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Risks in critical mineral supply

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The Energy Transition Creates New Geopolitical Risks

- New energy trends and technological innovations are emerging as we aim to achieve an energy transition.
- However, this also alters the nature of geopolitical risks.

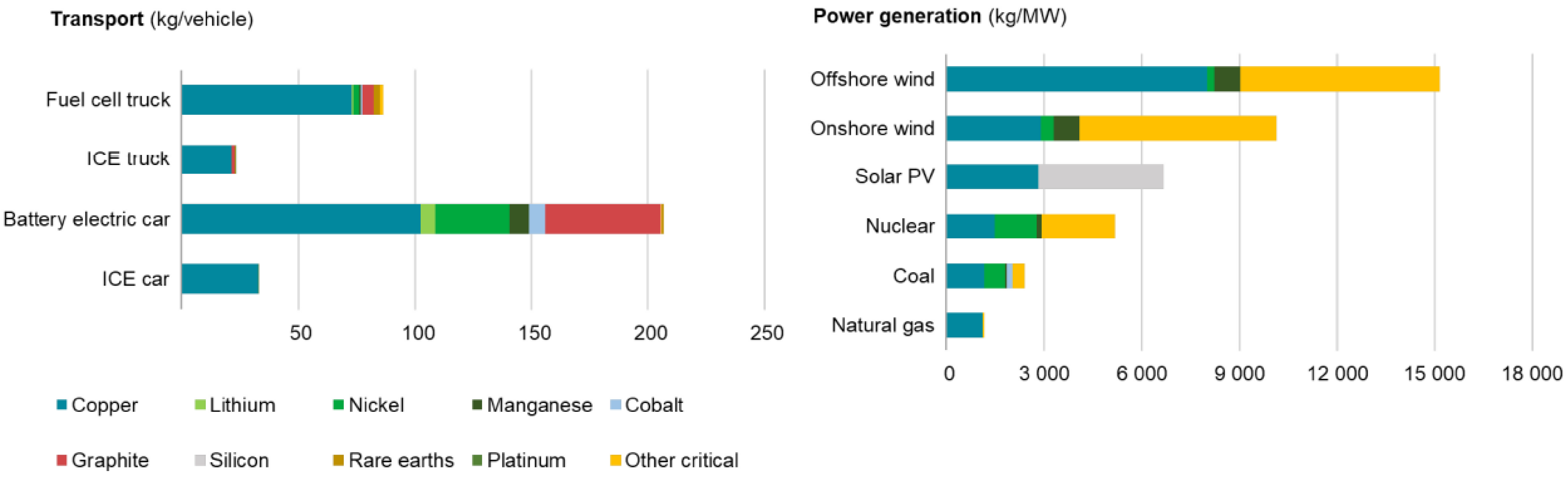
	Fossil energy	Clean energy
Energy systems	Fossil energy • Energy systems primarily based on fossil energy. • Major imports of fossil energy.	Clean energy • Primarily electricity generated from domestic energy such as renewables. • Reduction in fossil energy imports.
Core technologies	Combustion technologies (Boilers, turbines, engines, etc.) • Japan has high technological prowess. • Limited consumption of critical minerals.	Clean technologies (Renewables, batteries, nuclear power, etc.) • An area Japan is not necessarily ahead. • Dependence on import of critical mineral supply for manufacturing.
Origin of geopolitical risks	Fossil energy imports	Stable electricity supply Import of clean tech., critical minerals

There are also transitional risks

The Need for Critical Minerals in Clean Energy Technology

- Clean energy technologies consume greater critical minerals than conventional technologies.
- The demand for critical minerals is expected to rise rapidly as clean technology becomes used more widely.

Consumption of critical minerals for automobiles (left) and power generation (right)



Source: IEA, Energy Technology Perspective 2023

The Potential Supply Crisis in Critical Minerals

- Conflict and supply risks have occurred with regard to strategic commodities.
  - Oil: Oil producing nations in the Middle East enacted an embargo on oil exports to pro-Israel nations during the first oil crisis. This caused rising prices and pressure on the physical supply of oil, the mainstay of energy at the time, causing a major impact on the world, including Japan.
  - Natural gas: Russia has been leveraging natural gas as a weapon against Europe as part of its invasion of Ukraine, reminding the world of the importance and risks of strategic commodities.
- As critical minerals rise in importance moving forward, they may potentially be used as a political weapon due to the uneven distribution of producing countries, which can raise prices and impede the supply.
- Japan in fact already experienced a crisis in the rare earth mineral supply in 2010.
  - At the time, Japan was dependent on China for over 90% of its rare earth mineral supply.
  - China effectively ceased the export of rare earth minerals to Japan in September 2010, triggered by the Senkaku Islands problem.
  - The supply volume recovered by December 2010, but the average price thereof rose from 3,878 Yen/kg in August 2010 to a peak of 18,608 Yen/kg by October 2011.
- Currently, China has also started the export control of gallium and germanium due to tensions between the US and China (August 2023).

Uneven Distribution of Critical Minerals - 1

- Reserves of many critical minerals are distributed unevenly to specific countries.
- Meanwhile, ore production and downstream processes are also distributed unevenly among countries.
- Therefore, caution is required not only for the uneven distribution of reserves, but of downstream processes as well.

Country-wise share of reserves in selected minerals

	Cu (copper)	Co (cobalt)	Ni (nickel)	Li (lithium)	V (vanadium)	PGM (platinum group)	REO (rare earth)
United States	5%	1%	0%	3%	0%	1%	2%
Canada	1%	3%	2%	0%	0%	0%	1%
Mexico	6%	0%	0%	0%	0%	0%	0%
Brazil	0%	0%	17%	0%	1%	0%	18%
Peru	9%	0%	0%	0%	0%	0%	0%
Chile	23%	0%	0%	42%	0%	0%	0%
Argentina	0%	0%	0%	10%	0%	0%	0%
Cuba	0%	7%	0%	0%	0%	0%	0%
Australia	11%	18%	22%	26%	25%	0%	3%
Indonesia	3%	8%	22%	0%	0%	0%	0%
Philippines	0%	3%	5%	0%	0%	0%	0%
Viet Nam	0%	0%	0%	0%	0%	0%	18%
China	3%	1%	3%	7%	40%	0%	37%
Kazakhstan	2%	0%	0%	0%	0%	0%	0%
Russia	1%	3%	8%	0%	21%	6%	18%
Zimbabwe	0%	0%	0%	1%	0%	2%	0%
DR Congo	4%	46%	0%	0%	0%	0%	0%
South Africa	0%	0%	0%	0%	15%	90%	1%
Others	33%	9%	21%	11%	0%	0%	4%

Share of nickel ore and primary nickel production by country (2019)

