H-UTokyo Lab.

H-UTokyo Lab. Industry-Academia Collaboration Forum
Toward Realizing Energy Systems to Support Society 5.0

Geopolitical Crises and Pathways for a Transition: Changing Landscapes and Local Perspectives

Hideaki Shiroyama

Director, Institute for Future Initiatives
Professor, Graduate School of Public Policy
The University of Tokyo

Tomoko Suzuki

Corporate Chief Engineer
Research & Development Group
Hitachi, Ltd.

25 Jan. 2023

Table of Contents

1. Review of transition scenarios up to last fiscal year

2. Direction for updating this fiscal year's transition scenarios

3. International Landscape of Energy Geopolitics

3－1. Increase in fossil fuel prices and global responses

3－2. Acceleration of decarbonization and new trends in Europe

3－3. Transformation of Japan & Asia-Pacific energy trade/Cooperation with Japan

3－4. Coal, gas-fired thermal power: Consensus-building and green job creation during transitional period

3－5. Hydrogen and ammonia-fired power: Social acceptability and development of supply chain

3－6. Nuclear power: Policy shifts and limitations

4. Japan's regions and decarbonation

4－1. Possibility of regional new power and issues at hand

4－2. New transitions in regions with large-scale renewable energy deployment (Akita)

4－3. Transformation of industrial clusters/chemical industrial complexes

4－4. Solar power: Increase in cost competitiveness and business sustainability

4－5. Petrochemicals: Transformation from supply chain innovations to recycling-oriented business model

4－6. Agriculture: Transformation of food systems and unique challenges

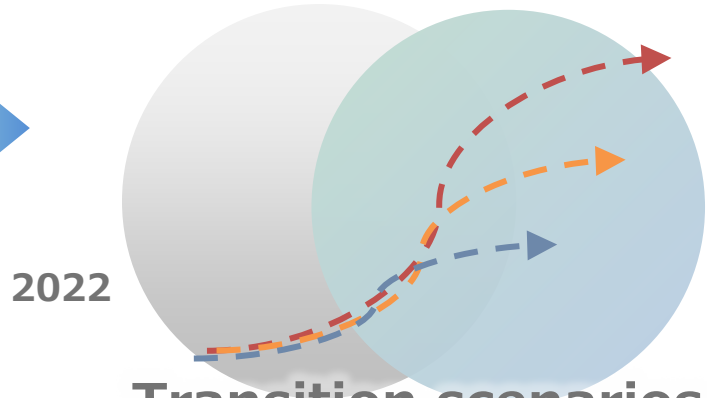
5. Insights gained from this fiscal year's activities

1-1. “Transition Scenario” by H-UTokyo Lab

H-UTokyo Lab.

Scenarios for a just and systemic transition based on dialogues with actors in wide-ranging sectors

- **Expert interviews** of diverse actors
- **Scenario descriptions** of power, industry, and behavior modification
- Discussion through **forums**



Transition scenarios

Present ways of making social and technological transitions toward 2050

Present ways of making **integrated transitions to sustainable energy systems**

Expert interviews up to now

International energy organizations, international renewable energy organizations, Japanese government, regional local governments (regions introducing renewable energy on a large scale, CCS, regions with industrial coastal areas)

International NGOs, researchers (climate-related policies, environmental economics, urban data, transportation planning, behavior modification, hydrogen, CCS, **agricultural policies), regional new-power support organizations**

Steel, **petrochemistry**, gasoline stations, automobiles, **aviation**, megabanks, **regional banks**, venture capital, **wind power generation**, biomass power generation, regional new power, compact nuclear reactors, **international trade cooperation organizations**

Held 38 times from November 2020 to December 2022; activities in **boldface** conducted from June to December 2022

*CCS: Carbon dioxide Capture and Storage

1-2. Previous Scenario: FY2020-2021

H-UTokyo Lab.

Multi-dimensional scenarios for energy, industry, and people in Japan
To gain strategic insights into domain-by-domain transitions

- We presented **transitions to achieve carbon neutrality in Japan** based on 12 domains and two time periods.
- We described in a qualitative manner the relationship between **two possible future visions** with respect to energy, industry, and citizens.
- We clarified **main actors** and important **junctures.** We **extracted insights and strategic suggestions.**

* Based on the 2021 report by RITE (Research Institute of Innovative Technology for the Earth), we described scenarios based on **two cases**: "diverse energy" and "100% renewable energy."

12 domains

Category	Domain
Power	Coal-fired thermal power
	Gas-fired thermal power
	Solar
	Wind power
	Hydroelectric, geothermal
	Biomass
	Nuclear power
	Hydrogen and ammonia
Industry	Steel
	Transport
	Petrochemicals
Behavior modification	
Integrated	

Two stages and cases in the transitions

Stage	2020-30 1st stage	2030-50 2nd stage
Features	Formation of preparatory conditions for transitions in power, industry, and behavior modification	Because of accelerated progress in transition, differences in conditions between scenarios widen
Junctures	**"Diverse energy sources" case:** Ammonia co-firing and CO2 capture technologies are being developed; negotiations between governments amid international movement toward decarbonization. **"100% renewable energy" case:** Participation of new actors in renewable energy sector is rapidly expanding. Public interest in climate and the environment increases, leading to policy changes by national government.	**"Diverse energy sources" case:** CCS-equipped fossil-fuel-fired plants are preserved. International distribution network for hydrogen and ammonia is formed. **"100% renewable energy" case:** Changes in urban living itself form major basis for transition toward green job creation related to climate and the environment.

1-2. Previous Scenario: FY2020-2021

H-UTokyo Lab.

Key points for short-, medium-, and long-term strategies in Japan are clarified by describing transition scenarios with focus on diverse actors

Key points observed from descriptions of transition scenarios

1. **Multilayered international cooperation on energy resources, innovation, power distribution grids, etc.**
   To achieve carbon neutrality in Japan, the procurement of new resources involving hydrogen and ammonia, recruitment of skilled personnel in the field of renewable energy, and development of multilayered platforms for international collaboration, such initiatives for international power distribution grids, will be critical.
2. **Consensus-building on transitional measures for future decarbonation**
   To achieve CO_2 capture and storage, social acceptance within Japan will of course be necessary. However, forming agreements with countries and regions for CO_2 storage will also be needed.
3. **Fair transitions and green job creation**
   Scenarios for regional prosperity through green job creation, in field such as coal/gas-fired power generation, supply chains for internal combustion vehicles, local gasoline stations, etc., are depicted.
4. **Investment in innovative decarbonization methods in manufacturing industry**
   In industrial fields including steel, long-term investments in innovative decarbonized manufacturing methods, based on considering a wide range of options involving technologies and systems, will be needed.
5. **Changes in people's value system regarding their city, work, and everyday life**
   Changes in energy systems will give rise to changes in society, which create the context for social transitions. There will especially be transitions in people's value system and lifestyle. In particular, choices in urban mobility, consumption, and energy supply may become subjects of serious concern among the people.
6. **New approaches to decision-making involving the environment and energy**
   Positioning of integrated policies and wide context on the environment and energy: New actors such as local governments, citizens, NGOs, and financial institutions will participate in decision-making.

2. Activities in FY2022

H-UTokyo Lab.

FY2020-2021

FY2020	Development of methodology based on multi-level perspective, theoretical transition scenarios, and review of related previous studies; mapping of issues and actors through interview of experts
FY2021	Formulation of transition scenarios based on descriptions of domain scenarios, which are based on further expert interviews and actor analysis; derivation of insights.

FY2022

1	Geopolitics of energy and climate change	Understand geopolitical conditions that should be considered for Japan to become carbon neutral by 2050 in Japan with regard to energy and climate change; identify areas for scenario revision.
2	Examination of transitions with focus on various regions of Japan	Focus on regions in Japan with strong relevance, such as regions with large-scale deployment of renewable energy and important areas for industry transformation; through case studies, obtain direction for scenario revision.
3	Establishment of deeper links to quantitative research	Quantitative backing for qualitative scenarios, in collaboration with WG1-2
4	Study of new fields	Carry out further expert interviews and study new domain scenarios involving agriculture, cycles in chemical industry, sustainable aviation fuels (SAF), etc.

Revised transition scenarios based on new knowledge and insights

*SAF: Sustainable Aviation Fuel

3-1. Global climate and energy crises

H-UTokyo Lab.

