

Analysis of Future Scenarios for ASEAN Mobility

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1. Introduction

Against the backdrop of accelerating climate change measures in recent years, there has been progress in the decarbonization of power sources and the electrification of powertrains. This trend is not limited to developed countries. In developing countries, governments and the automotive industry are making efforts to popularize battery electric vehicles (BEVs), including two-wheelers and three-wheelers. While decarbonization efforts have been underway in the transportation sector, Russia's invasion into Ukraine in February 2022 has heightened interest in economic security, including stable energy supply, in both developed and developing countries. In particular, what economic and industrial policies each country will adopt in light of the Russian invasion into Ukraine is attracting a great deal of attention as the current industrial structure, including the automotive industry, is supported by global supply chains.

In light of this situation, we have held a workshop¹ to examine the pictures of the future energy supply structure and automotive industry using a scenario planning approach². The following overviews of the scenarios are compiled based on the workshop. Although the workshop developed global and regional scenarios, this paper outlines regional scenarios for the Association of Southeast Asian Nations (ASEAN). It should be noted that ASEAN in this report represents Indonesia and Thailand.

2. Approach to scenario formulation

- The scenarios cover the period from 2022 to 2050. As a result of discussions at the workshop, we selected two driving forces – whether climate change measures will be enhanced (in each country) by 2030 and whether each country will strengthen its policies that emphasize economic security by 2025 to 2030 – in depicting scenarios. Using these two driving forces, we developed a quadrant for depicting scenarios.
- The world population is assumed to increase in all scenarios. Based on the United Nations' World Population Prospects for 2022, Central and South Asia and Sub-Saharan Africa will account for most of the population growth through 2050. In developed countries, the population will age

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¹ The researchers participating in the workshop (posts at the time of the workshop) are as follows: Ken Koyama (Senior Managing Director and Chief Economist), Ichiro Kutani (Senior Research Director, Strategy Research Unit), Yoshikazu Kobayashi (Executive Analyst, Fossil Energy and International Cooperation Unit), Takahiko Tagami (Executive Analyst, Global Environment Unit), Yoshiaki Shibata (Executive Analyst, Electric Power Industry & New and Renewable Energy Unit), Shigeru Suehiro (Executive Economist, Energy Data and Modelling Center), and Kei Shimogori (Senior Researcher, Strategy Research Unit).

² Scenario planning is an approach for examining images of different futures that are highly uncertain. When considering the future picture of a specific problem area, various factors influence the future picture. The approach extracts the most important and highly uncertain factors among them and logically depicts completely different future world pictures according to different developments of the factors. In this sense, the approach does not represent a simple extension of the current situation or a future prediction based on trend analysis, but different future scenarios that are potentially and logically consistent, with the aim of contributing to strategic decision-making on responses and policies for different scenarios.

further.

- Against the backdrop of population and economic growth, the frequency and amount of movement of people and goods will increase. The two selected driving forces basically have negative effects on the movement of people and goods. However, the domestic cargo movement frequency alone will increase due to e-commerce growth amid smart city development. The frequency and amount of movement of people and goods (ton-kilometers and person-kilometers) are assumed to increase in Scenario 3, remain unchanged from the present level in Scenarios 2 and 4, and decrease in Scenario 1.
- As the world moving toward decarbonization is politically correct, Europe and the U.S. Democratic Party, which have traditionally led climate change measures, are expected to accelerate the allocation of resources to green investment and climate change measures while remaining interdependent under a plan to focus policy (government) and finance (investors) on decarbonization. Specifically, a scenario in which climate change measures are enhanced aims to achieve the 1.5°C target, while a scenario in which these measures stall will continue low-carbonization initiatives, though failing to achieve the 2°C target. In addition, the electrification of energy demand will progress in all scenarios.
- The degree of emphasis placed on economic security in each country will influence progress in the division of the world into trading blocs and in the fragmentation of the global trading system. The key point here is the U.S. move (whether the United States will manage its relationship with China or intensify confrontation with China in a manner to accelerate its emphasis on economic security). The division of the world into trading blocs here refers to a situation where free trade will be maintained in each bloc, with production and supply completed within each bloc as much as possible. The high cost incurred as a result of the division of the world into blocs will be accepted as a cost for security. In a world in which geopolitical confrontation will be managed or eased, the global free trade system and the global division of labor will be promoted to develop optimum supply chains. In such a world, however, international competition will become more intense, widening gaps between industries and between companies.

