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Challenges and Response Strategies for Energy Security Under the New Reality

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A new reality

- In recent years, climate change has been at the centre of energy and climate policy debates.
- But over the past year or so, the energy security crisis has never been greater.
  - Energy prices in Europe have soared since the middle of 2021 due to weather conditions (low temperatures in Spring 2021, prolonged wind deterioration) and unforeseen factors, such as a decline in natural gas supply due to breakdowns.
  - Russia invaded Ukraine in February 2022. Subsequently, Western countries decided to impose a (gradual) embargo on Russian energy. Russia responded by using its own energy exports as a weapon (Reduce export volume, take over assets).
  - Shortage of physical energy supply, especially natural gas, is a real threat.
  - International prices for all kinds of fossil fuels are at historic highs, in part because of the escalating geopolitical risks of conflict with no way out.
  - In some developing countries, soaring prices of imported energy have strained their finances and hindered fuel procurement.
- Energy security is the foundation of people's lives and all economic activities, and in the short term at least, securing energy supplies has become a top priority.
- However, there is no time to wait for action on climate change, and ***the question is how to reconcile energy security and climate action***.

Key points of this report

1. Energy security strategy in view of war in Ukraine and energy transition

- ✓ Japan needs to prepare for unforeseen circumstances while continuing to seek to maintain its procurement of Russian LNG. To avoid a "scramble under a zero-sum game", it is necessary to reacknowledge the role of LNG and the importance of upstream investment, and to take concrete steps to expand supply.
- ✓ In Asia, decarbonisation, which follows the process of first shifting from coal to natural gas, is considered a realistic path considering the amount of renewable energy available and the economics considering integration costs. If the promotion of natural gas and LNG investment becomes a reality, it will help stabilise markets and avoid the negative impact of Asia's energy transition on regional economies.
- ✓ Blue hydrogen and ammonia will play a major role in the decarbonisation of fossil fuels, but the high price of natural gas makes them uncompetitive. Therefore, it is necessary to stabilise the natural gas market to ensure the introduction of blue hydrogen and ammonia.

2. Strengthening stable power supply and importance of nuclear power generation

- ✓ In advanced countries, lopsided power generation mix and reduced supply capacity have increased vulnerability to risks such as heat waves, cold waves and earthquakes. The shortage of kWh caused by fuel shortages due to fuel price hikes and fuel supplier risk has also become a problem. Securing a stable supply has become an issue.
- ✓ With the growing importance of energy security, the role of nuclear power generation is being reviewed and new plans are being developed. Construction by China and Russia is currently dominant in the global market. Western companies are urged to apply the lessons learned from current projects.

3. Critical mineral issues in energy and economic security

- ✓ The supply and demand for critical minerals such as lithium may become tight as the introduction of electric vehicles, renewable energy and storage batteries increases. A multifaceted response is required to develop new mines, strengthen resource diplomacy, promote recycling, and develop technologies for non-use and reduced usage to ensure a stable supply. In addition, the supply and processing of critical minerals is highly dependent on specific countries, and diversification of the supply chain is also a challenge.

4. Economic impact of green investment

- ✓ In the real world, "green growth" may not be realised depending on the availability of funds and differences in industrial structures. How to limit negative economic impacts and how to even out the different impacts between economies and industries is important.

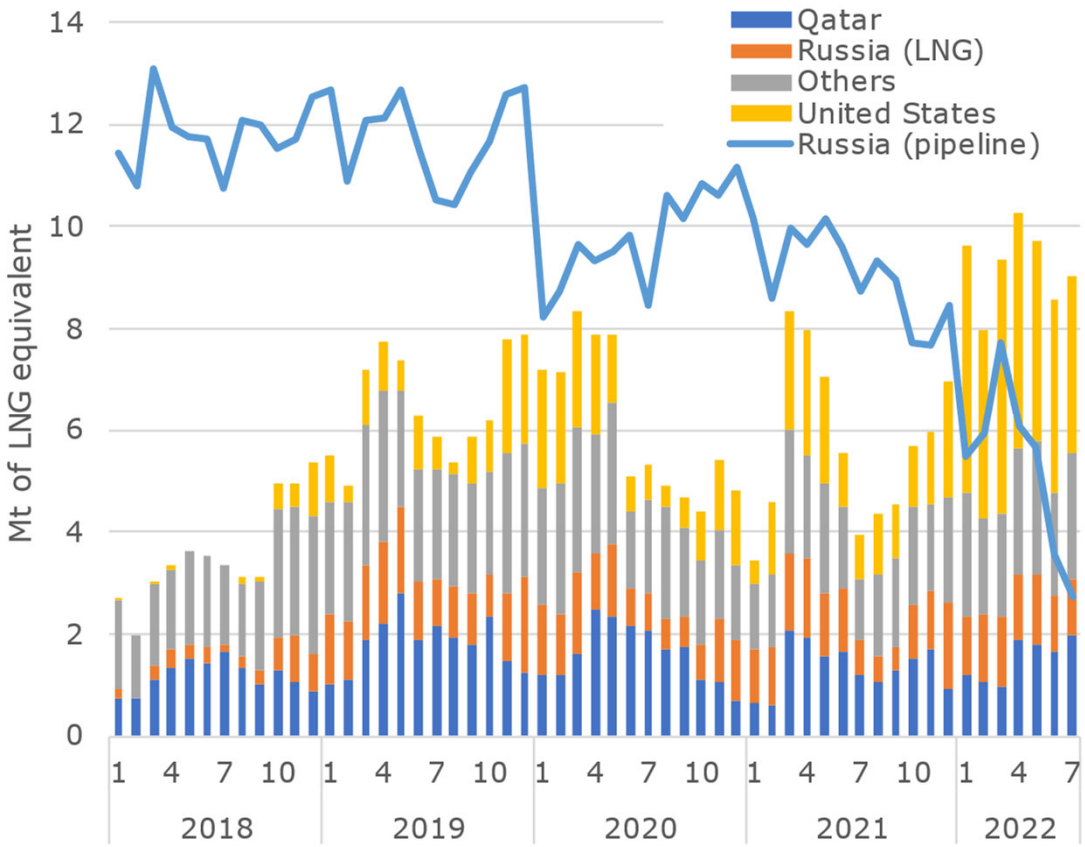
Structure of this report

1. Energy security strategy in view of war in Ukraine and energy transition
2. Strengthening stable power supply and importance of nuclear power generation
3. Critical mineral issues in energy and economic security
4. Economic impact of green investment

1.1 The challenges of response strategies toward ending dependence on Russian natural gas

- The European Union's policy of ending dependence on Russia is different from Japan's.
  - ✓ EU countries were highly dependent on Russian natural gas, but Japan's introduction of Russian LNG was more about source diversification.
- The EU is set to end its dependence on Russia by 2027, but it must ensure stable supplies until the time.
  - ✓ In the short term, they are exposed to Russia's threat amid uncertainty about securing alternative supplies.
  - ✓ This has led to a tightening of the global LNG market.
- For Japan, it is desirable to continue to secure Sakhalin 2 LNG both in terms of equity participation and supply.
  - ✓ Meanwhile, urgently needed to prepare for unexpected loss of equity participation and supply.