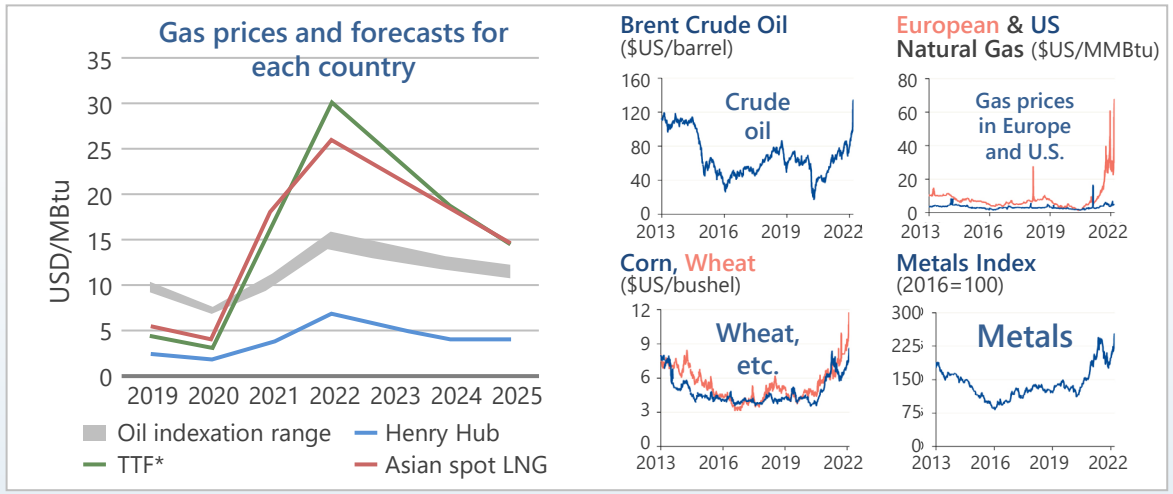
The Russian invasion of Ukraine has had profound impacts on the global energy systems
Europe seeks to secure LNG to for non-Russian energy; U.S. accelerates its climate actions with Inflation Reduction Act

Climate change measures

Up to 2021, countries have adopted climate change measures. However, measures to limit temperature increase to 1.5ºC have been insufficient.

Sharp rise in fuel prices due to invasion of Ukraine

After Russia invaded Ukraine in February 2022, prices of energy (crude oil, gas, coal) and food (wheat, fertilizer, etc.) exported by both countries soared.



*TTF: Title Transfer Facility

EU countries: Moving quickly to reduce energy dependence on Russi

- "**Versailles declaration**" by EU leaders at summit (March)
- Member countries are moving faster to reduce dependence on fossil fuels.
- Diversifying supply sources and routes
- Further development of hydrogen market etc.

https://presidence-francaise.consilium.europa.eu/en/news/the-versailles-declaration-10-and-11-march-2022/

→ Germany is expanding investment in LNG, France is relaxing restrictions on coal-fired thermal power, etc.

U.S.: Inflation Reduction Act (IRA*) enacted (Aug.)

- Largest climate change legislative package in U.S. history
- Reforms such as minimum corporate tax rate will increase tax revenues by $737 billion. Of this, $369 billion (about 52.5 trillion yen) is for "**energy security and climate change**."
- 40% reduction in carbon emissions by 2030 (does not meet Paris Agreement target)
- Tax credit "incentives" instead of "regulations" such as carbon pricing

→ There is criticism that IRA's corporate tax hike hinders innovation, that the law favors American producers, and its tax credits violate the general principles of the World Trade Organization.

*IRA: Inflation Reduction Act

Source: IEA. 2022. "Gas Market Report, Q3-2022." https://iea.blob.core.windows.net/assets/c7e74868-30fd-440c-a616-488215894356/GasMarketReport%2CQ3-2022.pdf,
Source: IMF. 2022. https://blogs.imf.org/2022/03/15/how-war-in-ukraine-is-reverberating-across-worlds-regions/

3-2. New Climate and Energy Policies in Europe

H-UTokyo Lab.

Europe seeks to break its dependency on Russian energy by accelerating transition. Amid risk of returning to fossil fuels, EU governance structure allows for values-oriented decisions

EU: "REPowerEU" plan, released by European Commission (in May 2022): Raised "Fit for 55" targets and called for additional policy support and investments

"REPowerEU" is energy bill presented by European Commission to rid dependence on Russian fossil fuels by 2030.

Key measures: (1) Energy saving, (2) acceleration of green energy, (3) diversification of energy, (4) investment and reforms

Short-term responses

- "Joint purchasing mechanism" for gas, LNG, and hydrogen; filling gas storages to 80%
- New energy partnerships with reliable suppliers
- Quick launch of startup of solar, wind power, and hydrogen energy projects
- Acceleration of biomethane production
- Communication to residents and businesses with recommendations for how to save energy

Medium-term measures (until 2027)

- Investments and reforms worth 300 billion euros
- Acceleration of decarbonization of industries (3 billion euro fund)
- Acceleration of permitting of RE projects
- Investments in integrated gas and electricity infrastructure network
- By 2030: Increase from 9% to 13% of the binding Energy Efficiency Target
  RE rate: from 40% to 45%
- Ensuring access to critical resources
- Establishment of regulatory framework for water electrolyzers and hydrogen to secure energy for industries

EU's unique governance :

In the EU, the European Commission submits legislation. The bill is deliberated by the European Parliament and the Council of the European Union. While the governments of each EU country are directly elected, the **EU is viewed by some as making possible governance based on the values (principles) it stresses, rather than short-term economic benefits.**

3-3. Impacts on Asia-Pacific energy economy and cooperation

H-UTokyo Lab.

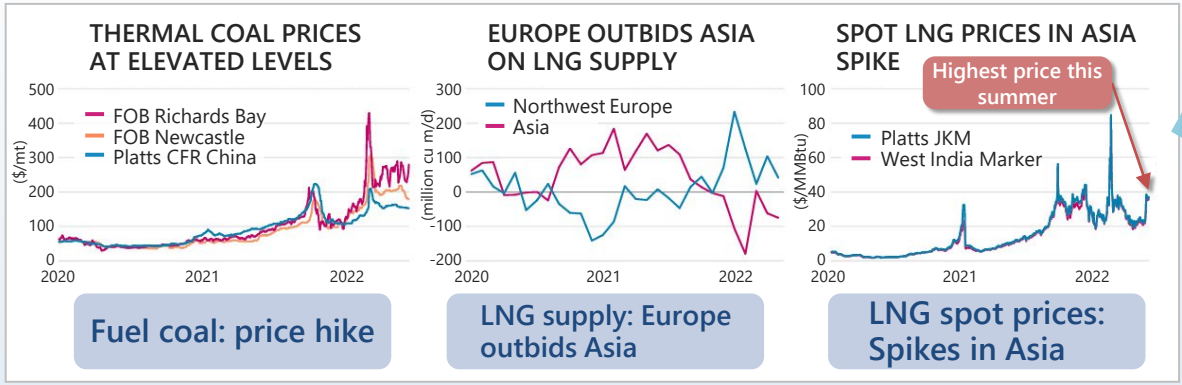
Rising energy and living costs bring political and economic crisis to Asian countries damaged by climate change and COVID-19. Japan needs to reinforce its partnerships with the rest of Asia, as Australia emerges as a future energy superpower

China, India: Importing cheap Russian energy

- China: From energy security perspective, seeking to ensure that procurement channels are not affected by U.S. Navy or Middle East politics.
- India: To curb inflation and economic turmoil, India is importing cheap Russian crude oil. As gas prices increase, the demand for coal is also growing.

Other Asian countries: Inflation hits amid climate change and COVID-19

- Simultaneous soaring energy and food prices affect poor areas amid historic heavy rains and heat waves. Ex. Pakistan
- Damage due to COVID-19 has created political and economic crisis in countries unable to adequately cope. Ex. Sri Lanka, Bangladesh



Australia: Alternative to Russia?

- As Europe seeks to wean off Russia, the presence of Australia as a resource-rich country in Asia may grow.
- Japan depends on Australia for 39.2% of its natural gas and 59.2% of its coal.
- Is politically stable, and a member of Quad alliance with Japan, U.S., and India.

Shift in domestic climate politics and new prospects for growth in Australia

- New change of government in May 2022 with Labor Party in control, signaling change in policies
- While enjoying benefits of current gas exports, the government is seeking to shift to exports whose demand is expected to grow. E.g. hydrogen and ammonia, rare metals (lithium, nickel, rare earths, etc.),

https://time.com/6177436/australia-election-climate-change/

New partnerships between Japan and Asia

- Under geopolitical realignment, new international supply networks for hydrogen and ammonia, rare metals, carbon sequestration, etc., are needed.
- Overcoming of risk of retrogression through strategic and mutually beneficial international collaboration on climate change and energy security

Source: S&P Global. https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/062722-factbox-asia-pacific-economies-face-escalating-energy-crisis

3-4. Coal, gas-fired thermal power: Consensus-building and green job creation during transitional period

H-UTokyo Lab.

Because of the energy crisis, being advanced are phasing-out of inefficient coal-fired thermal power and reduction of the proportion of fossil fuel-fired thermal power in power generation;
Building supply chains for carbon storage and utilization through international collaboration and regional green job creation

World

- Europe: With REPowerEU, seeks to complete ridding dependence on Russia by 2030. Accelerated implementation of renewable energy and energy saving.
- EU, UK, US, China, etc., are progressing with demonstration of and investments in CCUS.

Japan

- 6th Basic Energy Plan calls for maximal reduction of proportion of thermal power.
- Announcement of green growth strategy for transition of industrial structure and social economy
- Began international collaboration to establish "Asia CCUS Network" (including the U.S. and Australia).