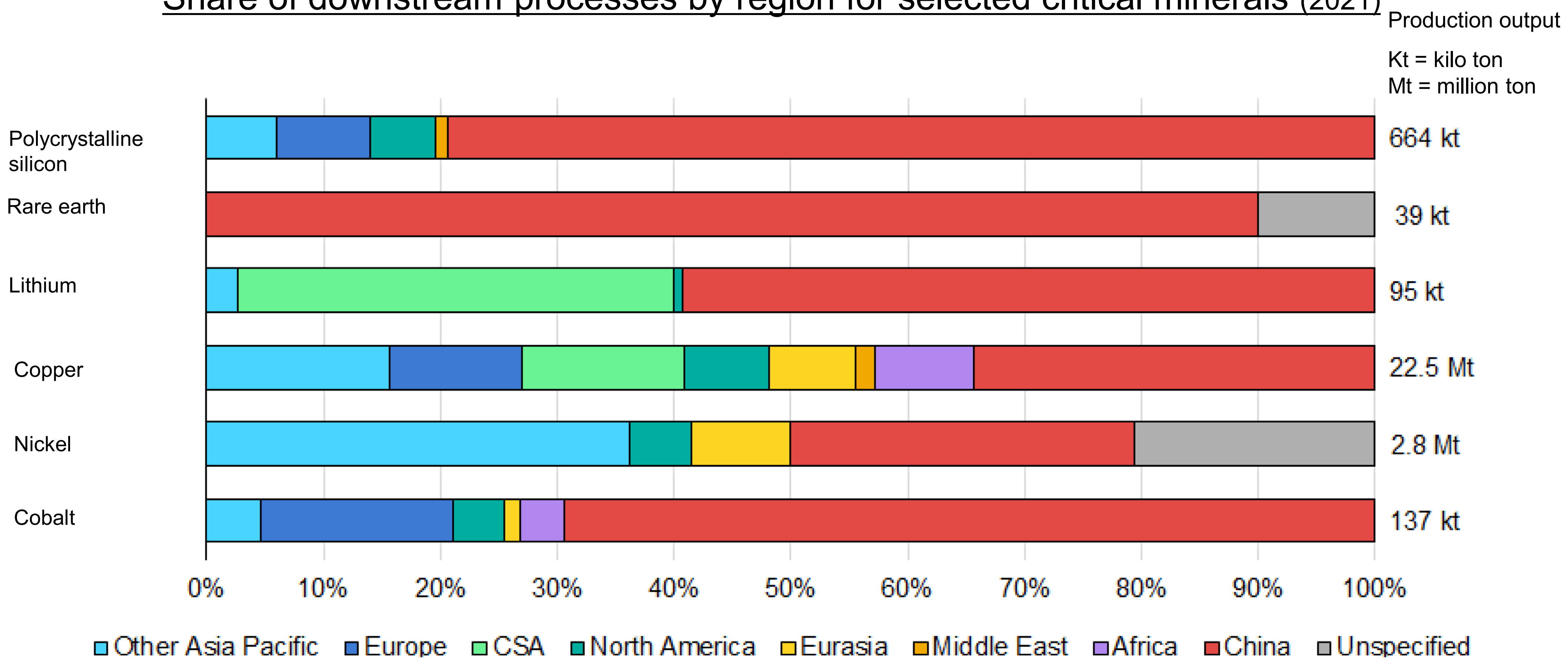
	Ore production	Primary nickel production
Americas	11%	12%
Europe	2%	17%
Japan	0%	8%
China	4%	34%
Indonesia	35%	16%
Philippines	13%	0%
Other Asia	8%	3%
Oceania	6%	8%
Russia	9%	0%
Africa	2%	3%
Others	10%	0%

Source: IEEJ Outlook 2023

Uneven Distribution of Critical Minerals - 2

- The degree to which downstream processes, such as refining, are distributed unevenly can sometimes exceed that of the original ore production.

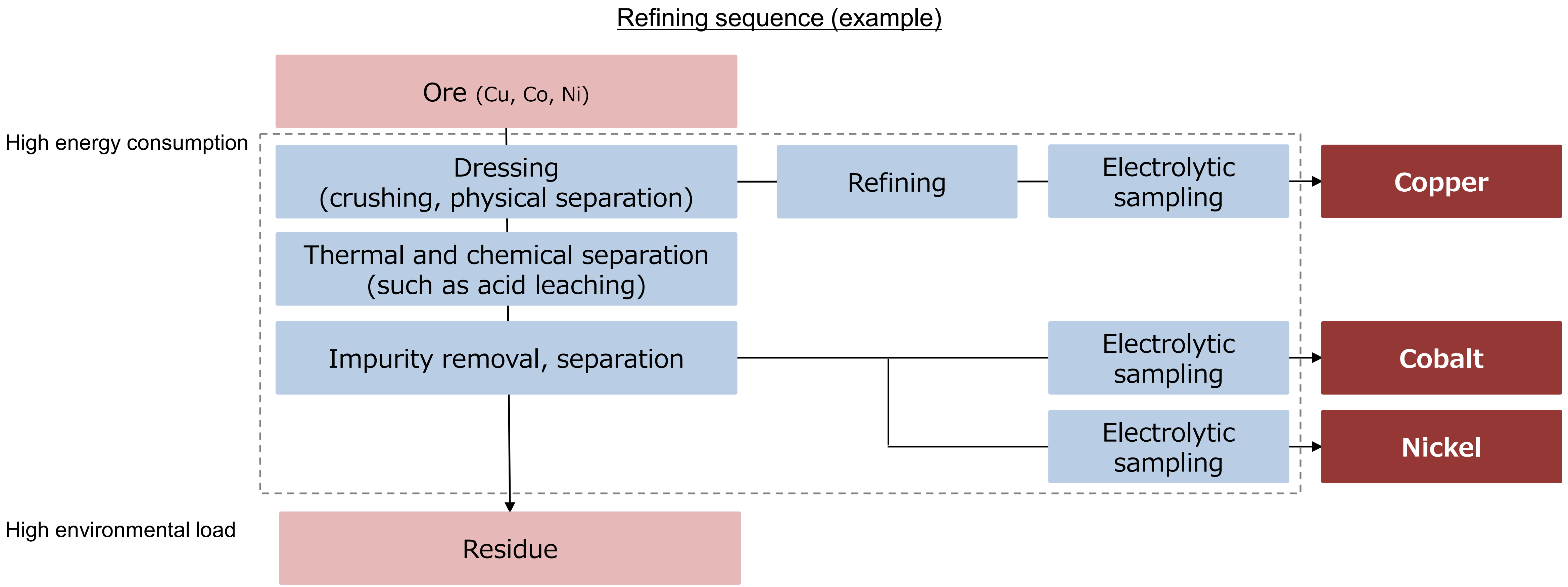
Share of downstream processes by region for selected critical minerals (2021)



Source: IEA, Energy Technology Perspective 2023

Why China?

- Lower cost and a large domestic market (large supply capacity, abundant inventory) have helped China become one of the world’s largest critical mineral exporter.