LNG and Russian Pipeline Gas Supplies to EU and UK



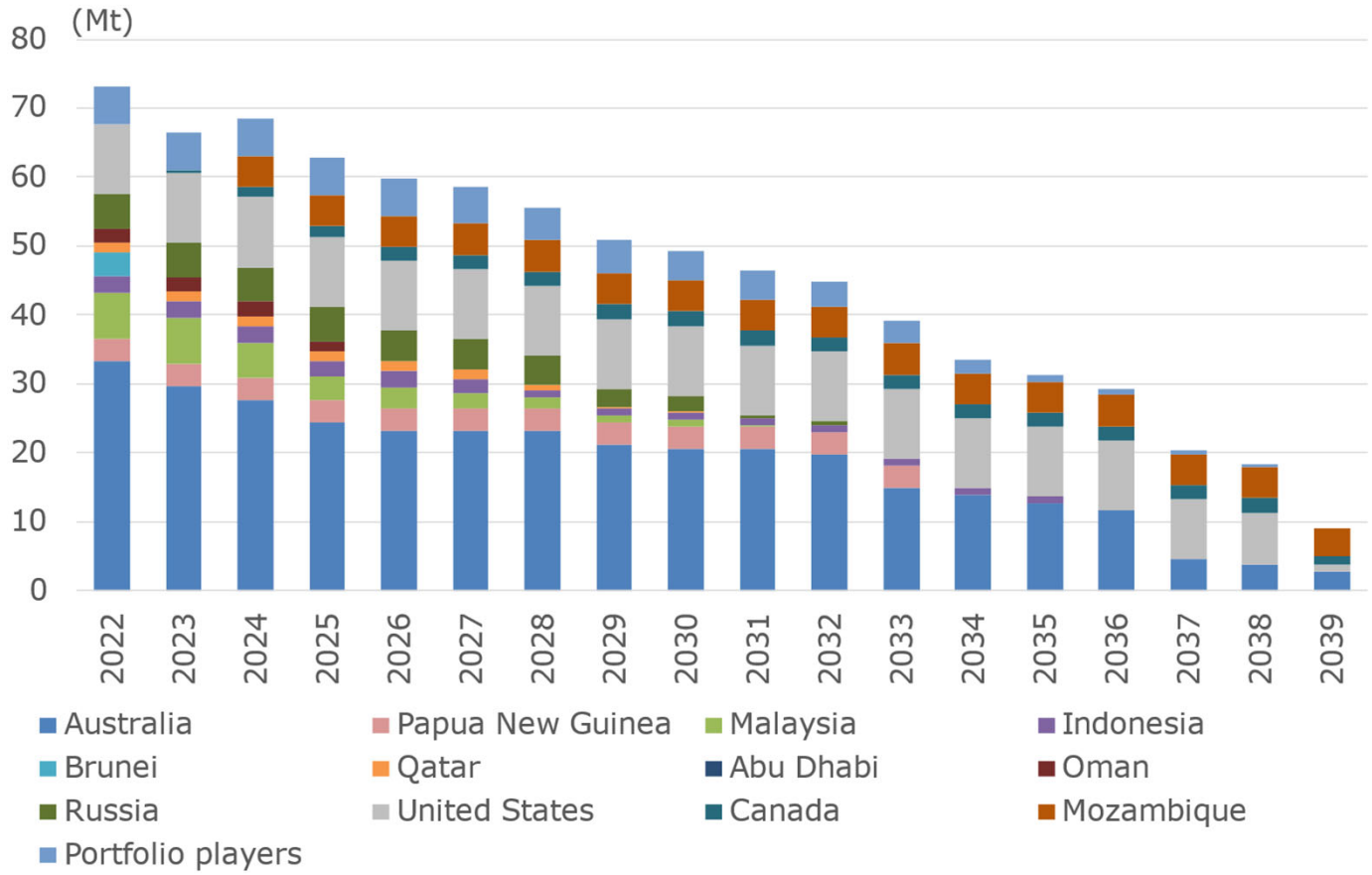
Source: Compiled from Cedigaz LNG Services, Eurostat, British trade statistics, and Gazprom

1.1 The challenges of response strategies toward ending dependence on Russian natural gas

[Measures for Japan]

- Until 2025, Japan is expected to secure supplies from other projects and portfolio players.
- From 2026 onward, it is vital to secure long-term LNG contracts from other sources including new projects, and to ensure investment to support these new projects.
- New development projects in Russia will recede. The path to restoring Russia's future credibility as an investment destination and source of import is even more distant.
- As a way of laying the groundwork for the future, clear message should be advocated that both investment and procurement from the project are legitimate rights under the contract and there is no reason to be threatened by unilateral Russian notification.

Prospect of existing LNG term contracts by Japanese companies



Source: Estimates based on various sources

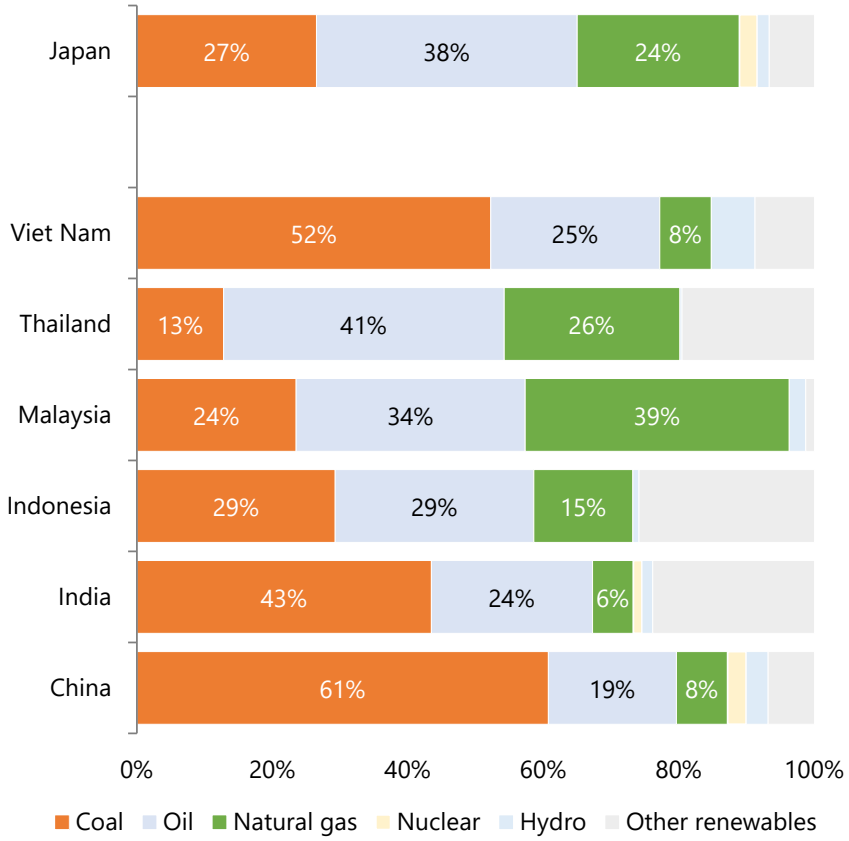
1.2 The role and challenges of natural gas in Asia's energy transition and energy security