Scenario descriptions

Diverse energy sources

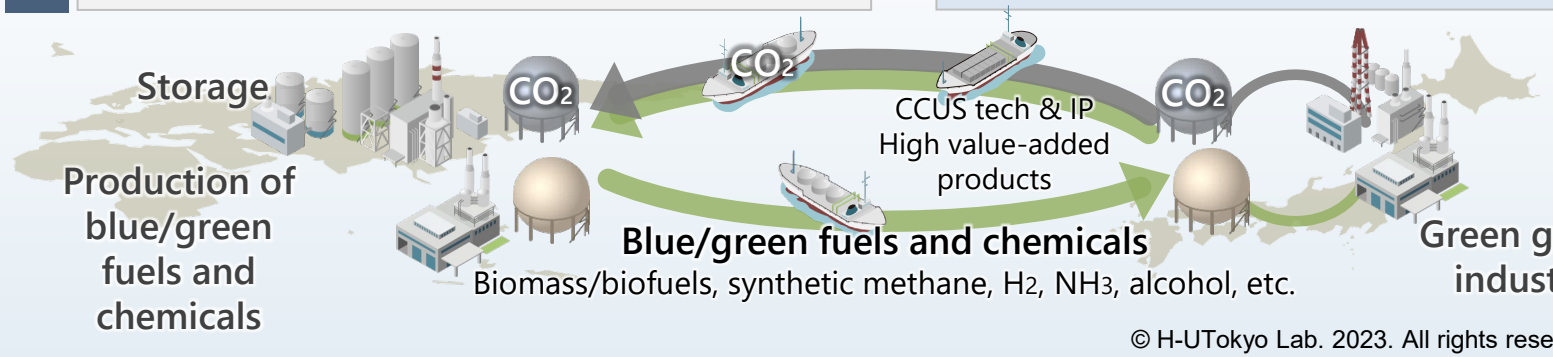
- 2020–2030: Temporary return to coal occurs because of the invasion of Ukraine. However, **inefficient coal-fired thermal power is phased out** and clean fuel conversion is **steadily advanced**. For CCUS, technologies are developed and international collaboration is formed.
- 2030-2050: Development of CCUS network is realized **through APAC collaboration**

100% renewable energy

- 2020–2030: Investments in fossil fuels stop; **phase-out of coal- and gas-fired thermal power accelerates.**
- 2030-2050: Government **promotes green job creation** as measure for stimulating regional economy.

Critical juncture points and key points

- Steady advancement of measures such as phase-out of inefficient thermal power, conversion to sustainable fuels (biomass, etc.), and thermal power with CO2 capture are necessary.
- Along with above phase-out, green job creation in line with Green Growth Strategy is critical.
- For spread of CCUS, it is necessary to develop technology, including domestic field testing, win public acceptance, and build global supply chain through APAC partnerships.



3-5. Hydrogen and ammonia-fired power: Social acceptability and development of supply chain

H-UTokyo Lab.

Will Japan's unique hydrogen and ammonia co-firing (partial continuation of fossil fuel power) be socially acceptable? Also, an extremely extensive large supply chain is necessary for its realization.

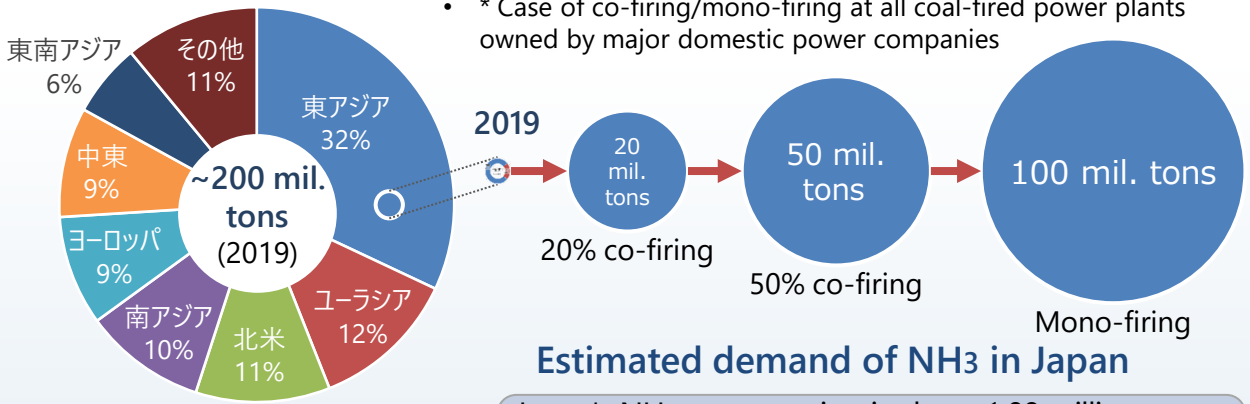
Pros and cons of continuation of use of fossil fuels with hydrogen and ammonia co-firing

- Use of hydrogen worldwide is being advanced in non-power sectors.
- **International efforts to eliminate coal-fired thermal power** are being carried out. **However, Japan is independently promoting continuation of fossil-fired power** through hydrogen/NH3 co-firing and mono-firing.

https://mainichi.jp/articles/20171110/k00/00m/040/117000c

Co-firing requires 20-50x current amount of ammonia. Mono-firing requires 100x current amount of ammonia*

- * Case of co-firing/mono-firing at all coal-fired power plants owned by major domestic power companies



Worldwide production of NH3 2019: ~200 million tons

Estimated demand of NH3 in Japan

Japan's NH3 consumption is about 1.08 million tons (2019). About 80% is produced domestically and 20% is imported from Indonesia and Malaysia.

Scenario descriptions

2020-30

- Japan advances development of international supply chain through leadership by Japanese government.
- Large-scale overseas production of hydrogen and NH3 begins (relocation of NH3 production plants).
- More countries permit use of fossil fuels for time being. Expectation of use of hydrogen and NH3 co-firing and mono-firing increases.

Diverse energy sources

2030-50

- Life of thermal power generation plants is prolonged. Conversion of co-firing/mono-firing proceeds gradually.
- Demand in Asia emerges. International supply chain is built.

100% renewable energy

2030-50

- Fossil fuel-fired power plants continue to close.
- Shift to co-firing and mono-firing is not realized. Construction of international supply chain construction stalls.

Critical juncture points and key points

- Large-scale production system for hydrogen and NH3 and construction of international supply chain
- International opinion about pros and cons of transitional use of fossil fuels (will co-firing be allowed?)

Source: Agency for Natural Resources and Energy https://www.enecho.meti.go.jp/about/special/johoteikyo/ammonia_01.html

3-6. Nuclear power: Policy shifts and limitations

The Japanese government is shifting its nuclear power policy. From 2030-50, it is preparing for construction of "next generation innovative reactors" and restarting and extending the life of existing nuclear power plants. However, in 2030-50 nuclear power will compete with renewable energy, which will have lower costs and become more stable.

World

- IEA: States that additional 10 GW of nuclear power generation capacity is needed annually through 2030 to achieve net-zero goal.
- Calculates that $100 billion investment is needed annually in late 2020s.

Japan

- Against background of climate change measures and power shortages, the government's GX Conference in 2022 promoted shift in nuclear power policy.
- Discussed "concentration of efforts by parties to restart operations," "promote development and construction of next-generation innovative reactors" and "accelerate reprocessing, decommissioning, and final disposal processes"

Scenario descriptions 2030-50

Diverse energy sources

- **Renovating existing plants and preparing new plants for "next generation innovative reactors"** takes place at sites of nuclear power plants. However, small modular reactors are not in commercial operation by 2050.
- Power plants built in 20th century are already aging, and **their operational life is further extended**.
- Energy share gradually shrinks from around 20% in 2030 to **about 10%** in 2050 (based on RITE reference values) amid **competition with low-price and stable RE sources**.

100% RE

- In Japan, **nuclear power generation gradually becomes zero** as public becomes concerned over **lengthened construction of new reactors** and the issue of investment return.

Critical juncture points and key points

- In relation to RE, which will have lower costs and stable supply in medium to long term, how to **rationally invest in nuclear power personnel, tech development, and construction of plants**?
- **Public understanding of the various benefits and risks,** and **consensus-building with the community residents on plant sites and radioactive waste disposal are critical.**
- **There is disconnect between economic debate** on energy **and broader social reality, which includes the environment and people's consciousness**.

https://nettv.gov-online.go.jp/prg/prg24873.html

4-1. Possibility of regional new power and issues at hand

H-UTokyo Lab.

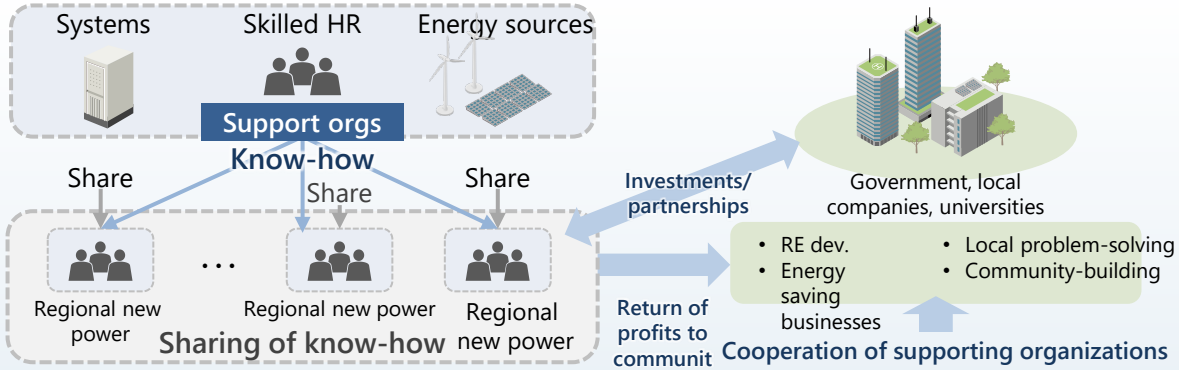
Regional new power promotes decarbonation and building of circular economy while engaging in energy-centric development of region.
However, many companies are suffering due to soaring fuel prices.