Source: compiled based on various sources

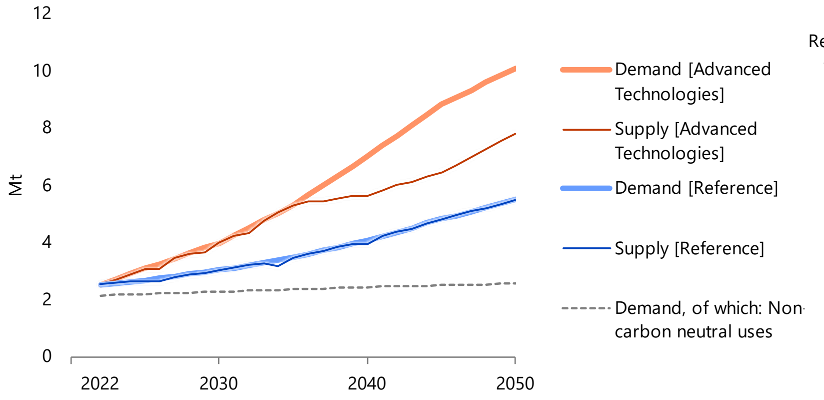
Critical Mineral supply shortage risk - 1

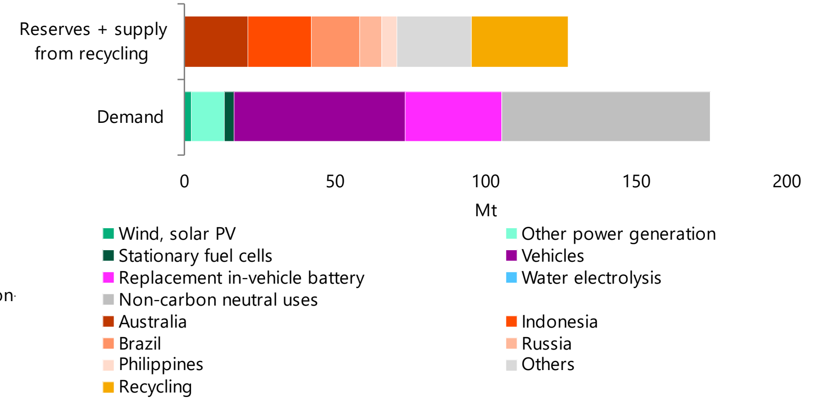
Supply-demand outlook

Comparison of cumulative demand and reserves (+ recycled supply)

Nickel (Ni) (used in lithium-ion batteries)

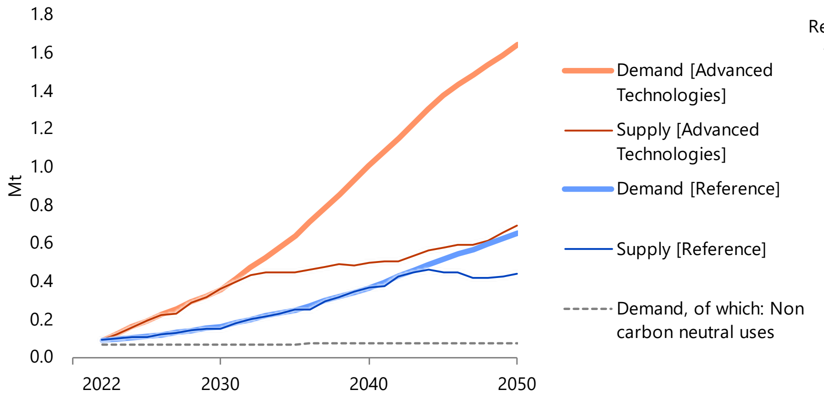
- In the Advanced Technologies Scenario (ATS) in which the electrification of the automobile advances greatly, the demand will increase more than 3 times from current levels by 2050.
- In ATS, demand will exceed supply (mine production + recycling) around 2035.
- Cumulative demand in ATS through 2050 will exceed reserves (+ recycled supply).

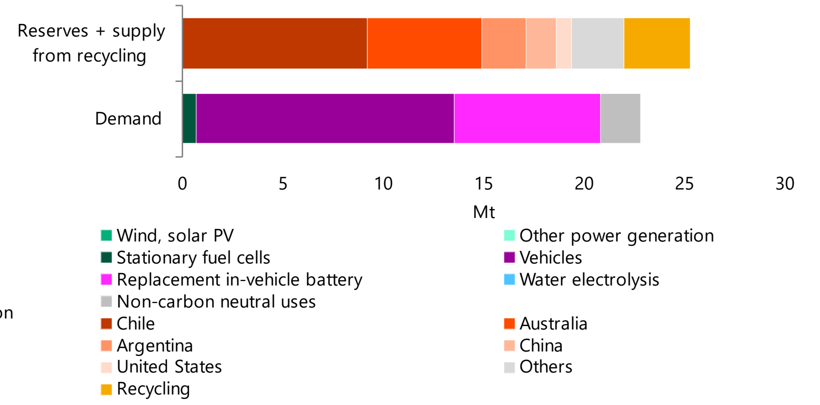




Lithium (Li)

- Demand will grow significantly mainly with the increase in electric vehicles. In ATS, it will increase by more than 10 times from current levels by 2050.
- In ATS, demand will exceed supply (mine production + recycling) around 2030.
- Cumulative demand through 2050 will be slightly below reserves.

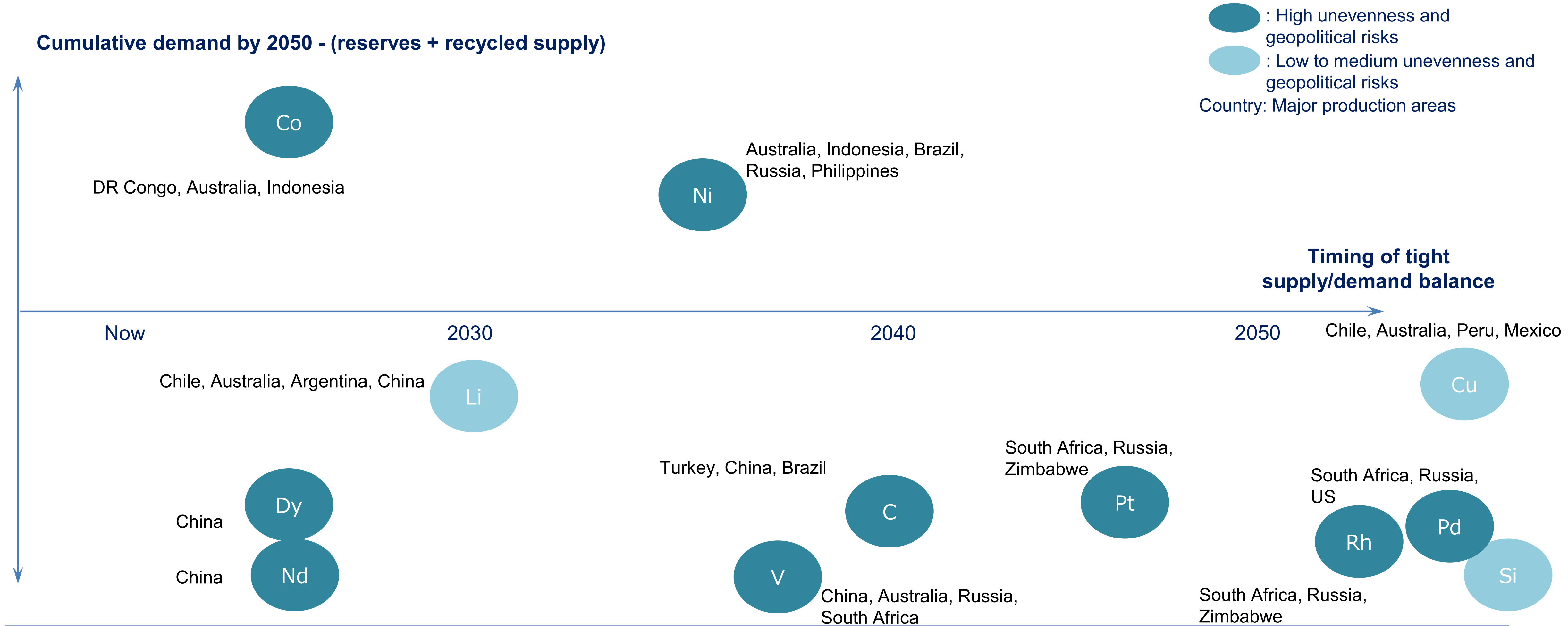




Source: IEEJ Outlook 2023

Uneven Distribution and Supply-Demand Balance
(Advanced Technology Scenario)