- A growing number of Asian countries have also declared themselves carbon neutral (CN), but the roadmap to achieve this is unclear.

  e.g., China by 2060, India by 2070, Indonesia by 2060, Viet Nam by 2050

- The energy supply and demand structure of Asian countries is highly carbon intensive, and to realise CN, they need to re-structure energy system in the limited time frame of the next three or four decades.
- In addition, developing countries have unique challenges.
  - ✓ Energy demand will inevitably continue increasing in the future, necessitating a stable supply of large amounts of energy.
  - ✓ Cheap energy supplies are essential in light of protecting low-income people as well as industrial development,.
- Challenges exist in Asia's energy transition.
  - Renewable energy lacks strength to supply the fast growing energy demand.
  - Some countries have limited renewable energy availability.
  - There is a strong demand for energy affordability, and the cost of integrating variable renewable energy will become an issue.

Energy mix of major Asian countries



Source: Compiled from IEA "World Energy Balance 2022"

1.2 The role and challenges of natural gas in Asia's energy transition and energy security

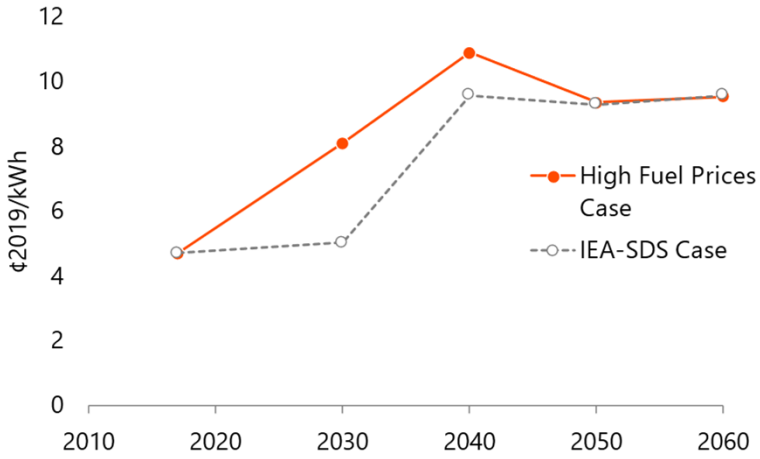
- A two-stage decarbonisation scenario that takes advantage of natural gas (*) could be a realistic solution for Asia, which faces the challenge of energy transition (see previous page). But there are challenges.

  * Can stably supply large amount of energy (high energy density). Can lower GHG emission by switching from coal.

Asian decarbonisation taking advantage of natural gas	Challenges of natural gas
Stage 1: Satisfy energy needs and achieve low carbonisation by switching from coal to natural gas Stage 2: Decarbonisation by commercialising various technologies under development (hydrogen, CCUS) as well as avoiding making natural gas asset stranded.	• The economics of natural gas has declined due to soaring prices. • There is concern that the role of natural gas will diminish as investments in other decarbonised energy increase if the price remains extremely high for an extended period of time.

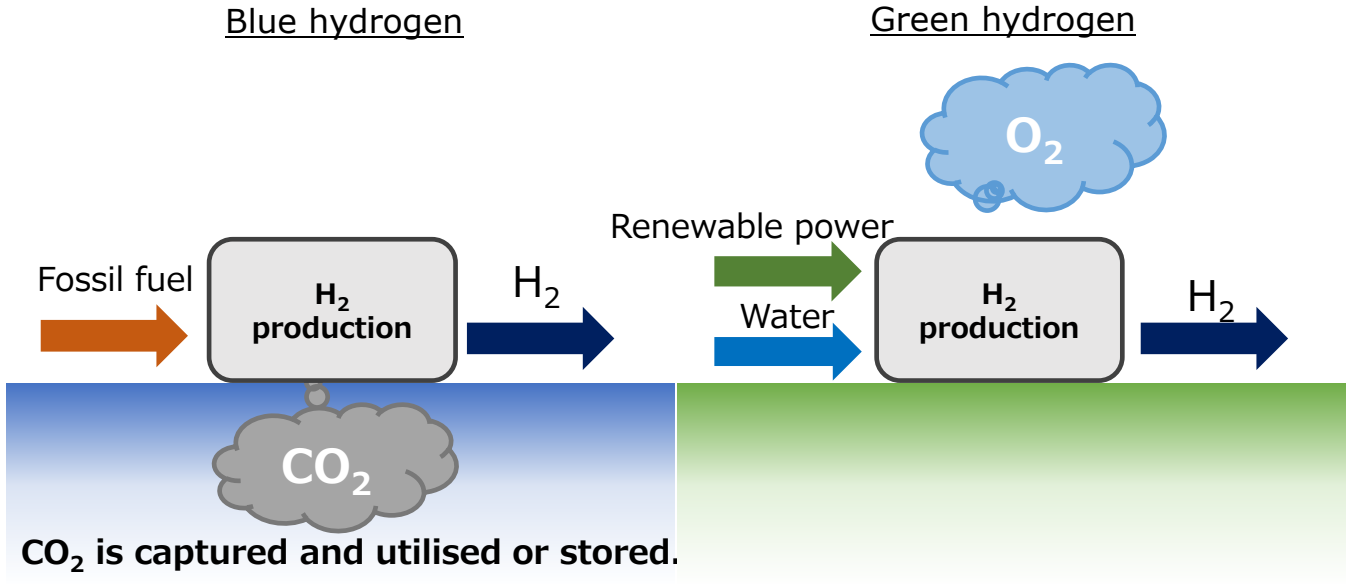
- Asia's energy transition/security will be more costly (right figure) and could weaken Asia's relative economic power against other region if constraints on natural gas investment trigger its high price.
- The promotion of natural gas and LNG investment will not only help to stabilise the markets, but will also contribute to curbing the cost of energy transition/security in Asia and averting negative impacts on the regional economy.
- Therefore, it is necessary to develop an environment for appropriate use of natural gas.
  - Clarify its role as a transition energy
  - Promotion of natural gas-related investment
  - Supporting technology to decarbonise natural gas (CCS, CCUS, hydrogen)