What is regional new power?

Retail energy providers that aim to realize local production and consumption of electricity using regional renewable energy sources. In many cases, they are jointly owned by local governments and private companies. The total amount of electricity generated is increasing (as of 2020).

Expansion of services to communities and role as local think tank

Under conditions of falling birthrate, aging population, declining industry, and demand for decarbonation, regional new power promotes deployment of renewable energy in communities and expands local services through its income. Some companies are also playing role as regional think tanks.



Heavy costs of systems and bearing of know-how → **Mechanism of sharing systems and human resources among regional new powers**

Seeking to create value for communities with RE as starting point

Regional new power companies	Features
Local Energy	In Yonago City, Tottori Pref. Established for purpose of creating new economic base through local production/local consumption of energy.
Mikawa no Yamasato Community Power	In Toyota City, Aichi Pref. Returns business profits for use in local transportation systems.
Tantan Energy	In Fukuchiyama City, Kyoto Pref. Developing cycle of energy costs within the region, which had been drained out of the region. Returns profits to the environment, culture, and sports.
Hioki Regional Energy	In Hioki City, Kagoshima Pref. Mainly a local gas company. Partners with companies outside the area as specific power transmission and distribution business.

Issue 1 Continued outsourcing to new power companies headquartered in large cities; no creation of jobs or know-how in the region → Participation of local companies is key

Issue 2 Sharp rise in bankruptcies and withdrawals of new power companies due to soaring fuel prices. Regional new power companies face challenge of both maintaining relationship of trust with communities and turning a profit.

*Some also see restarting nuclear power as keeping down energy prices and contributing to stabilization of new power.

4-2. New transitions in regions with large-scale renewable energy deployment

H-UTokyo Lab.

Tohoku is a region with a distinct natural environment and social challenges. Its people are taking on the challenge of creating a new industry centered on wind power generation with collaboration among local governments, local renewable energy companies, regional banks, and fisheries.

Regional challenges in Tohoku and Akita and wind power generation

- Aging population, outflow of young people from the region, low value-added industrial structure, etc.
- Akita Prefecture is optimal location for wind power generation. 296 generators are in operation. Ranks first in Japan in wind power generation.
- Diverse actors are engaged in Japan's first large-scale offshore wind power project.

https://www.city.akita.lg.jp/kurashi/recycle/1006073/1006102.html

Local governments: Advancing wind power projects by collaborating with diverse actors

- Establishment of study groups and councils with municipalities, national government, and fishery-related businesses.
- Creation of industry in the prefecture: Parts and maintenance industry. Support for obtaining licenses.
- Collaboration with universities and technical schools for green human resources development
- Communication of information to residents and building consensus

Regional wind power generation companies: Revitalizing local Industries with unique initiatives

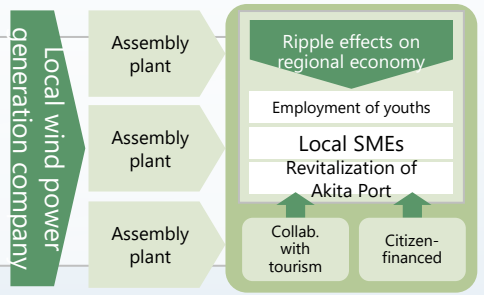
- Engagements in a wide range of enterprises including selection of suitable sites, alliances with partners, launching of generators, and maintenance.
- Efforts to form consortiums of companies and revitalize local industries
- Accumulation of know-how from foreign companies and forming connections to the next level of growth.

Fisheries: Seeking to overcome structural challenges and coexist with wind power

- Decline in fish catches and aging population of fishermen are challenges.
- Concerns about impact of offshore wind power development on fisheries.
- Exploring cooperation with fisheries (e.g. creation of fishing reefs)

Regional banks: Support of local businesses

- There is need for large-scale financing.
- Working alongside local businesses with low creditworthiness to provide project financing



Goal for Japan: To utilize regional resources, have vision for cross-sectoral design of systems, and develop processes for transparent advancement of projects

4-3. Transformation of industrial clusters/chemical industrial complexes

H-UTokyo Lab.

Diverse industries are concentrated in high growth-supporting industrial complexes, which produce great amounts of carbon emissions. Local governments are supporting the transition to renewable energy and circular economy. Allocation of capital investment is an issue.

Characteristics of Kawasaki Keihin waterfront industrial area

- Kawasaki Keihin Industrial Area supported Japan's rapid economic growth. It is a concentration of factories and facilities, including for petroleum refining, chemicals, steel, energy, cement, and logistics.
- Kawasaki produces the most carbon emissions of all Japan-government ordinance cities. Keihin Industrial Area makes up 73% of this amount.
- Kawasaki accounts for 10% of domestic hydrogen demand. It has hydrogen pipelines.
- Kawasaki is one of the largest plastic recycling bases in Japan (processes up to 10% of Japan's total recycling)

Efforts to date

- Kawasaki Hydrogen Strategy ('15) → Public-private consortium
- Advances hydrogen project, promotion of plastic recycling
- Kawasaki CN industrial complex concept (Mar. 2022) (Hydrogen strategy, carbon cycle strategy, regional energy optimization strategy)

Challenges of industrial complexes

https://www.k-kankou.jp/study/

Investment allocation | **Design of chemical cycling processes and business models** | **Development of public infrastructure and formulation of policies**

① Allocating investment capital, such as for recycling plants, carbon separation, and facilities related to hydrogen bases

② Forming cooperation among companies based on chemical processes that make effective use of byproducts

③ Development of shared infrastructure: Long-term design cannot be done by government alone; goal is not only to maintain existing enterprises

Request to country

- Vision and support that is not vertically segmented by industry sector but views industry clusters in an integrated manner
- Support for development of sustainable infrastructure
- Design of mechanisms for collaboration between businesses and residents

Present direction for industrial complex areas to realize CN society; become flagbearer

4-4. Solar power: Increase in cost competitiveness and business sustainability

H-UTokyo Lab.

Since invasion of Ukraine, solar power's cost competitiveness is increasing because of rising fuel prices. In scenario, demand for home power generation increases in 2020-30. Installation in offices and homes increases with participation of diverse companies.

World

- Solar installation costs have increased since invasion of Ukraine. However, cost competitiveness of renewable energy has further improved because of much higher prices of natural gas, petroleum, and coal.
- Renewable energy plan is moving ahead of schedule to rid dependence on Russia.

Japan

- The Sixth Basic Energy Plan raises RE share in energy mix from 22-24% to 36-38% by 2030.
- FIP (Feed-in Premium) system is introduced. Expansion in deployment of renewable energy that coexists with local communities; maximum utilization of existing RE sources.

Diverse energy sources

100% renewable energy

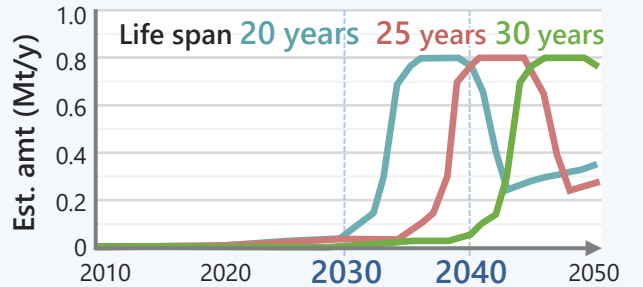
Scenario descriptions 2020-30

- Although the government's Basic Energy Plan increases the target for renewable energy deployment, actual renewable energy deployment slows down compared to initial increase.
- However, after invasion of Ukraine, as result of rising electricity prices, **cost competitiveness of solar power generation increases. At the same time, demand for private power generation in offices and homes grows.**
- **Participation of companies with diverse backgrounds,** including telecommunications, automotive, and petrochemical companies
- Mandatory residential installation and promotion of solar power generation by local governments drive expansion of power generation.

Critical juncture points and key points

- New actors will participate. Resolving **issues related to environmental impact and business rules** will be critical.
- It is expected that equipment will **need to be disposed of and replaced in the 2030s and 2040s**.
- Smart power transmission and distribution networks are important to support rapid EV adoption and local decarbonation.

Estimated emissions by solar modules



Source: https://www.env.go.jp/press/files/jp/102441.pdf

4-5. Petrochemicals: Transformation from supply chain innovations to recycling-oriented business model

H-UTokyo Lab.

From 2030 to 2050, business models based on circular economy will be established.
Important key points will be policies for creation of new ecosystem and collaboration among companies.

Scenario descriptions 2030-50

2020-30

- Government-led carbon capture infrastructure development begins. Companies advance development and accumulation of carbon capture technologies and know-how.
- Public interest in non-fossil fuel-derived raw materials and chemical recycling grows; efforts to change production processes **and international supply chains** become full-fledged.

