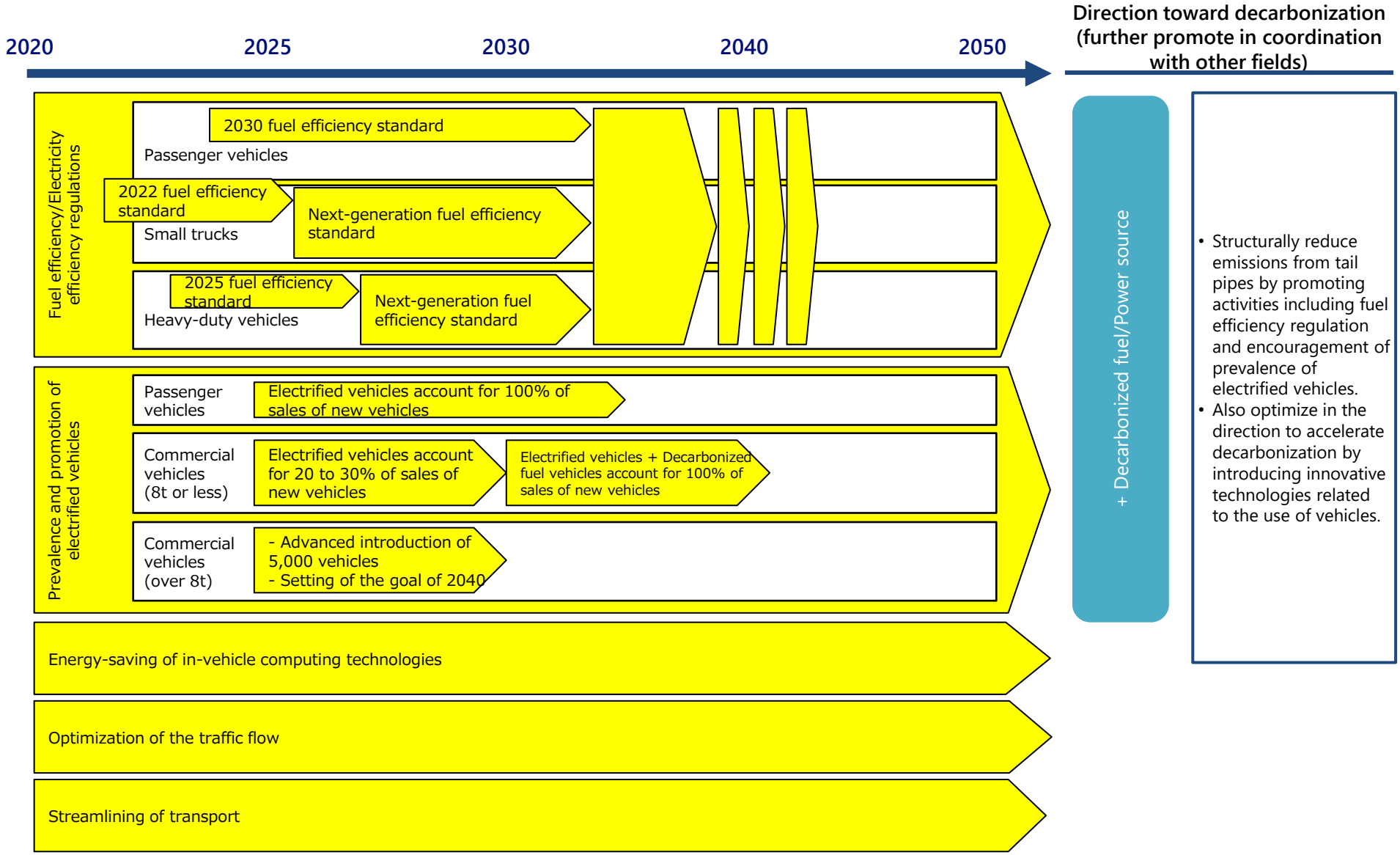
Technology name	Overview	Emission factor*1	Year of implementation*2	Main references*3
Fuel efficiency/Electricity efficiency regulations *BEV and PHEV will also be **subject to the standard of 2030**.	✓ Intensification of enforcement toward compliance with the fuel efficiency standard ✓ Technology-neutral fuel efficiency regulation	-	Introduced	• Green growth strategy • Strategic Energy Plan • CN action plan
Prevalence and promotion of electrified vehicles	[Passenger vehicles] ✓ electrified vehicles account for 100% of sales of new passenger vehicles in 2035 [Commercial vehicles] ✓ As for small vehicles of 8t or smaller, make electrified vehicles account for 20 to 30% in sales of new vehicles by 2030 and 100% in combination with vehicles which use decarbonized fuel by 2040 ✓ As for large vehicles over 8t, have advanced introduction of 5,000 vehicles in 2020s and set the goal of electrified vehicles being prevalent in 2040 by 2030	-	Partially introduced (timeline is as shown on the left)	• Next-generation vehicle strategy 2010 • Green growth strategy • Strategic Energy Plan
Energy-saving of in-vehicle computing technologies	✓ Performance improvement and energy-saving of in-vehicle computing (self-driving software, sensing technology, etc.), digital development infrastructures, etc.	-	Partially introduced	• Green growth strategy • GI fund - Social implementation plan*4
Optimization of the traffic flow	✓ Optimization of vehicles alone and the whole traffic flow through social implementation of AD/ADAS, narrowband communications function, etc.	-	Partially introduced	• Green growth strategy
Streamlining of transport	✓ Streamlining of modal shift and truck transport through coordination among related parties including shipper companies and logistics operators, etc. ✓ Realization of level 4 self-driving trucks on expressways ✓ Improvement in the loading rate by coordination of truck data and optimization of driving management and energy management	-	Partially introduced	• Green growth strategy • GI fund - Social implementation plan*4