The impact of fossil fuel prices on the marginal cost of electricity in ASEAN



1.3 Importance of stabilising markets to decarbonise fossil fuels (natural gas)

- Blue hydrogen and ammonia play a central role in the decarbonisation of fossil fuels.
  - Blue hydrogen/ammonia is also expected to play a role in shaping the market in the early stages of hydrogen/ammonia introduction (Green hydrogen/ammonia is more difficult to implement early in terms of both quantity and price).
  - The natural gas market needs to be stabilised in order to ensure the introduction of blue hydrogen/ammonia because blue hydrogen/ammonia cannot be competitive to materialise the scenario when natural gas price is high.



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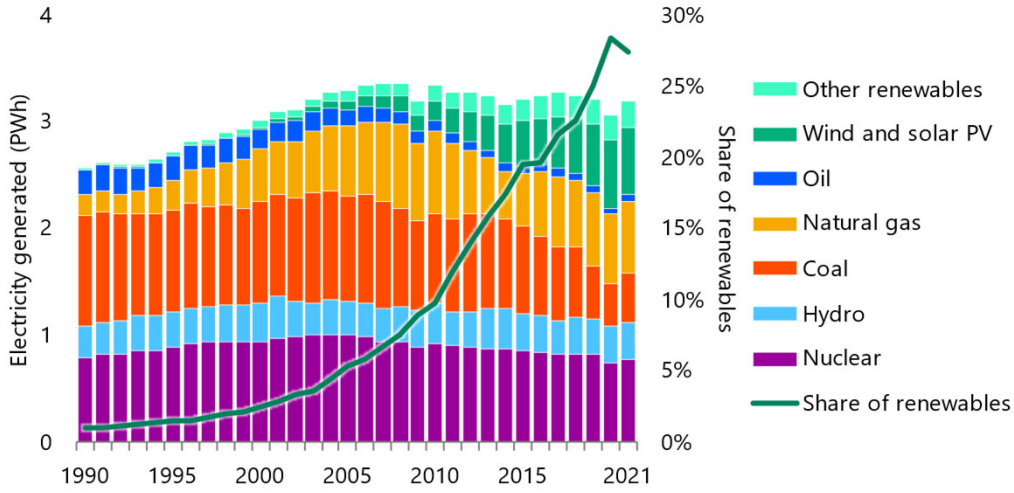
2.1 The challenges of stable electricity supply under market deregulation, mass introduction of REs and soaring fuel prices

- In advanced economies, the power generation mix has changed significantly throughout the 2010s due to delegulation of electricity market, the promotion of decarbonisation policies, the expansion of renewable power generation, and low primary energy prices through 2020, resulting in a downward trend in conventional power generation capacities. Overall, there is less reserve capacity and greater vulnerability to shocks.
- Electricity supply and demand becomes more vulnerable against external shocks such like heat waves, cold waves, earthquakes, and prolonged bad wind conditions. Examples include tight supply due to summer heat wave at the California ISO from 2020 to 2022, rolling blackout due to cold wave at ERCOT, Texas in February 2021, and tight supply in Tokyo area due to outage of power station due to earthquake combined with cold/heat wave in March/June 2022.

- In advanced economies, increasing number of country/region are introducing capacity markets, which are a mechanism to pay for the availability of supply capacity, to secure investment for new capacities as well as to ensure operation of existing capacities. But even in these countries, there have been cases in which they are fail to secure sufficient supply capacity at a time when demand actually increases.
- Withdrawal of power station for economic reasons is difficult to predict, making long-term reliability assessment difficult thereby investment in new power generation difficult. The United Kingdom is attempting to introduce technologies that can both decarbonise and provide a stable supply through a support mechanism that takes into account the characteristics of each next-generation technology. It is likely that similar policies will prevail among countries and regions.

Electricity generated by source in EU 28



Source: Compiled from IEA "World Energy Balance 2022"

2.1 The challenges of stable electricity supply under market deregulation, mass introduction of REs and soaring fuel prices

- In Europe, where many countries are abolishing coal-fired power generation as a policy in their efforts to decarbonise, wind power generation has become low in output since around the autumn of 2021, and wholesale electricity spot prices have soared due to rising natural gas prices. This, combined with war in Ukraine, has led to a protracted crisis. In addition, during the summer of 2022, a combination of heat waves caused power station to shut down and output to fall, further tightening the reserve capacity. A shortage of natural gas supplies from Russia heading into winter could lead to electricity shortages.
- In China and India, where the share of coal-fired power generation is high, planned power outage due to coal shortages also occurred in 2021 and 2022. In January 2021, wholesale electricity spot prices soared in Japan due to LNG shortages. These are all issues of "kWh shortage" associated with fuel constraints. The conventional kW shortage still needs to be addressed, but in addition, the kWh shortage also needs to be addressed.
- Until now, the adequacy of supply capacity (the possibility of a kW shortage) has been an indicator to assess supply stability. However, on the other hand, quantitative assessment of risk of a kWh shortage, including the risks in the fuel supply countries, is difficult. Quantitative assessment of the kWh shortage risk would be a major issue for future policy response.

2.2 Trends to promote nuclear power under the new reality and future challenges

- Nuclear power generation is promising as a zero-emission baseload power source. In addition, nuclear could play a role by taking advantage of its characteristics as the demand for energy security intensifies.
- In the case of the United Kingdom and France, to reach ambitious policy goal, bold measures are taken that diverge in part from the market deregulation policy. These policy examples may have important implications for Japan.

Examples in United Kingdom

<u>Adhering to the necessity of nuclear</u>

- The Government announced the Energy Security Strategy in early April 2022. The strategy includes an ambitious target for nuclear to cover 25% of electricity supply by installing up to 24 GW by 2050.
  - ✓ Nuclear, which is capable of stable power generation, is considered to have attracted renewed attention because the country is necessary to prepare for the situation in which the output of wind power, which is increasing every year, is not as expected, and it is also necessary to break away from dependence on fossil fuels, including natural gas, in the future.