- Cumulative demand will exceed reserves + recycling by 2050: nickel, cobalt
- Concerns over early supply shortages: lithium, cobalt, neodymium, dysprosium
- Uneven distribution, geopolitical risks: nickel, cobalt, graphite, PGMs, neodymium, dysprosium, vanadium



Note: Cu (copper), Li (lithium), Si (silicon), Ni (nickel), Co (cobalt), C (graphite), Pt (platinum), Pd (palladium), Rh (rhodium), Nd (neodymium), Dy (dysprosium), V (vanadium)
Source: IEEJ Outlook 2023

Global Trends

- Actions to secure critical minerals are accelerating in the US, Canada, Europe, and Australia.
- International cooperation is also progressing because no country can build a supply structure on their own.
- The following points were confirmed by the G7 in 2023.
    - Agreement was reached on the Five-Point Plan for Critical Minerals Security at the Ministers' Meeting on Climate, Energy and Environment.
      1. Forecast Long-term Supply and Demand
      2. Develop Resources and Supply Chains Responsibly
      3. Recycle More and Share Capabilities
      4. Save with Innovations
      5. Prepare for Supply Disruptions
    - Meanwhile, the following points were confirmed at the Hiroshima Summit within the context of economic security.
      - The need to manage critical mineral risks
      - Support for transparent and fair critical mineral trade
      - Opposition to policies to monopolize critical minerals
      - Promote recycling of critical minerals
      - Enhanced emergency preparedness and resilience

Examples of critical mineral policy

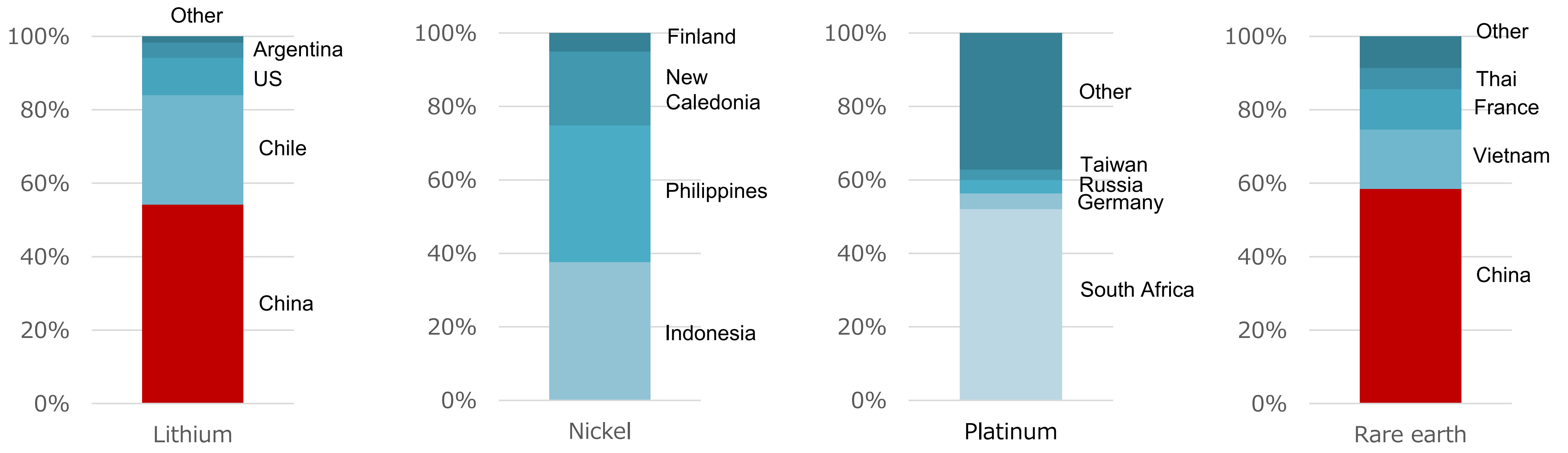
	US	Europe (EU)
Strategy	America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition (2022)	European Action Plan on Critical Raw Materials (2020)
Resource conservation, recycling	Support for strengthening domestic supply network ($675M, 2022) R&D Support ($30M, 2021)	Circular Economy Action Plan (2020) Battery R&D Support (€3.2B, 2019)
Expanding supply, stockpiling	Support for strengthening domestic supply network ($675M, 2022) Tax cuts under the Inflation Reduction Act (2022) R&D Support ($30M, 2021) Support under the Infrastructure and Jobs act (2021)	European Raw Materials Alliance (2021)
International cooperation, expansion	Critical Mineral Mapping Initiative (US, Canada, Australia)	EU External energy engagement in a changing world (2022) Minerals Security Partnership (2022, Europe, US, Canada, Australia, Japan, Korea)

Source: IEA, Critical Mineral Policy Tracker, as of June 2023

Japan's Critical Mineral Supply

- Overall, there is a supply oligopoly for the procurement of critical minerals in Japan.
- However, some minerals are imported from friendly countries, including the G7, and there is room for cooperation with those countries.

Supply structure for major critical minerals in Japan (2020)



Lithium: Total net lithium including lithium carbonate, lithium hydroxide, and metallic lithium.
Nickel: Total including ore, matte, and mixed sulfide.
Platinum: "Other" a total of 25% including domestic refining by-products and domestic recovery.