*1: Emission factors are calculated based on the emission factors of existing technologies and the reduction range of the target technologies. The emission reduction range is the range of reduction in the relevant process.
*2: Regarding the Social Implementation Plan, see the start year of the introduction expansion and cost reduction phase.
*3: Underline the references of the years of implementation.
*4: Research and development and social implementation plans in the green innovation fund.

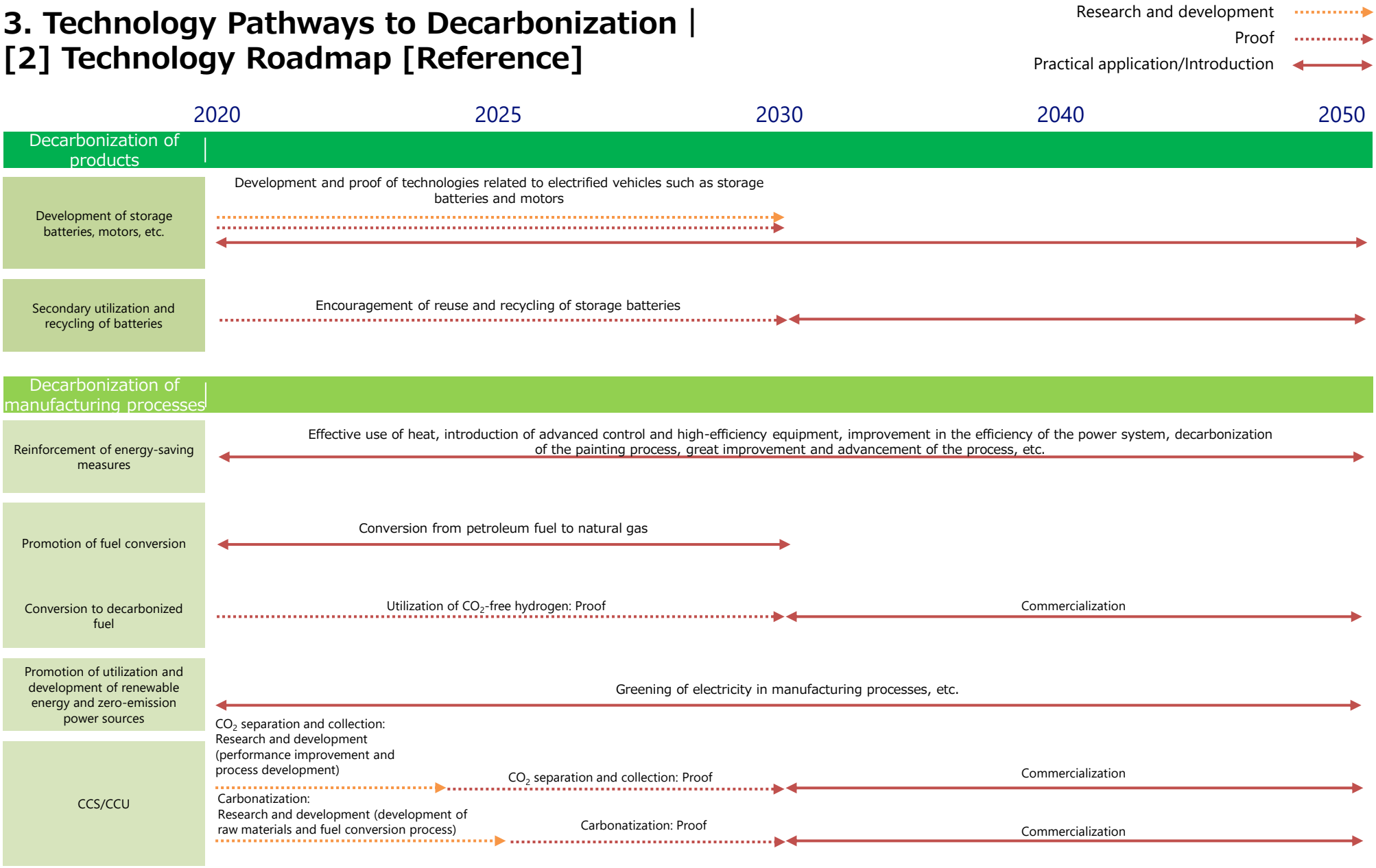
3. Technology Pathways to Decarbonization |
[2] Technology Roadmap “Product Manufacturing” “Energy Source Manufacturing And Supply”