<u>Supporting measures</u>

- A review of the support mechanism (so called RAB model) is under consideration to promote the investment for new reactors.
  - ✓ The current mechanism (Contract for Difference, CfD) is designed to support only when power station start operation, and it does not sufficiently contain the uncertainty of nuclear project, which requires large investments and long construction period before generate a profit.

Examples in France

<u>Strategies based on a long-term perspective</u>

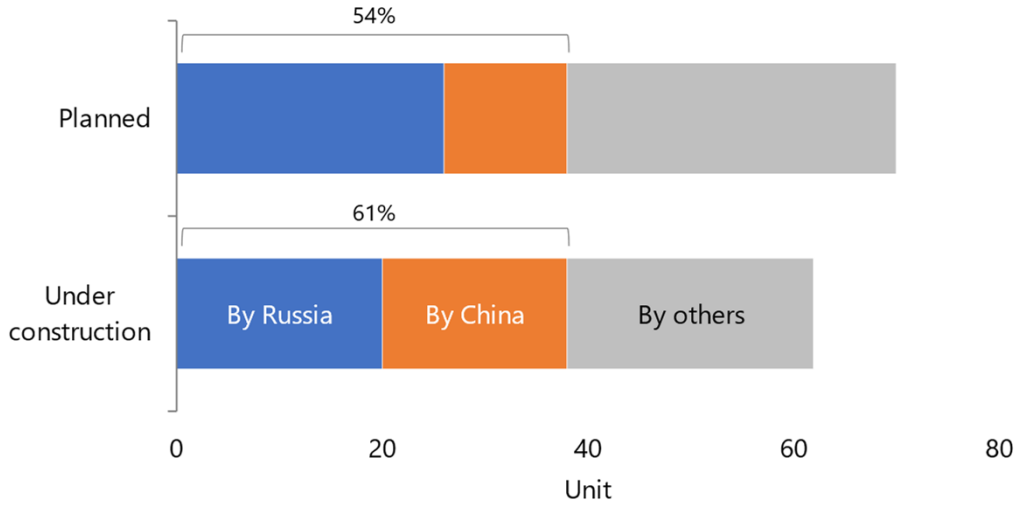
- In February 2022 (before the Russian invasion of Ukraine), President Emmanuel Macron said at least six of the next generation of the European pressurised water reactors (EPR 2) would be built and eight more would be considered.
  - ✓ This strategy is sought to be based on the results of an analysis published in October 2021 by transmission system operator RTE.
  - ✓ Scenario analysis of the long-term power mix. The study resulted to identify that achieving carbon neutrality without new nuclear power capacity is unrealistic, and that the total cost of the electricity system, including integration costs, is cheaper in a scenario where assumes the addition of nuclear capacity.
- Planning and implementation based on the long-term perspective is ideal since decision-making and construction of nuclear power takes a long time.

<u>Strengthening the state-led implementation system</u>

- In July 2022, Prime Minister Élisabeth Borne announced a plan to fully nationalise power giant Électricité de France (EDF) in order to make a strong push for decarbonisation.

2.2 Trends to promote nuclear power under the new reality and future challenges

- China and Russia dominate the world nuclear market (figure), although there is a trend away from dependence on Russia.
  - Finland cancelled its contract to build the Hanhikivi 1
  - Ukraine plans to install nine Westinghouse-built light water reactors.
  - Poland has established partnerships with U.S. and French companies.
  - On the other hand, construction of Russian nuclear reactors is underway in China, India, Turkey, Bangladesh, Hungary, Egypt and other countries.
- Delays and cost overruns have been seen in new development of Western countries in recent decades due to a sharp decline in the number of new projects and the loss of construction know-how.
  - Growing emphasis on energy security alone cannot ensure Western companies to seize business. The key is whether they can take advantage of the lessons learned from current projects.



World's under construction and planned nuclear reactors (As of 1 January 2022)

Source: Compiled from "World Nuclear Power Plants" (2022 edition) of Nuclear Power in the World, published by the Japan Atomic Industrial Forum.

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Analysis framework

- Analysed supply and demand balance of critical minerals.
  ➔ Comparing supply and demand, and comparing cumulative demand and resource reserves + recycled supply as time series (up to 2050)

Subjected technologies and minerals

- Carbon neutral (CN) technologies: renewable energy, stationary storage batteries, electric vehicles, fuel cell vehicles, water electrolysis, etc. (decreases in mineral demand due to abolish of conventional technologies are also considered. Demand for non-carbon neutral technologies also considered)
- Critical minerals: Copper, lithium, nickel, cobalt, graphite, silicon, dysprosium, neodymium, platinum, palladium, rhodium, and vanadium

Methodology

- Demand = Amount of CN technology installed × Mineral resource intensity of technology
  − Conventional technology to be replaced × Mineral resource intensity of technology.
- Supply = Mine production + Recycling supply.
  Production from mine = *f*(mine development stage, production capacity),
  Recycled amount = Waste amount × Product recovery rate × Recycling rate.

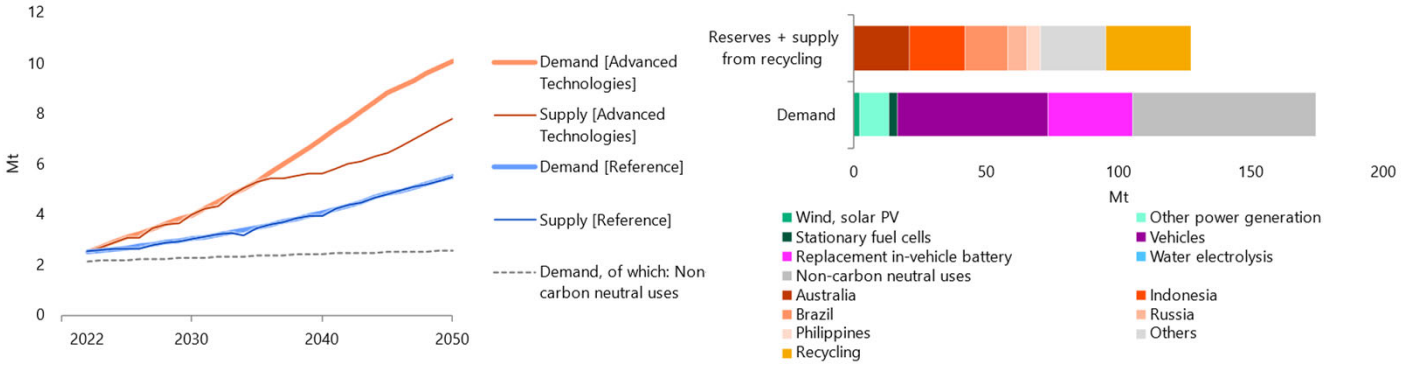
Analysis: example of Nickel and Lithium

Supply-demand outlook

Comparison of cumulative demand and reserves (+ recycled supply)