Diverse energy sources

2030-50

- Establishment of international supply chain for carbon capture
- Thin-profit businesses and products that are difficult to produce in Japan expand overseas; **industrial reallocation** progresses.
- Transition of business models and renewal of ecosystem to respond to circular economy

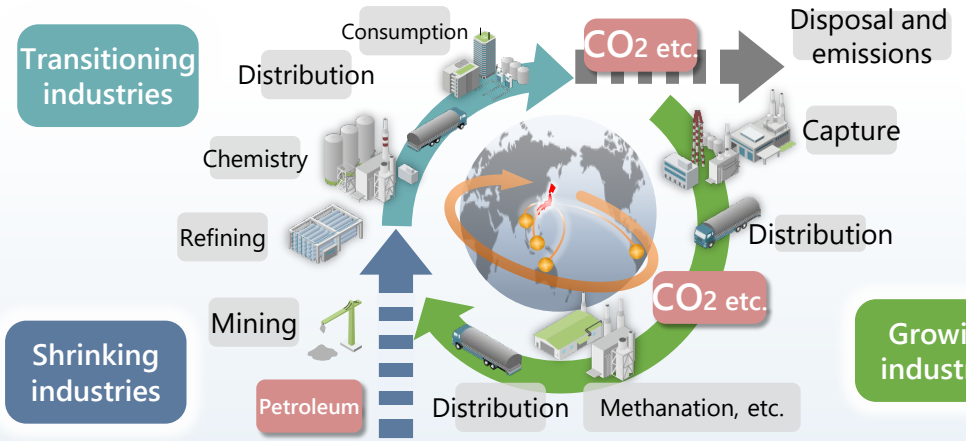
100% renewable energy

2030-50

- Decline in demand for domestic carbon capture (decrease in large sources of CO2 emissions)
- Strong domestic businesses consolidate; advancement of **industrial reallocation**.
- Transition of business models and renewal of ecosystem to respond to circular economy

Critical juncture points and key points

- Establishment of domestic and international supply chain and technological development for carbon capture and sequestration
- Innovation of **business models and ecosystems** within and outside of industrial complexes (upstream/downstream supply chain, inter-industry collaboration, international collaboration)
- **Public leadership (regional leadership and strategic Industry policies) and private leadership**
- Employment and education as part of business structure transition



Transition in supply and demand for fuels and raw materials, transformation of production processes and distribution, and industrial relocation ⇒ **Use of energy in right places and production of raw materials in right places**

4-6. Agriculture: Transformation of food systems and unique challenges

H-UTokyo Lab.

The current food system, which contributes to carbon emissions and environmental collapse, is being forced to undergo transition. In Japan, the government is taking the lead in reducing chemical pesticides and fertilizers. Land use reform and changing ways of producing food patterns are key.

Non-sustainability and sustainability of world food system (e.g. through)

- Current food system is unsustainable from perspective of global environment
- **1/4 of GHG* emitted worldwide comes from food production systems**
- Current food production systems brings about deforestation, loss of biodiversity, consumption of fresh water, and pesticide runoff.
- These is need to stop farmland expansion. **Regenerative agriculture** and **sustainable intensification** are necessary.

Farm to Fork (2030 goals)

- Supply of food based on Earth's environmental limits
- Reduction by 50 percent of the use and risk of pesticides, fertilizers, and antimicrobials
- Sustainable food consumption and healthy eating habits, etc.

➢ Agricultural policies account for 40% of EU budget.
➢ Common Agricultural Policy has strong binding force.

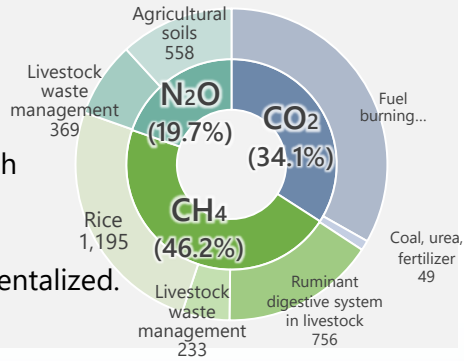
Green Food System Strategy (2050 goals))

- Zero CO2 emission in agriculture, forestry and fisheries
- 50% reduction in use of chemical pesticides
- 30% reduction in chemical fertilizer use
- Increase in organic farming to 25% of farmland

Emphasis on stable provision of food supply and multiple functions of agriculture amid challenges such as declining birthrate and aging farmers

Japanese agriculture have unique conditions in becoming carbon neutral

- GHG* emissions from production sector make up about 4% of total emissions, but nearly half are methane gas.
  40% of agricultural land is paddy fields.
- Carbon absorption by agricultural soil is a possibility.
- About 40% of farm income is price support through government's direct financial support and tariffs
- Greening of government subsidies is important.
- Land use reform is needed, but ownership is segmentalized.



Change in current food-related practices

- Change in consumer food choices. From eating meat to eating meat alternatives and to vegetarianism and veganism; prevention of food loss.

Sustainable aviation fuel (SAF)

- Increase in demand for SAF/biofuels due to International aviation agreements
- In Japan, economic participation of agricultural sector is a challenge.
- However, airlines expect effort from petrochemical industry.

*GHG: Green House Gas

Source: Ministry of Agriculture, Forestry and Fisheries, 2022. "Green Food System Strategy" https://www.maff.go.jp/j/kanbo/kankyo/seisaku/midori/attach/pdf/index-112.pdf

5. Insights gained from this fiscal year's activities

H-UTokyo Lab.

Even under rapidly changing geopolitical conditions, governance that accelerates climate and energy transitions supported by regional initiative while seeking new partnerships with the Asia-Pacific region is key.

1 Responses to current geopolitical crises define future pathways. Can governance mechanisms to accelerate systemic transitions be created?

- The EU and U.S. are accelerating climate change measures in the medium- to long-term under policy of ridding dependence on Russia. On the other hand, Japan is experiencing delays in public awareness and structural transformation.
- For rapid geopolitical transitions, governance that accelerates cross-sector transitions and integrated transitions will become increasingly important.

2 Amid climate change and rising fuel prices, can Japan lead international collaboration for climate and energy transitions in Asia-Pacific region?

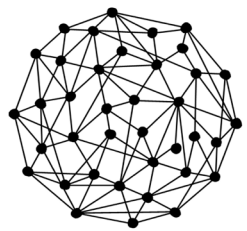
- In Asia-Pacific region, high energy and food prices also bring risk of reversing progress on decarbonation.
- Amid geopolitical transition, it is essential to secure supply chains for resources such as hydrogen and ammonia and rare metals and for carbon sequestration.
- Japan should lead multilayered international cooperation on climate and energy with Australia, which is strengthening climate measures, and Asian countries that are highly dependent on fossil fuels.

3 Can government empower agency of local actors in diverse natural environments to show different transition paths in different regions?

- Even In Japan, each region has different social issues, lifestyles, and energy potentials. Transitional paths are multidimensional.
- Should aim for prosperity centered on green transition of energy and food by supporting the building of capabilities of local actors (behavior agents) such as residents and local businesses.
- Adjustment capacity of energy on demand side is critical for improving efficiency and stability of regional energy. Digital innovation will play a major role.

4 Can government form consensus with people and businesses based on strategic industrial policy, while supporting the cooperation capabilities of local governments?

- The coordination capabilities of local governments are becoming increasingly important because of unprecedented challenges. Meanwhile, human capital, know-how, and the creation of cross-sectoral mechanisms are lacking.
- Based on its strategic industry policy, the government should overcome bureaucratic sectionalism and provide support to maximize the power of local communities.
- The national government and local governments should develop consensus-building platforms based on scientific data and open dialogue together with people and businesses.



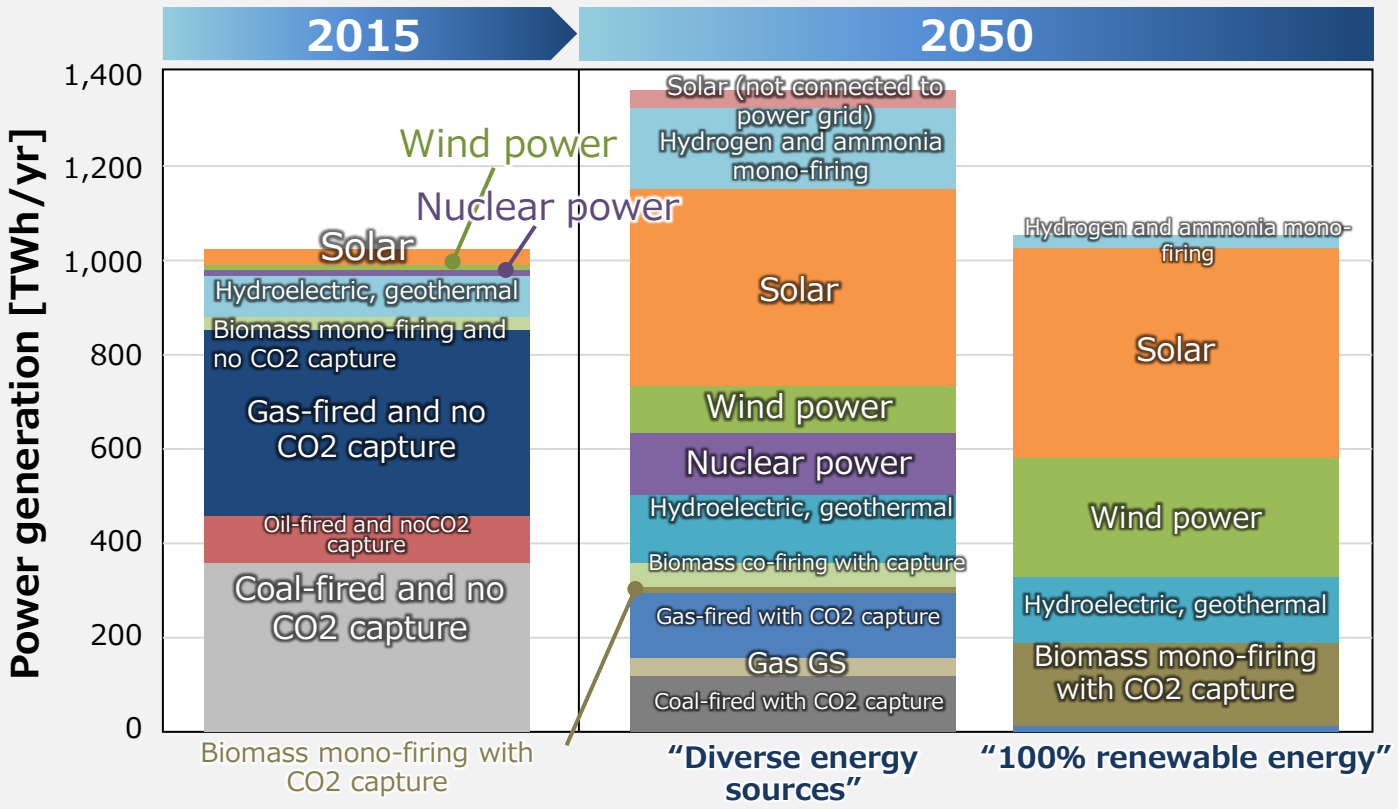
H-UTokyo Lab.