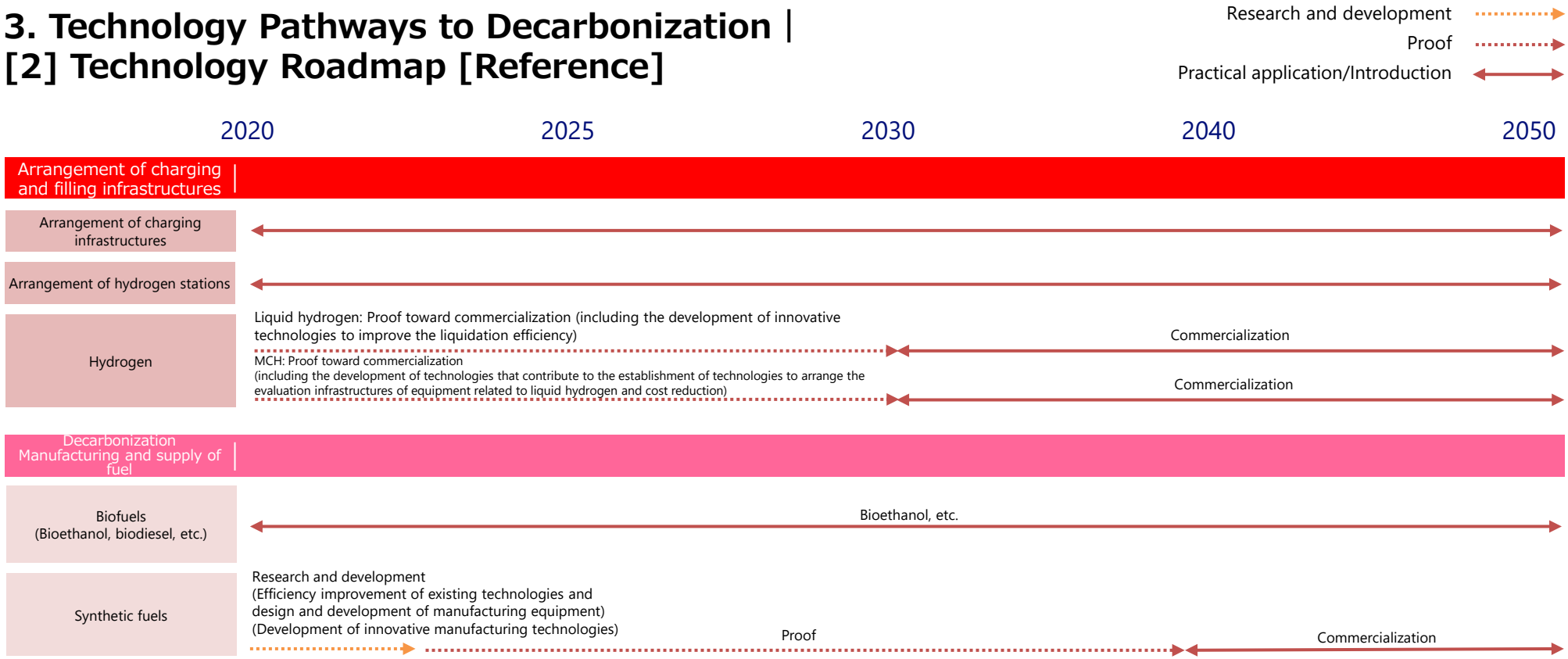
3. Technology Pathways to Decarbonization | [2] Technology Roadmap “Use”