Source: JOGMEC, Mineral Resources Material Flow 2021

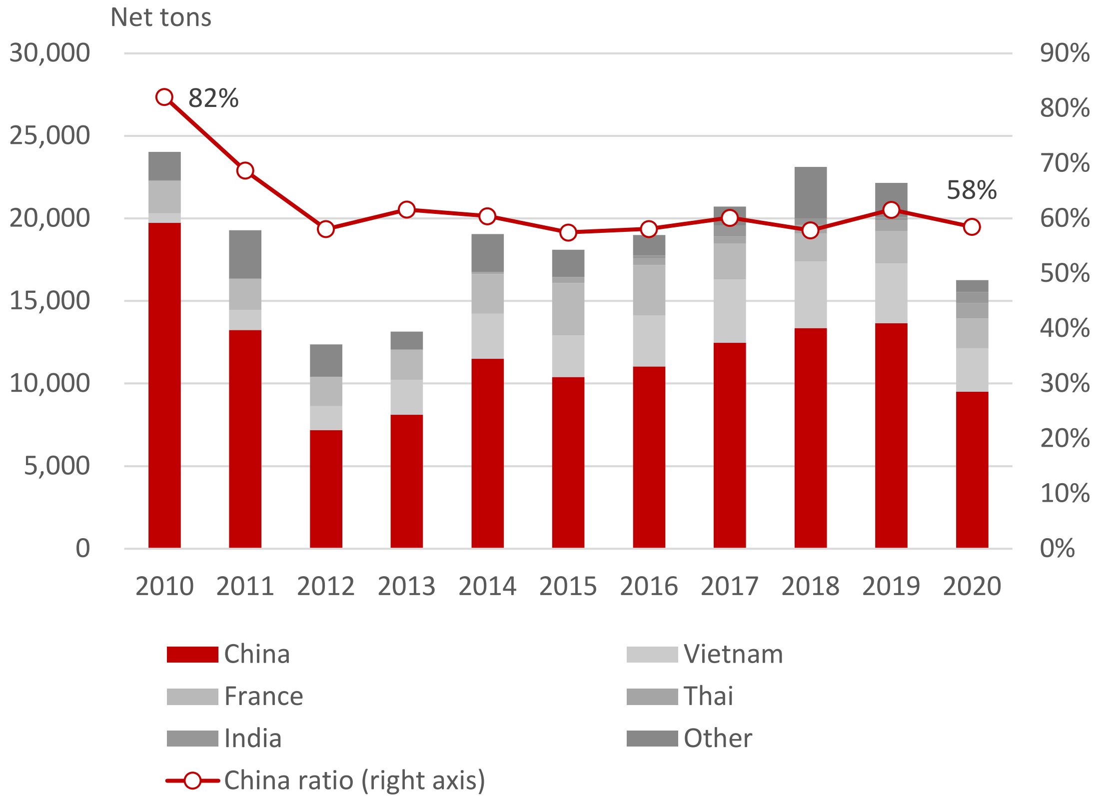
The Experience of 2010 in Japan

- Progress has been made in securing resources outside of China and developing resource conservation and replacement technologies since the rare earth crisis.
- While dependence on China has successfully been reduced, further improvements have stalled.

Comprehensive Rare Earth Measures (October 2010)

Development of alternative materials and tech to reduce use (12B Yen)	・Accelerated development of tech to use alternative materials (6 ores) ・Progress in joint international research (International clean energy technology cooperation)
Make Japan a global powerhouse of rare earth recycling (3B Yen)	・Development of recycling technology ・Promote capital investment
Enhancement of industries using rare earth (39B Yen)	Support for capital investment required for resilience against rare earth supply risks. ・Adoption of facilities to reduce use. ・Introduction of new processes that do not use rare earth. ・Stronger concentration of domestic industries with high-level rare earth use.
Secure mining concessions and development/supply (46B Yen)	Secure concessions and develop sources other than China ・JOGMEC investment, risk money supply ・Stronger relations with supplier states

Share of China vs. other countries in Japanese rare earth imports



Source: Ministry of Economy, Trade and Industry

Source: JOGMEC, Mineral Resources Material Flow 2020 and 2021

Major policies in Japan

New International Resource Strategy (2020)

- Includes strengthening rare metals security for industrial competitiveness as one of the pillars.
  - Establishes measures to secure each mineral
  - Promotes diversification of suppliers
  - Reviews stockpiling programs
  - International cooperation to secure resources
  - Stronger industrial base

Policy on Initiatives to Ensure Stable Supplies of Critical Minerals (2023)

- Aims to secure the minerals required to meet 2030 domestic production goals for storage batteries (150GWh) and permanent magnets.
- Support for securing resources and developing technologies overseas.
  - Exploration and FS support
  - Mine development support
  - Support for smelting businesses
  - Technology development support (higher efficiency and lower cost in smelting)

Economic Security Promotion Act (2022)

- Includes securing a stable supply of critical minerals as a pillar.
- Designates 11 specific critical commodities by Cabinet Order.
  - Antimicrobial medications, fertilizers, **permanent magnets,** machine tools and industrial robots, aircraft components, semiconductors, **storage batteries**, cloud applications, natural gas**,** **critical minerals**, and ship components.

Japan-U.S. Critical Minerals Agreement (2023)

- Adheres to free trade between the two nations.
- Cooperation on global supply chain problems and disruptions.
- Cooperation to build sustainable supply chains (transparency, environmental protection, labor conditions, etc.)

Source: compiled based on various sources.

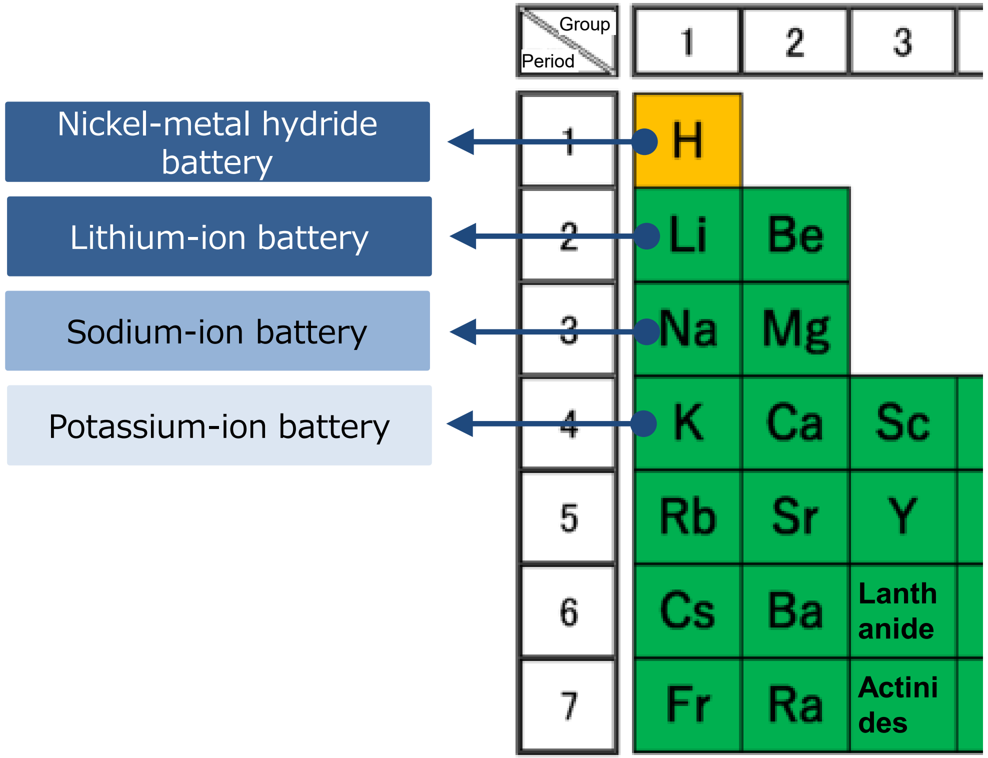
Future Policy Directions

- Reduce required amount through resource conservation technology and alternative resource technology (private sector + government support)
- Reduce imports through stronger recycling (private sector + government support)
- Strengthen securing of resources domestically/globally (private sector + government support)
  - Independent development
  - Diversify import source countries
- Stronger stockpiling (government)