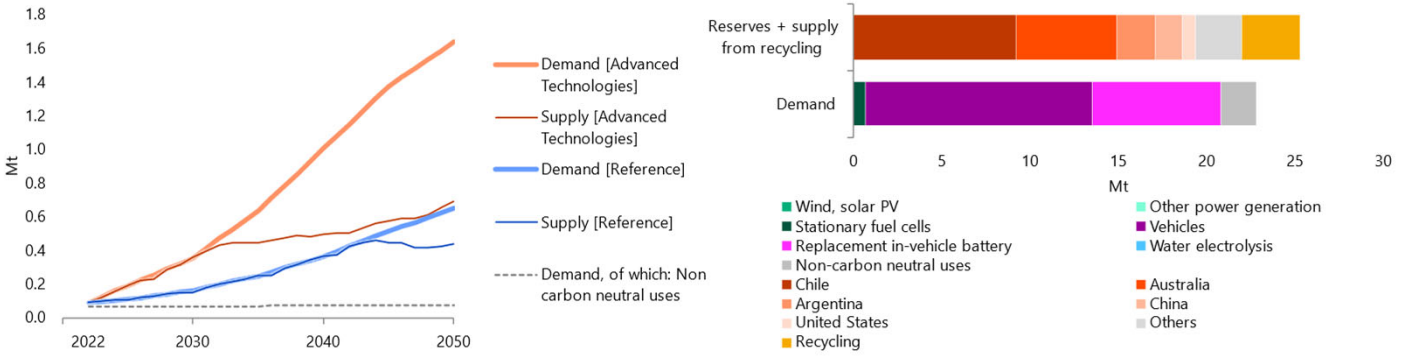
Nickel (Ni) (used in lithium-ion batteries)

- 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 in ATS through 2050 will be slightly below reserves (+ recycled supply).



Uneven distribution of critical minerals

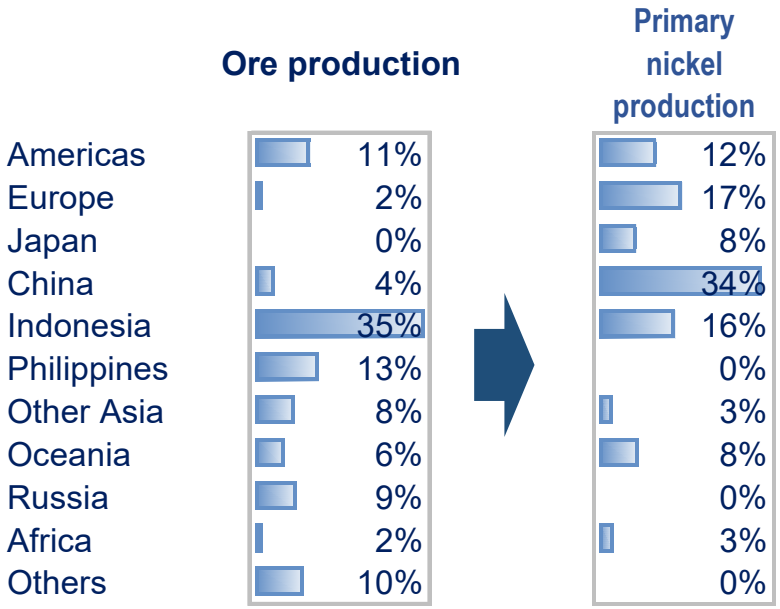
- Reserves of many critical minerals are unevenly distributed around the globe.
- However, geographical distribution of reserves and downstream processes is often different. For example, Indonesia has the largest share of nickel production, while China has the largest share of primary nickel production after refining.

Country-wise share of reserves

	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%

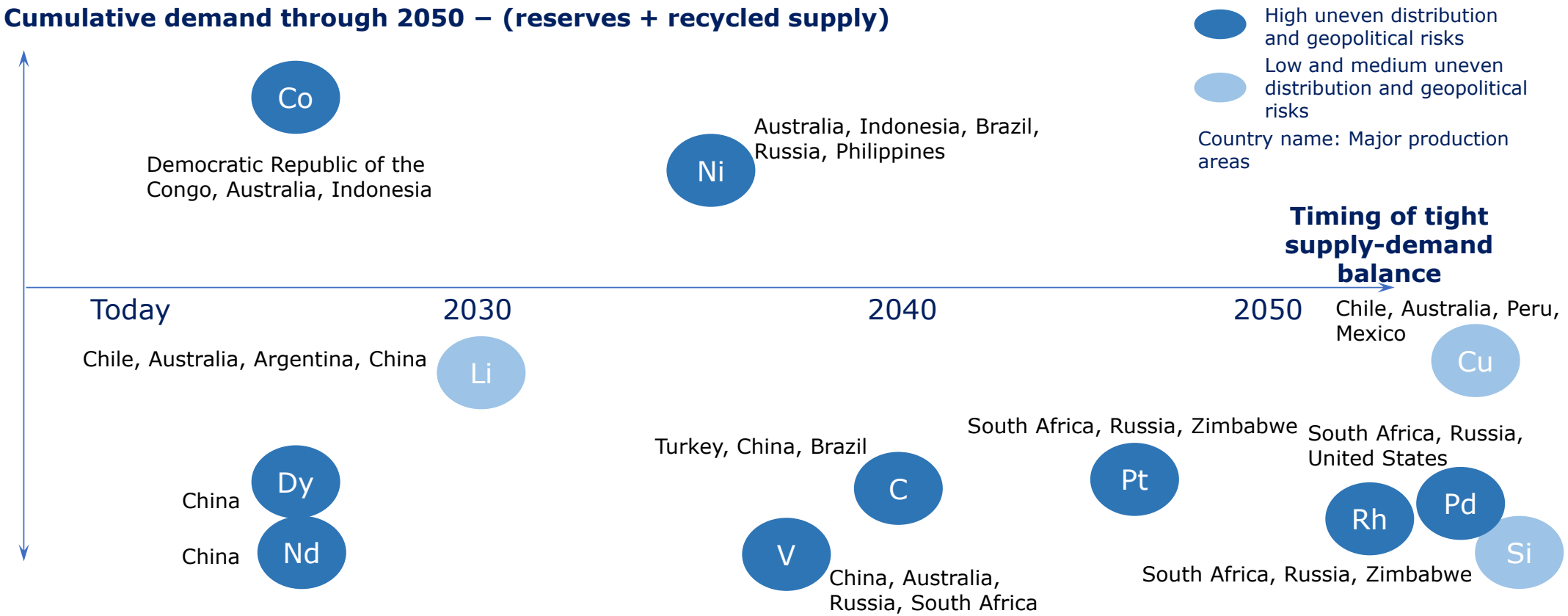
Note: Compiled from USGS Mineral Commodity Summaries 2022