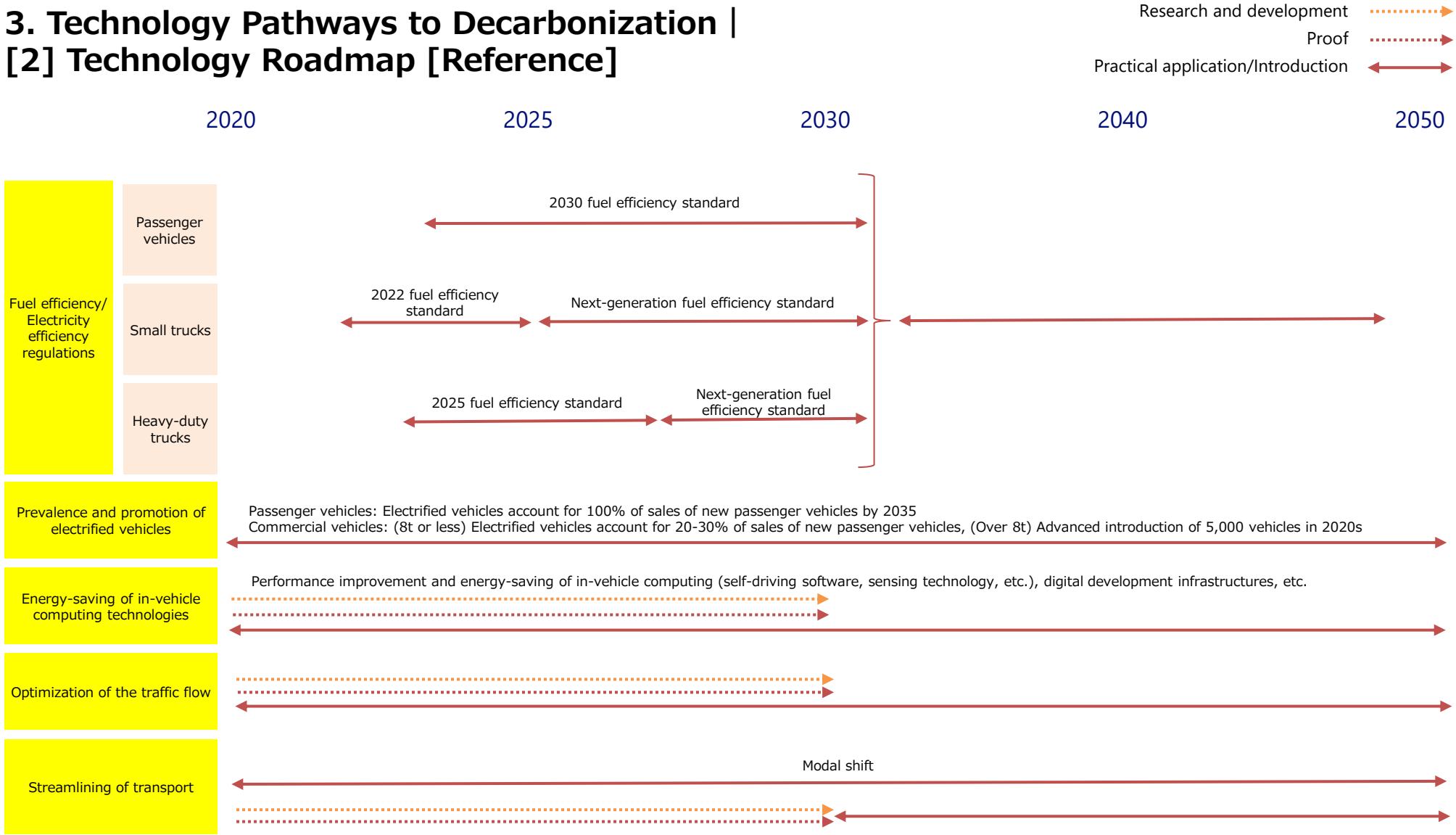
3. Technology Pathways to Decarbonization | [2] Technology Roadmap [Reference]