Supplement: Description of domains and scenarios for each future case

H-UTokyo Lab.

Description of domains and scenarios based on assumptions of (1) case of “diverse energy sources,” where diverse power sources, including fossil fuels, are used, and (2) case of “100% renewable energy,” where fossil fuel power generation are discontinued

Based on RITE (Research Institute of Innovative Technology for the Earth) 2021 report. Scenarios are described by selection two cases – “Reference values” =”Diverse energy sources” and “100% renewable energy」.”



Source: RITE “Scenario Analyses for 2050 Carbon Neutrality in Japan” (May 2015). Several other cases have also been analyzed.

Two cases: domains and scenarios

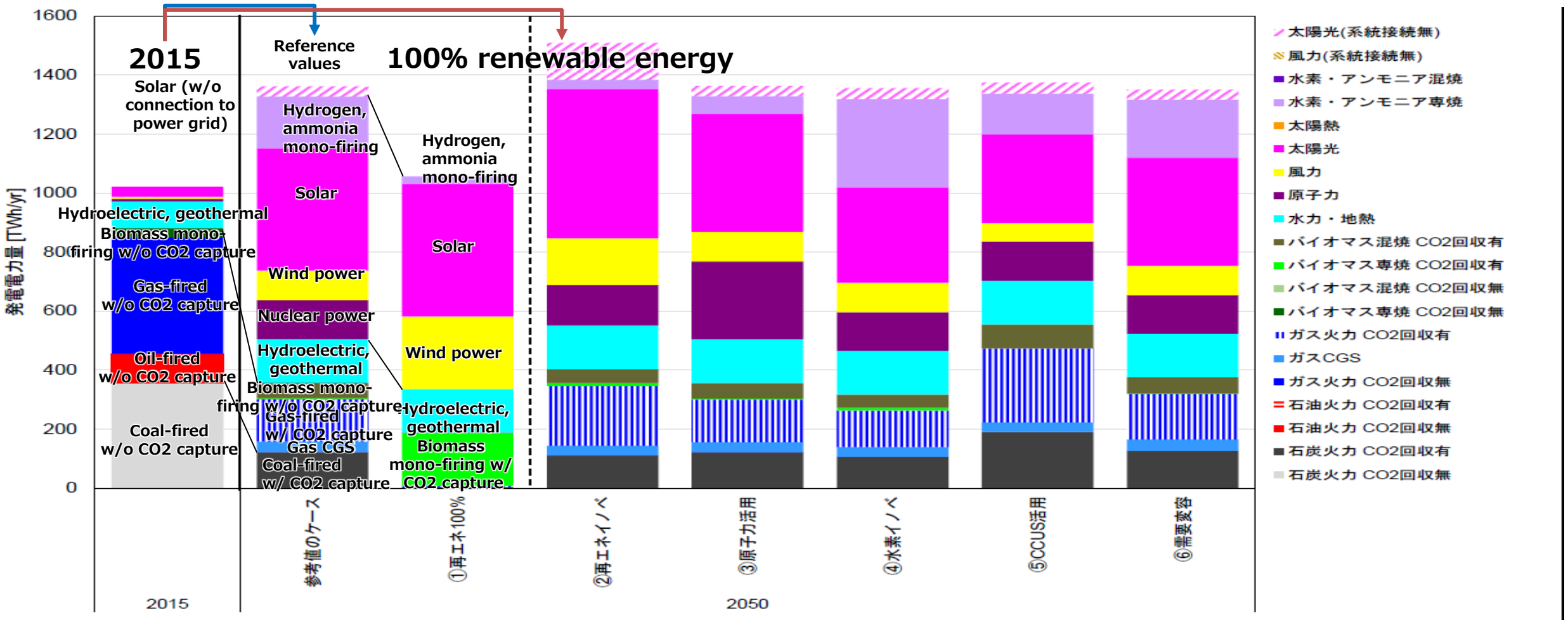
○:Implemented ●: This report

Category	Domain	Diverse energy sources	100% renewable energy
Electric power	Coal-fired thermal power	●	●
	Gas-fired thermal power	●	●
	Solar	●	●
	Wind power	●	●
	Hydroelectric, geothermal	○	○
	Biomass	○	○
	Nuclear power	●	●
	Hydrogen and ammonia	●	●
Industry	Steel	○	○
	Transport	○	○
	petrochemicals	●	●
Behavior modification		○	○
Integrated		○	○

Supplement: RITE reference value case assumptions

H-UTokyo Lab.

**RITE report (2020) assumes seven cases for the composition of power sources in 2050.
Our activities here focus on "reference values" and "100% renewable energy." We describe transitions to achieve them.**