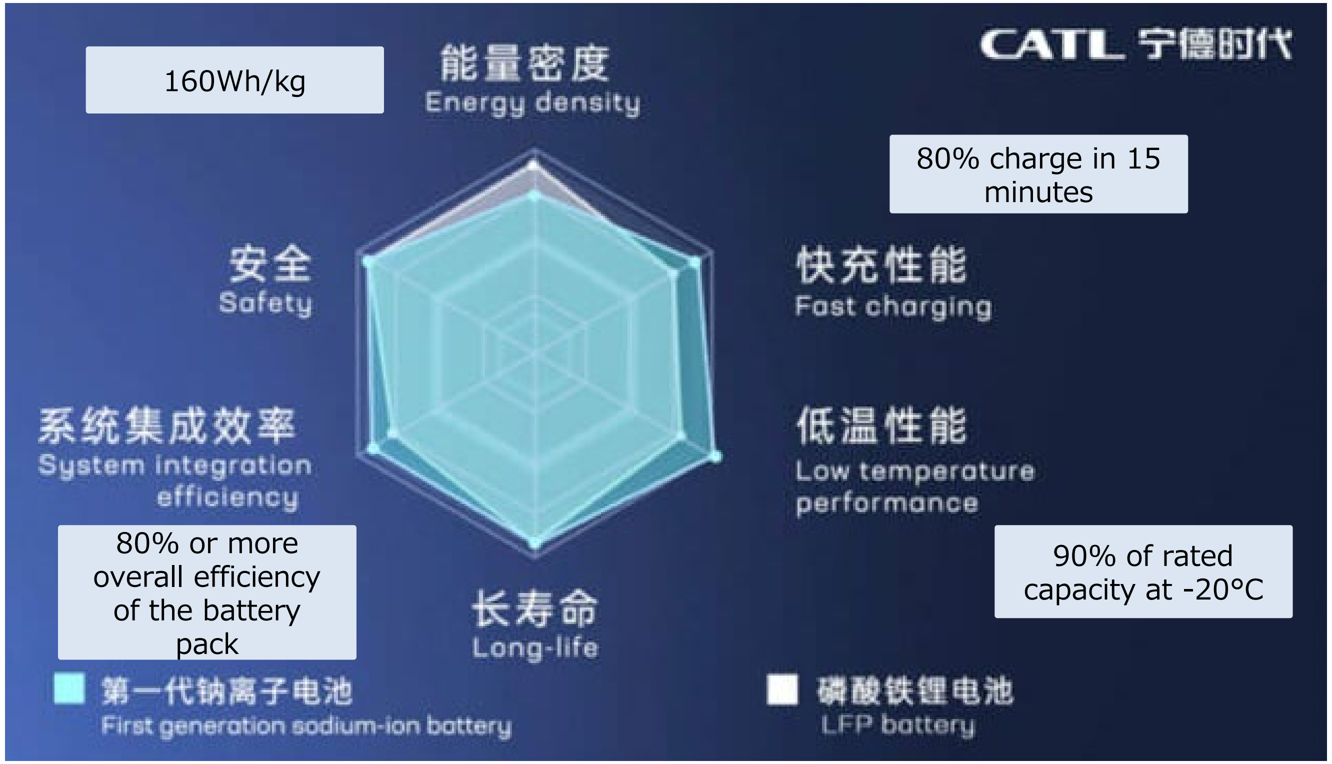
Potential Alternative Technologies - 1

- Progress is being made in developing batteries using alternative materials in place of lithium, which has uneven distribution.
- For example, commercialization of sodium-ion batteries would effect major changes in the risks related to battery materials.

Periodic table and battery potential



Comparison of lithium-ion iron phosphate batteries and sodium-ion batteries



Source: compiled based on periodic table from Science Stock and other sources.

LFP battery = lithium-ion iron phosphate battery
Source: compiled based on EVsmartBlog

Potential Alternative Technologies - 2

- Much of the demand for critical minerals comes from renewable energy and storage batteries.
- The use of alternative energy sources and technologies can distribute and mitigate the risks.

Power generation

Renewable energy + storage batteries

- An immediate decarbonization technology that is maturing.
- An oligopoly exists among technology supplier countries.
- Major risk of critical minerals.

Decarbonized thermal power generation

- High technical feasibility.
- Low critical mineral risk.
- Issues include building a fuel supply chain and costs.
  - ✓ Hydrogen, ammonia
  - ✓ CCS

Automobiles

Battery Electric Vehicles

- Rapidly commercializing. Can be an immediate decarbonization technology when synchronized with the decarbonization of electricity.
- An oligopoly exists among technology supplier countries.
- Major risk of critical minerals.

Decarbonized internal combustion engine vehicles

- Can reuse existing infrastructure.
- Low critical mineral risk.
- Fuel cost is an issue (synthetic and biofuels)

Different risks are incurred with each.

Potential of Recycling

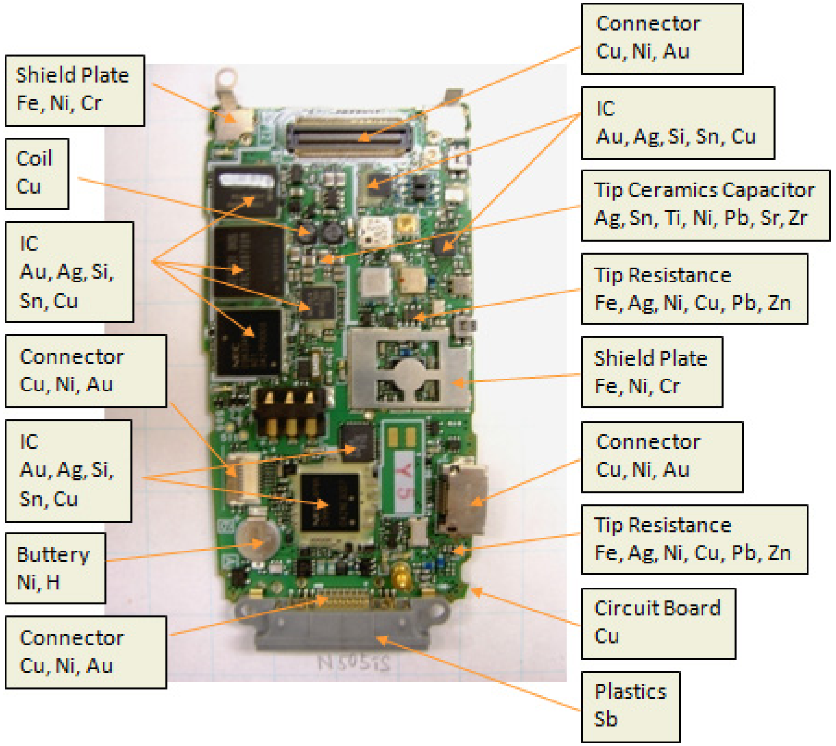
- Recycling is technically possible, but many used items are exported overseas.

- Technically possible to recycle, but it is not easy.
  - Difficulty of efficiently collecting product spread throughout the market.
  - Difficulty of disassembling the product and efficiently extracting the critical minerals.
  - High economic hurdles due to the above difficulties.

Material flow of lithium and nickel for lithium-ion batteries in Japan

Net tons		Lithium	Nickel
Final product input		765 tons	2,549 tons
Used volume collected [a]		246 tons	660 tons
	Exported used	127 tons	600 tons
	Wasted	108 tons	17 tons
	Recyclable raw material [b]	11 tons	43 tons
	Domestic recycling rate [b]/[a]	4%	7%