Country-wise production share of ore and primary nickel (2019)



Supply and demand balance (Advanced Technologies Scenario)

- Reserves + recycling < Cumulative demand (until 2050): Nickel and cobalt
- Early supply shortage concerns: lithium, cobalt, neodymium and dysprosium
- Uneven distribution and geopolitical risks: nickel, cobalt, graphite, platinum-group metals, neodymium, dysprosium and vanadium



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

Reference: Major uses of critical minerals

Ore	Major uses
Cu (copper)	Wind power generation, solar photovoltaics power generation, electric vehicles, batteries. However, it is often used outside of CN technology.
Li (lithium)	Lithium-ion battery
Si (silicon)	Solar PV. However, it is often used outside of CN technology.
Ni (nickel)	Lithium-ion batteries. However, stainless steel and heat-resistant steel are the main applications.
Co (cobalt)	Lithium-ion batteries, special steel
C (graphite)	Lithium-ion batteries, metal crucibles, molds, electric furnace electrodes, etc.
Pt (platinum)	Exhaust gas catalysts for automobiles, electrocatalysts for fuel cells and water electrolysers
Pd (palladium)	Exhaust gas catalysts for automobiles, electrocatalysts for fuel cells and water electrolysers
Rh (rhodium)	Exhaust gas catalysts for automobiles
Nd (neodymium)	Electric vehicle motors, magnets in wind power generators
Dy (dysprosium)	Electric vehicle motors, magnets in wind power generators
V (vanadium)	Electrolyte for redox flow batteries. Other than CN technology, additives to steel are main.

Response required

- Under the Advanced Technologies Scenario, the cumulative demand for nickel and cobalt by 2050 will exceed the reserves (+ recycled supply). Also, demand for lithium, cobalt, neodymium and dysprosium will exceed supply by around 2030.
- With respect to these critical minerals, it is necessary to develop technologies that contribute to increasing the recycling rate, in conjunction with increasing production at existing mines and developing new mines.
- In order to secure critical minerals, it is necessary to develop recycling, non-use and reduced usage technologies, as well as acquisition or rights and long-term purchase contracts. Diversification of critical minerals is also important.
- Currently, the supply of critical minerals is an oligopoly of several countries. The introduction of new regulations and tax regime on resource development and exports in producing countries may cause supply constraints for demand countries. Therefore, it is necessary to pay close attention to the policy trends of producing countries. Diversification of the supply chain is also an issue to be addressed, since processing such as refining is concentrated in specific countries such as China.
- There are uncertainties in policies of resource producing country, prospects for developing technologies for recycling, non-use and reduced usage. Therefore, it is important to balance technology choices from the perspective of energy and economic security and the sustainability of critical minerals.

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Background of the analysis

Last year, IEEJ Outlook 2022 raised issues that should be considered during the course towards carbon neutrality.

- "Green growth" is expected, in which investments in climate action will form a virtuous cycle of emissions reductions and economic growth, but the effects may vary by economy and actor.

- That can create new gaps: (1) disparities among advanced economies and among developing economies, (2) disparities between advanced and developing economies, (3) disparities between economies that depend on fossil fuel exports and those that do not, and (4) disparities among citizens.

In this background, "IEEJ Outlook 2023" provides a quantitative assessment of how climate change investment (green investment) impacts countries or regions, and what disparities may arise.

Analytical method

- Quantitative assessment of the impact of green investment* on national economies

* Regard difference of investment in the Advanced Technologies Scenario to the Reference Scenario.

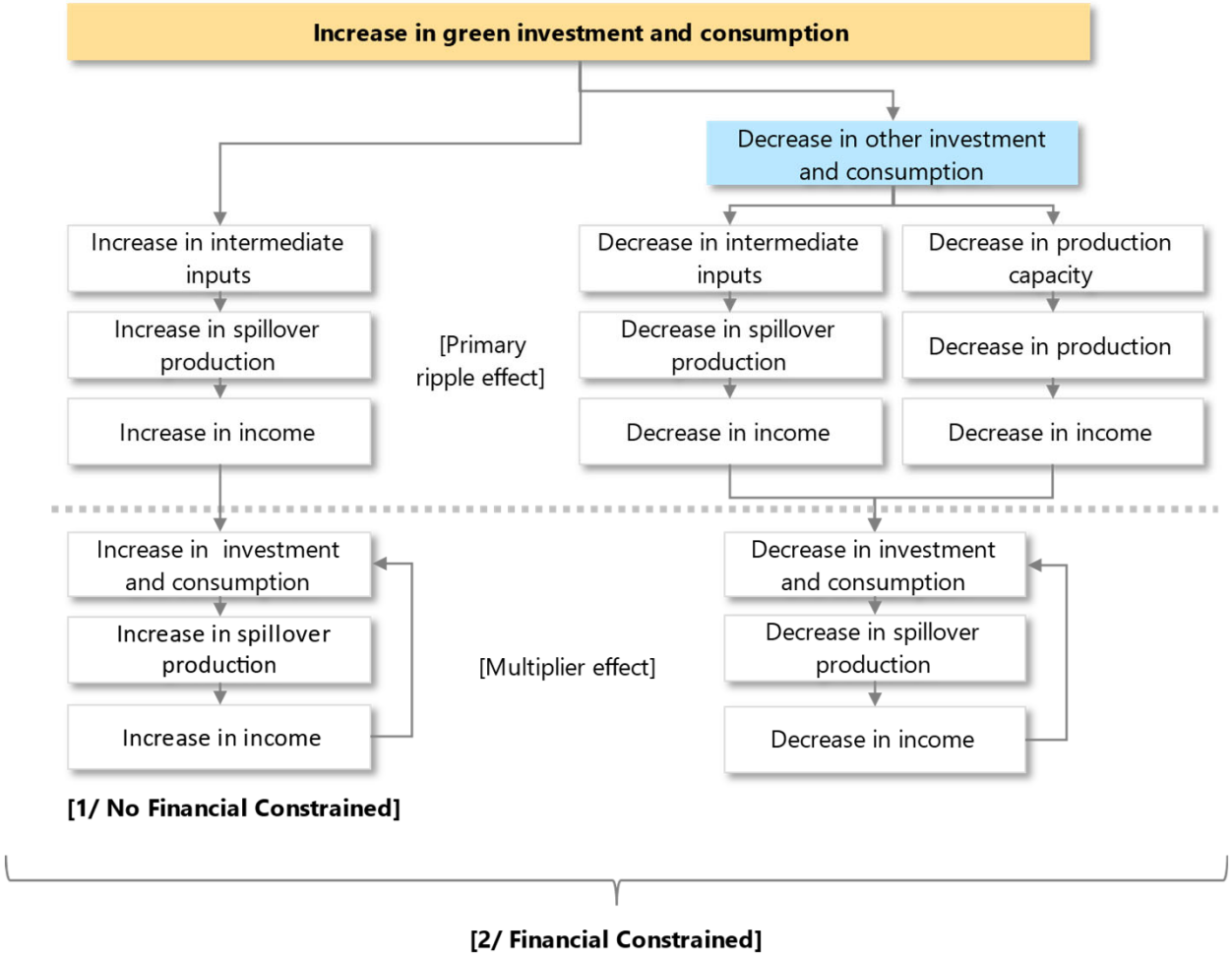
«Case settings»