3. Technology Pathways to Decarbonization | [2] Technology Roadmap [Reference]



3. Technology Pathways to Decarbonization | [2] Technology Roadmap [Reference]



3. Technology Pathways to Decarbonization | [3] Scientific Basis/Alignment with the Paris Agreement

- The Technology Roadmap is based on Japan's various policies and international scenarios aimed at achieving carbon neutrality by 2050, and is aligned with the Paris Agreement.
- Carbon neutrality will be achieved by 2050 through various energy-saving and efficiency improvements, and fuel switching in manufacturing as well as increased introduction of electrified vehicles and decarbonized fuel.
  - ➢ In designing this technology roadmap, we referred to the composition of powertrains and fuels in one of the scenarios (CNF scenario) in "Transitioning to Carbon Neutrality by 2050: A Scenario-Based Analysis" of JAMA.
    https://www.jama.or.jp/operation/ecology/carbon_neutral_scenario/PDF/Transitioning_to_CN_by_2050A_Scenario_Based_Analysis_EN.pdf

Main references/evidence

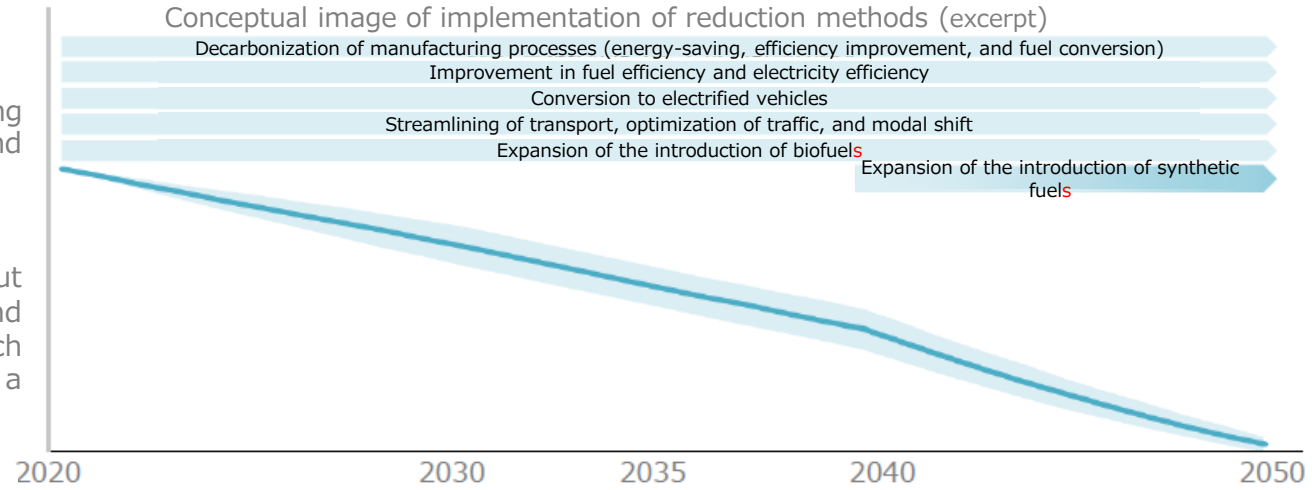
Main references/evidence

- ✓ Green Growth Strategy Through Achieving Carbon Neutrality in 2050 (Automobile and battery industry)
- ✓ Strategic Energy Plan
- ✓ Global Warming Prevention Plan
- ✓ R&D and Social Implementation Plan about "Development of In-vehicle Computing and Simulation Technology for Energy Saving such as Electric Vehicles." and " Establishment of a Smart Mobility Society" project

International scenarios, roadmaps, etc. aligned with Paris Agreement

- ✓ IPCC AR6 WGIII
- ✓ Clean Energy Technology Guide (IEA)
- ✓ Energy Technology Perspective 2020 (IEA)
- ✓ Net Zero by 2050 (IEA)
- ✓ Science Based Target initiative
- ✓ Transitioning to Carbon Neutrality by 2050: A Scenario-Based Analysis (JAMA)