Metals used in cell phones



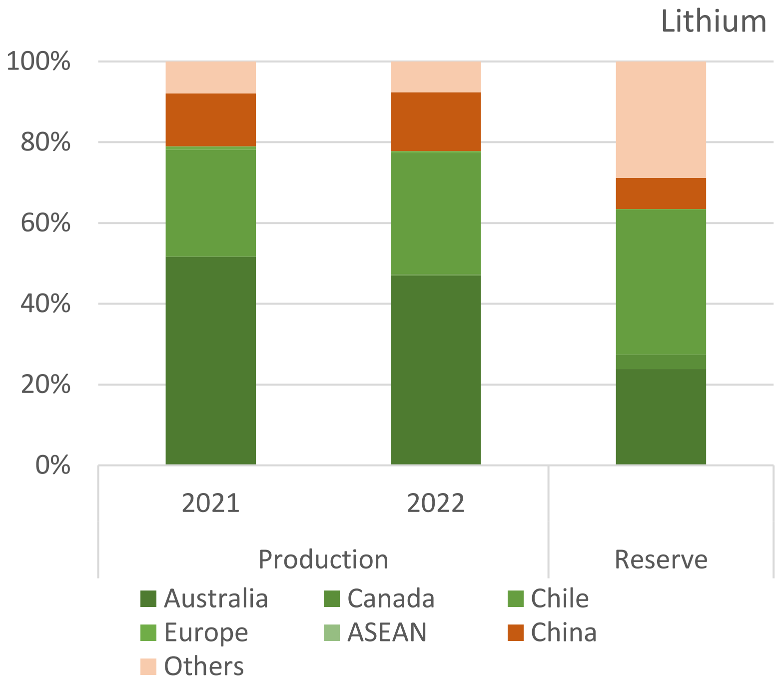
Source: Mitsubishi UFJ Research and Consulting, Summary of Results of the FY2022 Survey on Mineral Resources Recycling Flow/Stock, March 10, 2022.

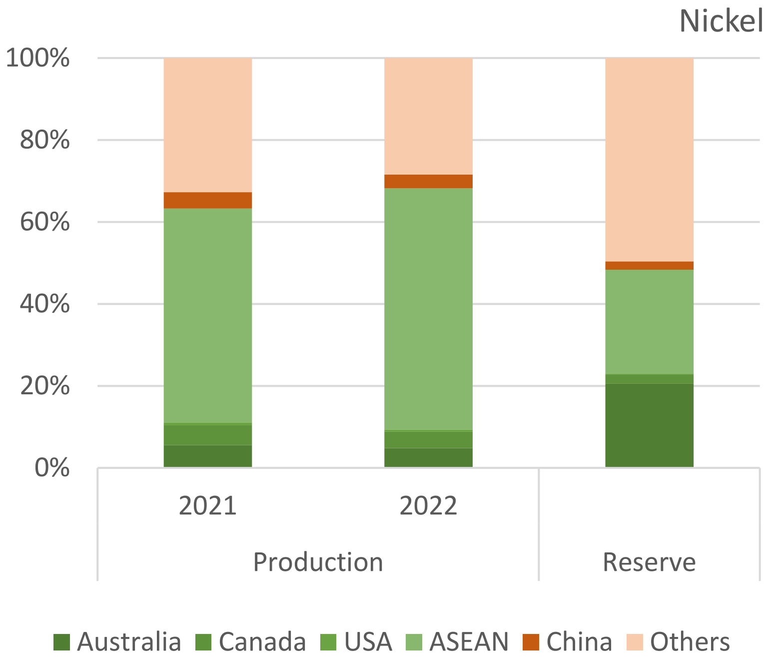
Source: National Institute for Materials Science

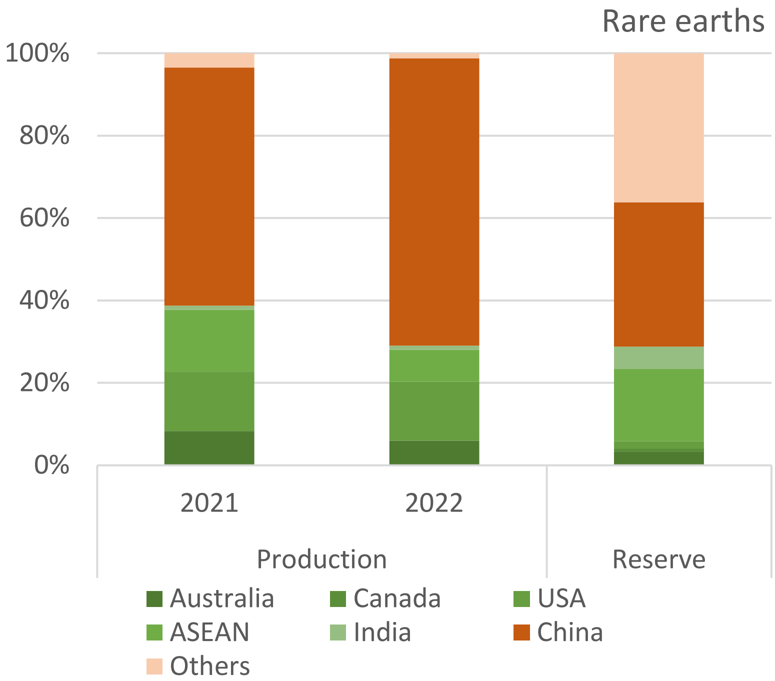
Choosing Partners of Resource Development and Import

- It is possible to mitigate the risks caused by uneven distribution through cooperation by international society.
  - Strengthen relationships with partners who can be trusted.
  - Joint development of resource extraction, downstream processes, and usage technologies.
  - Lobbying and rule making to maintain a system for fair trade.

Global share of resource extraction and reserves of primary critical minerals (*not downstream processes)







Source: USGS, Mineral Commodity Summaries 2023

Action to Dominate Resources

- Some resource-rich countries are taking action to control exports.
- The potential for nations with a commanding share of ore production to take similar action cannot be ruled out.

Unprocessed nickel export embargo by Indonesia

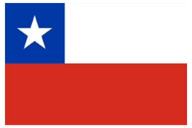
Background and measures	• The export of unprocessed nickel was prohibited from January 2020 in order to increase added value and enhance domestic industry.
Effects	• Domestic nickel refineries in Indonesia rose from 2 in 2014 to 13 in March 2021. Some say this will rise to 30 by 2024. • Direct overseas investment in BEV batteries has risen along with the increase in nickel refining.
International response	• The EU filed a complaint with the WTO in November 2019. • A WTO subcommittee ruled a violation of an agreement in November 2022. • Indonesia appealed to a high level committee of the WTO.

Source: prepared based on JOGMEC, World Economic Review, etc.

Nationalization of lithium

Mexico

- A revised mining law was passed in April 2022 to nationalize domestic lithium resources.
- The country does not produce lithium but is 10th place globally in resource volume.