1/ No Financial Constrained Case

Additional green investment will have a positive spillover effect as well as multiplier effect through 1) an increased demand ➔ 2) Increased income ➔ 3) increased consumption
(This case represent common concept of green growth)

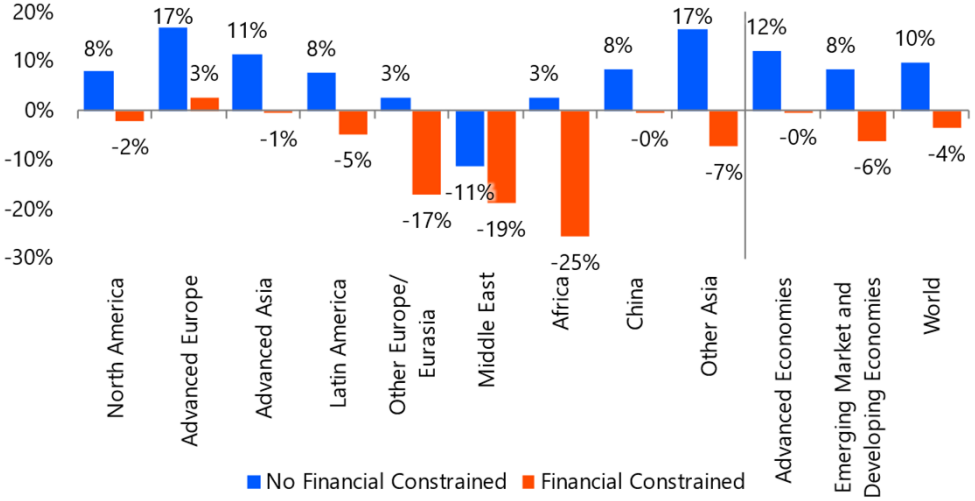
2/ Financial Constrained Case

Since funds have a constrain, the amount spent on green investments reduces other investments. Furthermore, since green investment itself is not an investment to expand production capacity, it is also considered that production and income will decrease through a decrease in production capacity due to a decrease in other investments.



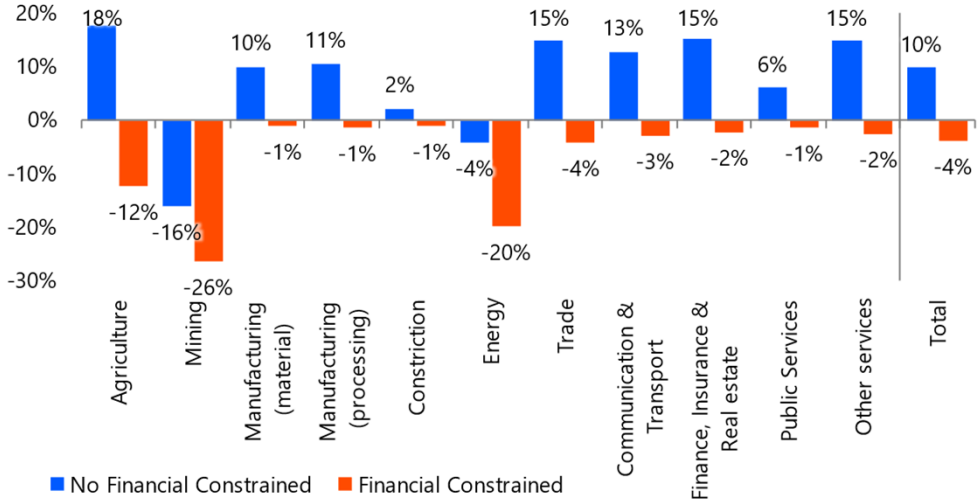
Green growth is unlikely when there are constraints in funds

Changes in production in 2050
(By region. Compared to Reference Scenario)



- Without financial constraints, global production would increase by 9.8%, while with constraints it would decrease by 3.7%.
- Regardless of financial constraints, the production value will decline in economies such as the Middle East, which is highly dependent on mining (fossil fuels).
- Advanced economies are more likely to enjoy green growth, while developing countries are not.

Changes in production in 2050
(By industry. Compared to Reference Scenario)



- Regardless of financial constraints, the production value of mining and energy supply related to fossil fuel will decrease.
- GDP accelerates by an average of 0.4% a year without financial constraints and decelerates by 0.1% with constraints
  (IEA analysed acceleration of 0.4% in the 2020s in their Net Zero Emissions by 2050 Scenario *).

* IEA (2021), Net Zero by 2050 - A Roadmap for the Global Energy Sector

Conclusion

- Although “green growth” is expected in green investment, many economies are unable to enjoy it if there are financial constraints.
- Regardless of financial constraints, advanced economies are more likely to enjoy green growth, whereas emerging and developing economies are not. In the real world, there are advanced economies with money to spare and developing economies without money to spare, and the economic gap between the two can become wider.
- In order to raise funds smoothly, it is necessary to utilise green finance, which mainly consists of private funds, as well as government budgets. It is important to clarify the direction of environmental policy in order to limit risks and encourage investment.
- Regardless of financial constraint, economies highly dependent on fossil fuel exports are negatively affected. It is necessary to break away from dependence on the fossil fuel industry, and re-education (reskilling) of workers will be important for smooth labour movement from declining industries to other industries.
- In a world striving for a low-carbon society, new disparities between economies or industries may arise. It is important to limit negative economic impacts and to even out the different impacts among economies and industries. If the availability of funds lead to greater inequality, it is also necessary for advanced economies to provide financial support to emerging and developing economies that cannot afford it.

Thank you for your attention.

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