Assumed CO_2 Reduction Pathway*1, 2, 3



Main reduction methods	Overview
(1) Improvement in fuel efficiency and electricity efficiency	• Reduce consumption of fuel, electricity, etc. as a whole by continuously improving fuel efficiency and electricity efficiency and introducing vehicles with high energy efficiency such as HEV and PHEV.
(2) Introduction of electrification and decarbonized fuel	• Reduce the emissions from driving by proceeding with the introduction of BEV and FCV as well as expanding the use of synthetic fuel to HEV and PHEV.
(3) Decarbonization of manufacturing processes	• Reduce emissions from automobile manufacturing by expanding the use of renewable energy, converting to low-carbon and decarbonized fuel, etc.

*1 This shows a conceptual image of reduction as target sectors of the Roadmap in the Japanese automobile industry. Actually, each company will aim to realize decarbonization under their own long-term strategies, so they are not required to meet the pathway image shown above.
*2 The pathways shown above show emissions for the sources listed on p. 11 (product manufacturing, energy source manufacturing and supply, and vehicle use), and do not include emissions related to manufacturing, transport, etc. of hydrogen and synthetic fuels.
*3 It assumes, for example, the advancement of energy-saving technologies, stable and inexpensive supply of new fuel including hydrogen and ammonia, and the construction of new social systems such as CCUS, its related infrastructures, and circular economy including DAC in coordination with other industries, etc.

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4. Toward Decarbonization and Achievement of the Paris Agreement

- The Technology Roadmap is intended to exemplify low-carbon and decarbonization technologies envisioned today and indicate an estimate of when these technologies are to be established for commercialization.
- Technology development in the automobile sector is assumed to require long-term development, and it is possible that other low-carbon and decarbonization technologies that are not described in the Technology Roadmap will be developed and adopted. In addition, there are some uncertainties, including economic feasibilities.
- Commercialization of low-carbon and decarbonization technologies in the automobile sector will also depend on the development of societal systems including linkages with other sectors, such as decarbonized power sources and CCUS. Therefore, efforts to achieve carbon neutrality will be made in cooperation with other sectors.
- Therefore, the Technology Roadmap will be revised and updated regularly and continuously to maintain the credibility and usability of the Technology Roadmap by considering the progress of other technologies, the trends of businesses and policies, and dialogue with investors.
- Automobile manufacturers will aim to achieve carbon neutrality by making the best combination of technologies listed in the Technology Roadmap according to their business decisions based on a long-term strategy.
- In addition, efforts for reducing CO_2 emissions may include the utilization of carbon credits and the purchase of carbon offset products, not limited to the *technology* of this technology roadmap.

Taskforce Formulating Roadmaps for Climate Transition Finance Automobile Sector: List of Committee Members

Committee chair	
Akimoto Keigo	Research Institute of Innovative Technology for the Earth (RITE) Group Leader of Systems Analysis Group and Chief Researcher
Committee members	
Oshida Shunsuke	Managing Director, Head of Credit Research, Japan, Manulife Investment Management (Japan) Limited
Kajiwara Atsuko	Executive Officer, Head of Sustainable Finance Evaluation Department, Japan Credit Rating Agency, Ltd.
Sekine Yasushi	Professor, Faculty of Science and Technology, School of Advanced Science and Engineering, Waseda University
Takamura Yukari	Professor, Institute for Future Initiatives, The University of Tokyo
Takegahara Keisuke	Executive Fellow/General Manager, Research Institute of Capital Formation and Head of Research Center on Financial Economics, Development Bank of Japan Inc.
Matsuhashi Ryuji	Professor, Electrical Engineering and Information Systems, Graduate School of Engineering, The University of Tokyo
Expert committee members	
Ohtsu Keiji	Chair, Environmental Technology & Policy Committee, Japan Automobile Manufacturers Association
Suehiro Shigeru	Senior Economist, Manager, Econometric and Statistical Analysis Group(ESA), Energy Data and Modelling Center（EDMC), The Institute of Energy Economics, Japan
Takeuchi Junko	Director, International Environment and Economy Institute Specially Appointed Professor, Tohoku University Joint Representative, U3innovations LLC