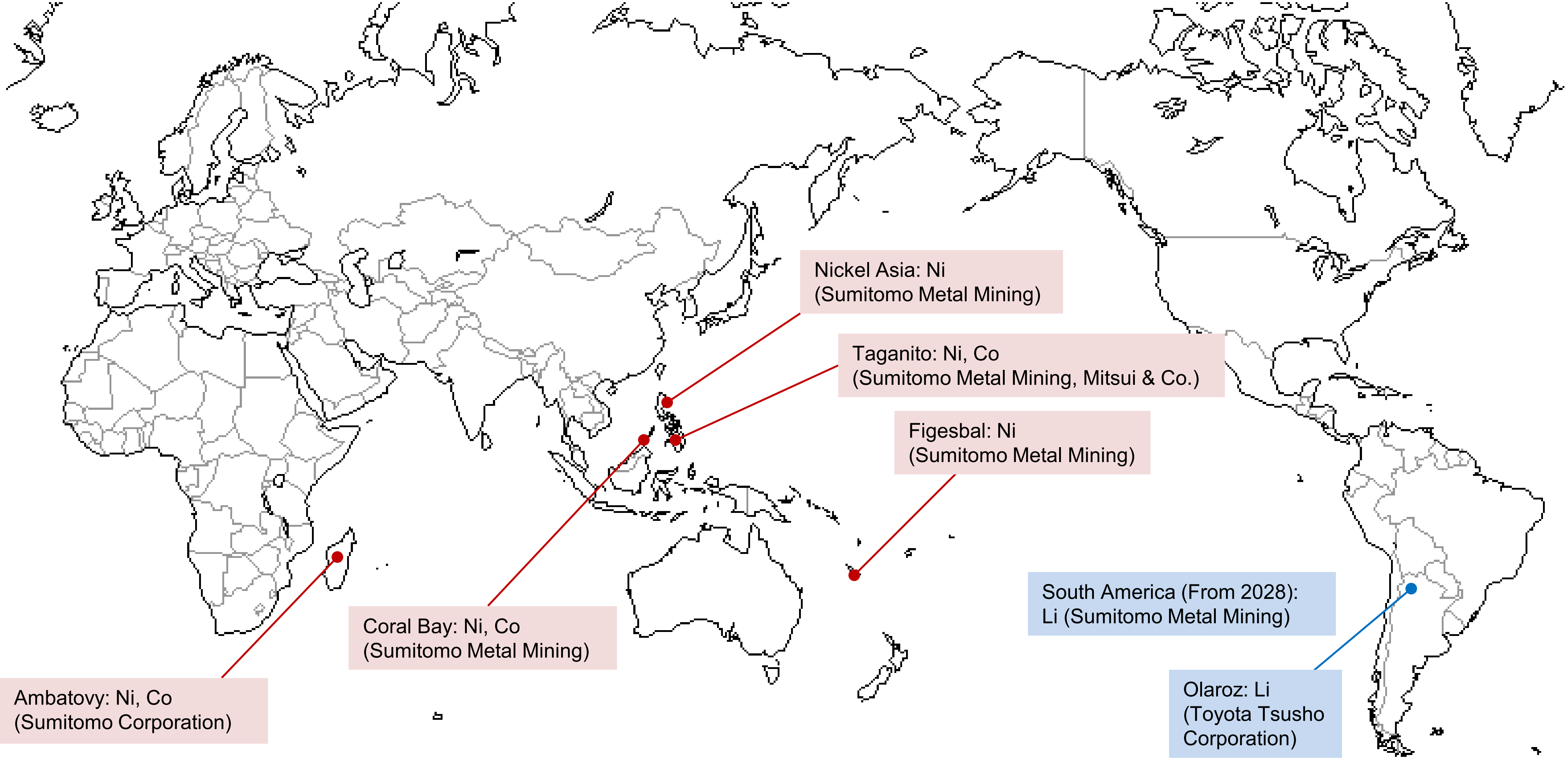


Chile

- In April 2023, President Boric announced the establishment of a new state-run company to manage the lithium industry.
- A bill to establish a state-run company will be submitted to the legislature during 2023.
- Has the 2nd highest production volume and highest reserves in the world (4th in the world in terms of resource volume.)

Source: compiled from various media reports; resource amounts from the USGS

Examples of critical mineral development overseas by Japanese companies

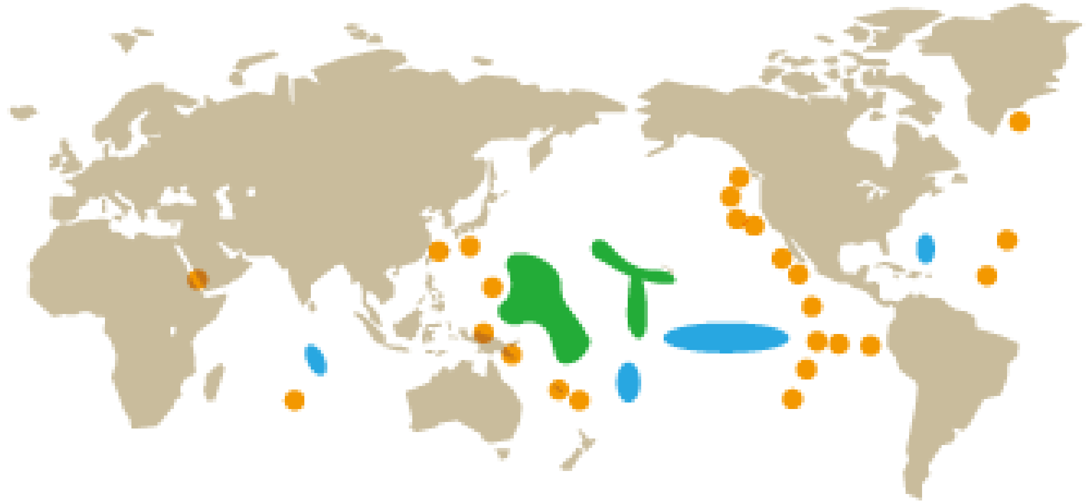


Source: compiled in August 2023 based on information from the Japan Mining Industry Association, company data, and press reports.

Potential of Marine Resources

- The presence of mineral resources within the territorial waters of Japan has been confirmed, and initiatives are taking place to develop them.

■Global distribution of deep-sea bottom mineral resources



Manganese nodules: widely distributed on flat regions of the seabed at depths of 4,000 to 6,000 meters. The main components are iron and manganese, and also includes nickel, copper, and cobalt.
Cobalt-rich crusts: found widely between 500 and 6,000 meters depth. The main components are iron and manganese, and also includes cobalt, nickel, tellurium, platinum, and rare earth minerals.
Submarine hydrothermal deposits: polymetallic sulfide deposits are formed when metallic components precipitate from hydrothermal fluids erupting on the seabed. They consist of copper, lead, zinc, gold, and silver, and also contain rare earth metals such as germanium and gallium.

Source: based on data from Deep Ocean Resources Development Co.

Development of marine mineral resources by Japan

Manganese nodules	Surveys were begun on the open seas off Hawaii in 1975. The Deep Ocean Resources Development Co., a joint public-private venture, concluded an exploration contract with the International Seabed Authority (ISA).
Cobalt rich crust	The first exploration contract in the world was concluded jointly with China with the International Seabed Authority in 2014.
Submarine hydrothermal deposits	The world's first successful mining and pumping pilot test was carried out in 2017 at a depth of 1,600 meters on the sea floor off Okinawa during which ore and seawater were continuously pumped to the surface using submersible pumps and pipes.
Rare earth mud	More than several thousand ppm of rare earth minerals were discovered in sediment from a depth of 4,000 to 6,000 meters in the exclusive economic zone surrounding Minami-Tori-Shima in 2013. The volume of resources is currently being measured.

Source: compiled based on data from JOGMEC.

Conclusions

- As progress is made in decarbonization, the demand for a stable supply of critical minerals, frequently used in clean technologies, is rising, and risks to that supply are emerging as well.

- These risks include both geographical unbalance and uncertainty of supply capacity, neither of which can be ignored.

- Japan has already formulated key policies in this regard, and it is important implement them steadily.
  - But as a more fundamental measure, technologies need to be developed which do not use critical minerals.
    Other options include the technology mix and the development of marine resources.
  - Meanwhile, commercialization of recycling faces high hurdles, and may not be particularly promising.
  - For Japan, a nation which must depend on the import of critical minerals, it is essential to cooperate with resource producing countries while maintaining and strengthening a fair international trade regime.

- However, vigorous resource and technology development is taking place with regard to critical minerals, and we must not forget that the success or failure thereof may have a major impact on the global landscape.

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