Clean energy tech and critical minerals

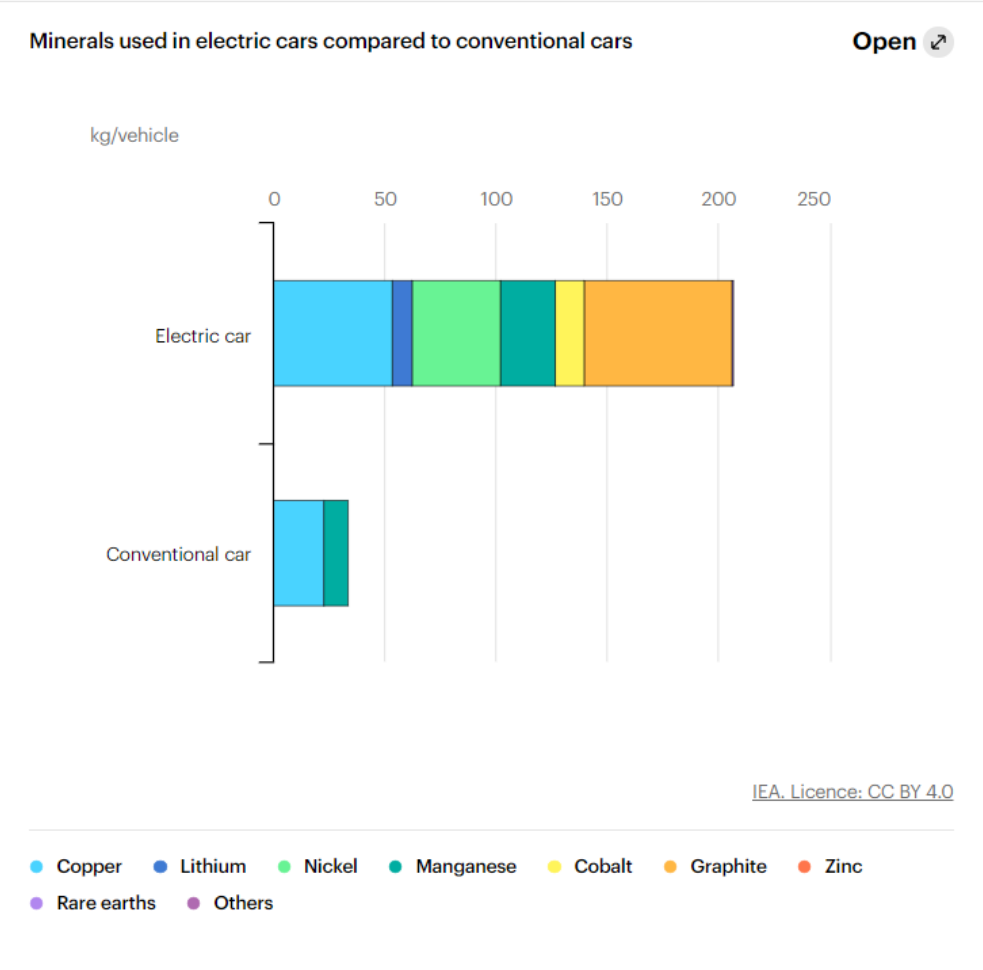


Fig. 1 Comparison of minerals used in electric and conventional vehicles

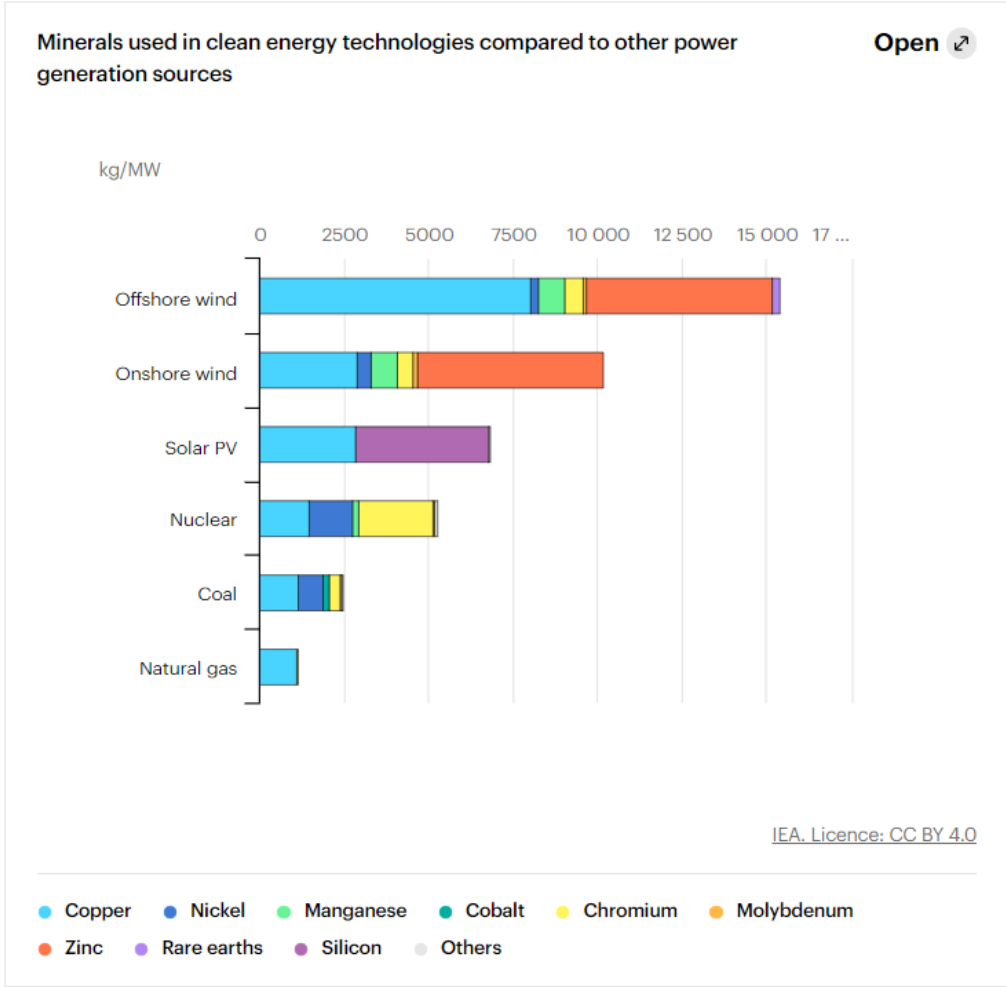


Fig. 2 Comparison of minerals used in clean energy tech and other sources of power generation

Source: IEA. 2021. "The Role of Critical Minerals in Clean Energy Transitions". https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary

Demand for minerals used in clean energy tech

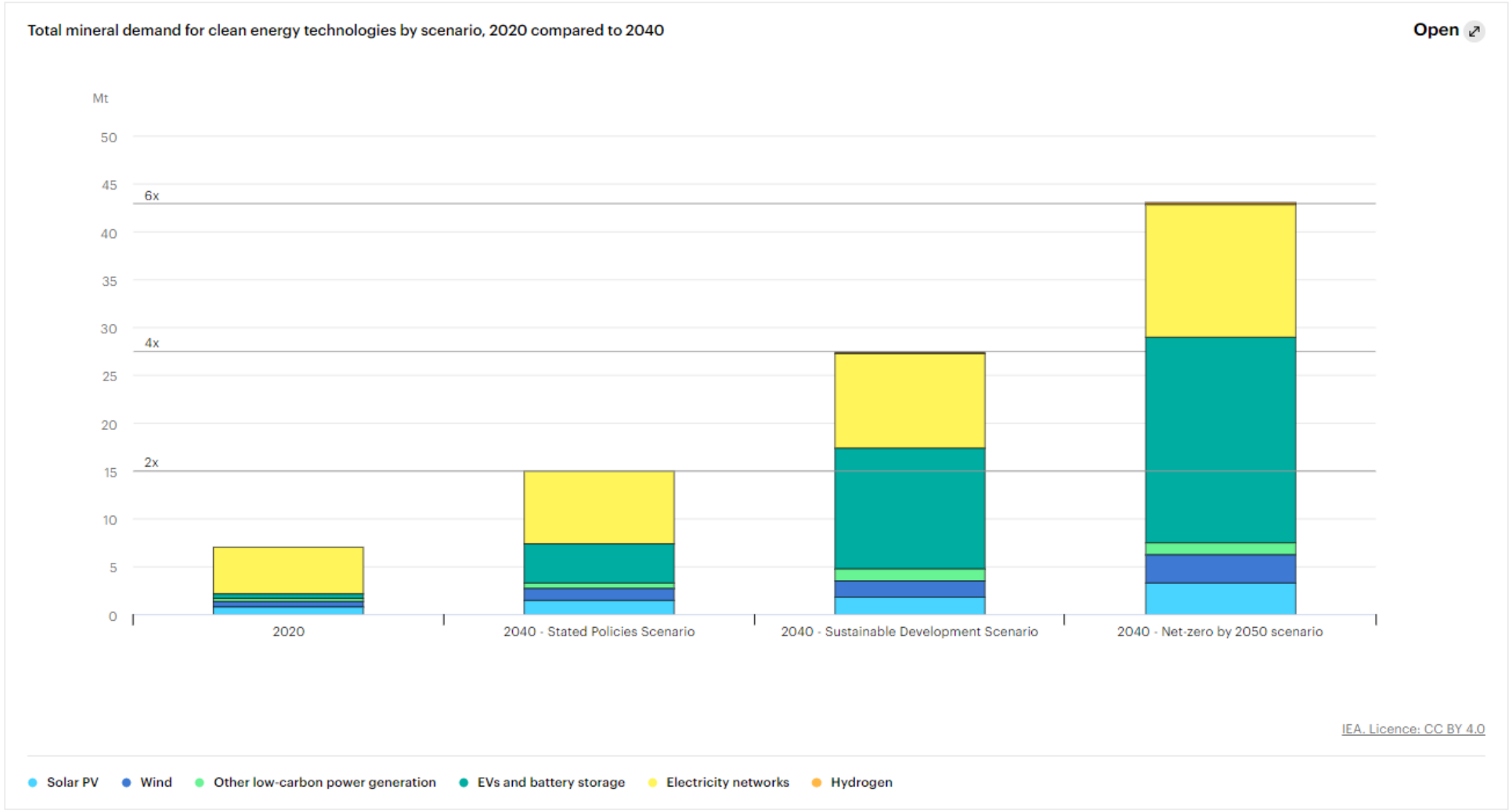


Fig. 3 Demand for minerals used in clean energy tech (in 2040, compared to 2020, by scenario)

Source: IEA. 2021. "The Role of Critical Minerals in Clean Energy Transitions". https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary

Growth in demand for minerals used in clean energy tech

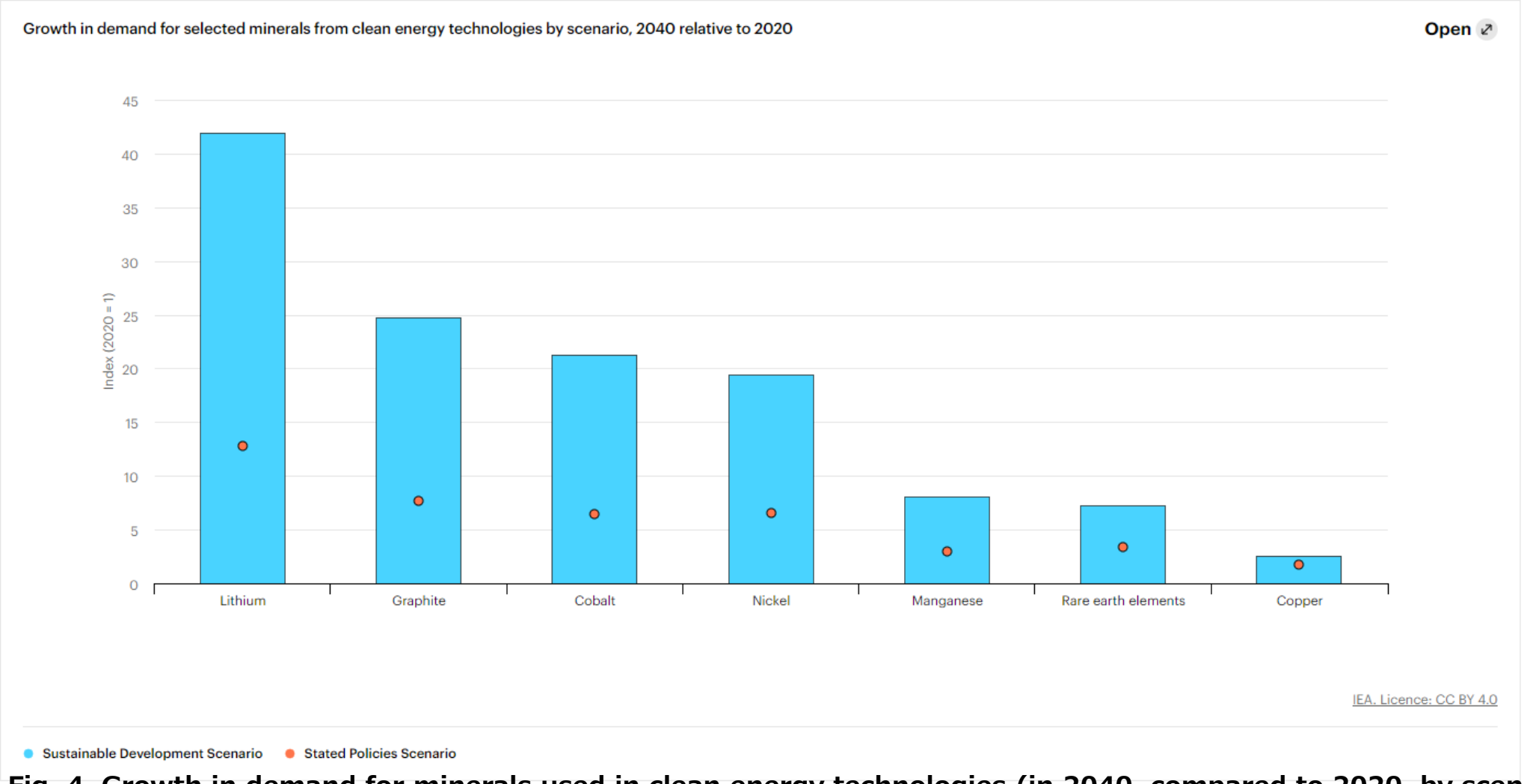


Fig. 4 Growth in demand for minerals used in clean energy technologies (in 2040, compared to 2020, by scenario)

Source: IEA. 2021. "The Role of Critical Minerals in Clean Energy Transitions". https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary

Share of major mineral and fossil fuel-producing countries

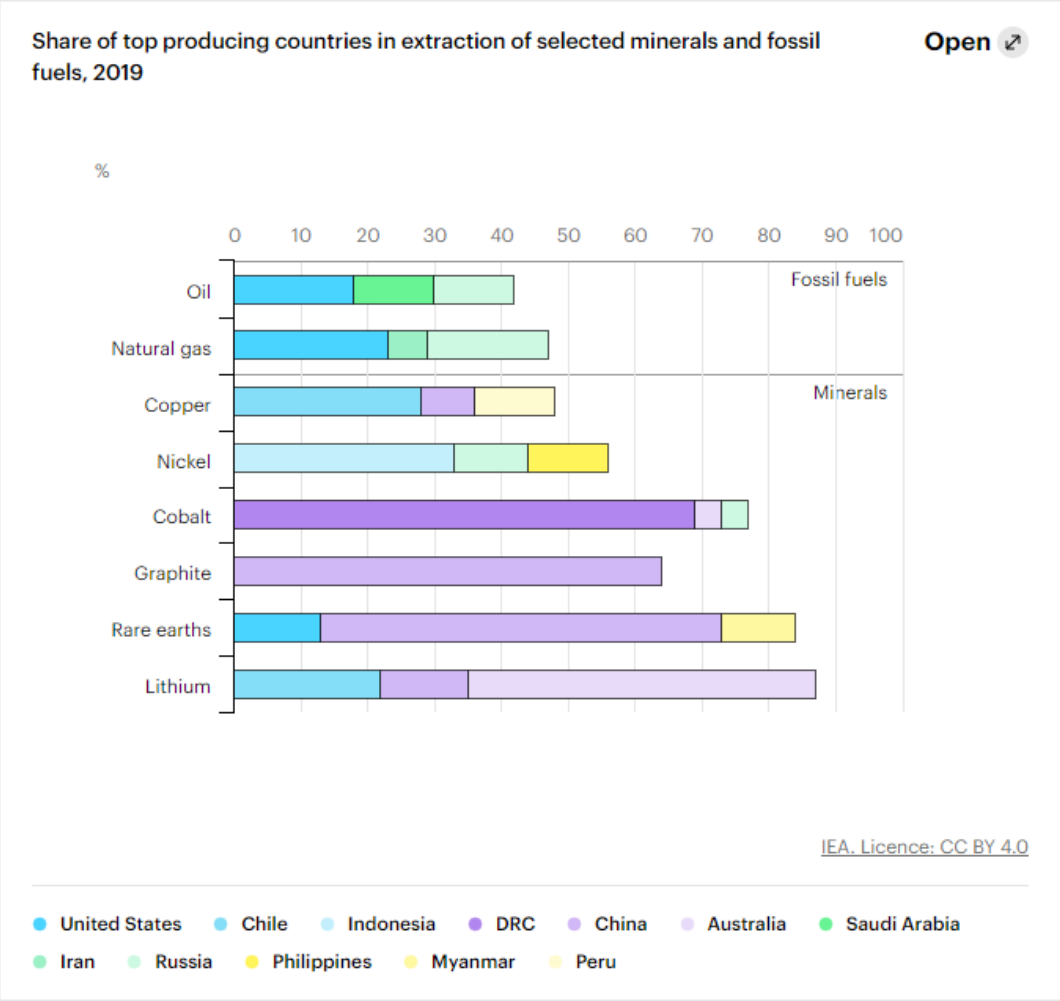


Fig. 5 Share of top export countries in mining minerals and fossil fuels (2019)

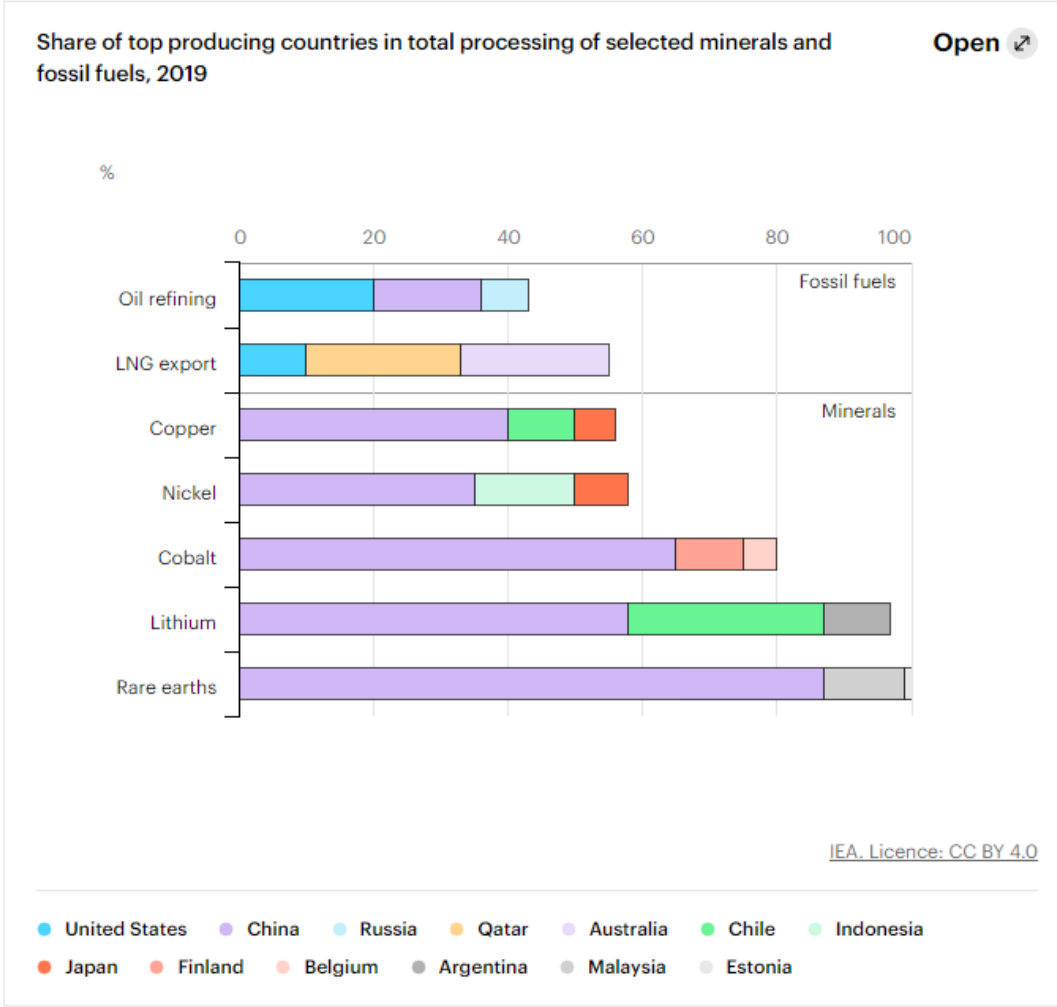
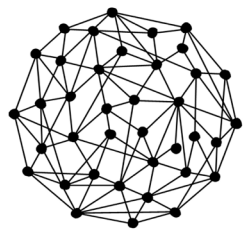


Fig. 6 Share of top exporting countries in processing minerals and fossil fuels (by volume) (2019)

Source: IEA. 2021. "The Role of Critical Minerals in Clean Energy Transitions". https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/executive-summary



H-UTokyo Lab.