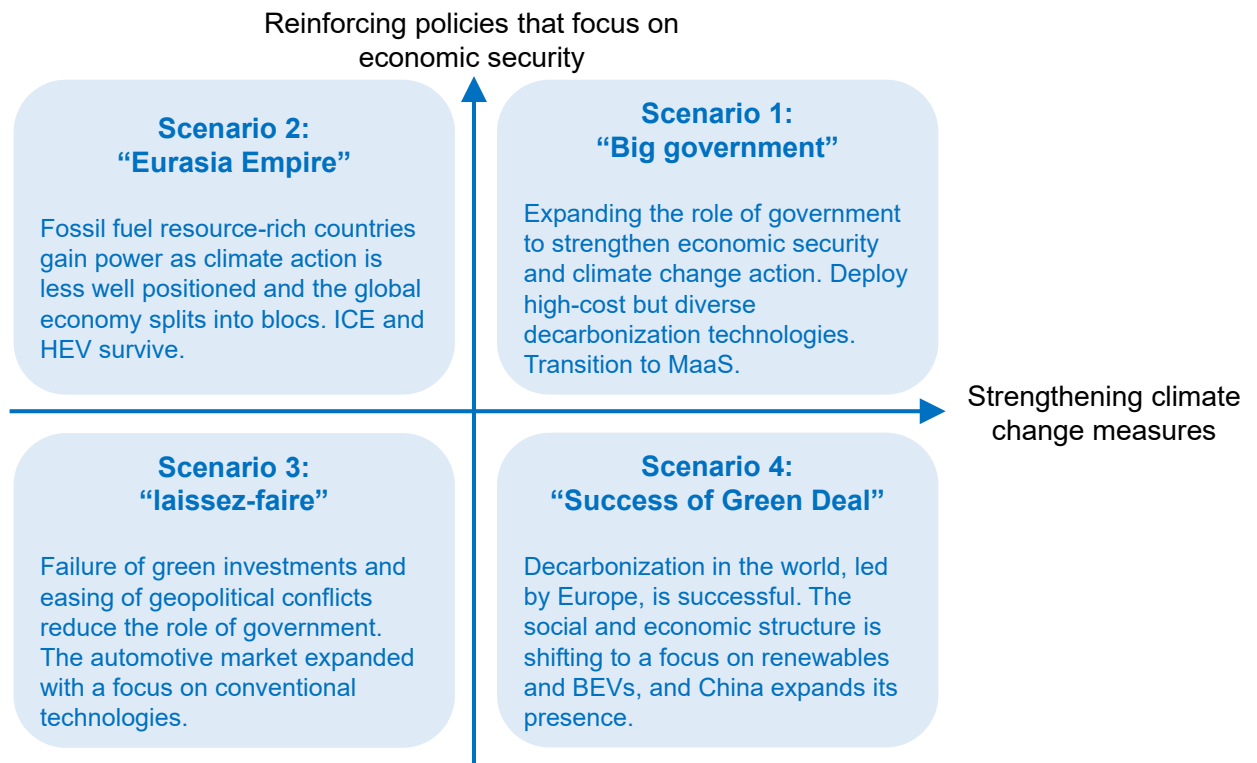


Figure 1 Scenario driving forces and scenario outline

Key Points of the Scenario Elements for the ASEAN Automotive Industry

- Affordability is highly important for considering the energy supply structure and the automotive industry of ASEAN. In each of the four scenarios outlined below, governments and citizens will require the most economical ways to ensure energy security and address climate change.
- The technologies at the heart of mobility in the ASEAN region differ by scenario. In Scenarios 1 and 4, in which climate change measures are enhanced, the diffusion of BEV cars makes common progress, though with differences seen in technological options for powertrains. In Scenario 1, in which various decarbonization technologies are used, biofuel consumption for large vehicles (buses and trucks) expands faster. Scenarios 2 and 3, in which climate change measures are weak, both see some progress in the BEV diffusion and the overwhelming presence of internal combustion engine (ICE) vehicles. Between the scenarios for the world’s split into blocs and for the maintenance of the global free trading system, however, gaps are seen in the size of accessible automotive markets for ASEAN and in the ASEAN automotive industry size, despite the industry seeking to expand exports.

3. Scenario 1 overview: Growing economic security concerns and accelerating climate change measures

3.1. Society & economy

- As countries focus on economic security in line with the U.S.-China confrontation, the global

economy will split into blocs. This framework will deviate from a world pursuing economic efficiency and minimized costs, leading growth markets to be locked up and thereby making strategically important goods costly. Industries and companies will belong to blocs, reducing their accessible market size. As a result, annual global economic growth will slow down to 1.5%. Since economic security and climate change measures cannot be achieved by market mechanisms alone, government market intervention will be the strongest among the four scenarios. Government intervention will exert great influence on income redistribution, contributing to narrowing income gaps.

- As the world's split into blocs makes progress, ASEAN will pursue neutral diplomacy giving priority to both the United States and China. U.S.-China competition to support ASEAN will encourage ASEAN's economic growth and transformation.
- From the perspective of climate action, each bloc will individually develop the prioritization of green investment. Under such circumstances, the world will achieve the 1.5°C target. Although there is a strong desire for climate change measures, the momentum to establish global standards will be lost due to the world's split into social and economic blocs.
- As blocs compete to win over emerging countries, financial aid to emerging and developing countries for decarbonization will be activated. In Scenario 1, all regions and countries will make efforts to reduce GHG emissions, even though the momentum to establish global standards will be lost. However, they will promote such efforts in various ways. Japan, the United States, and Europe will be more aggressive in reducing GHG emissions, while China and ASEAN cut GHG emissions as a result of their energy transition.

3.2. Mobility

- As for the assumed ASEAN urban structure, the government-led development of public transportation networks (railways, subways, and buses) will be promoted, with a focus on walking and bicycles, if the construction of new cities progresses with technical and financial support from developed countries and China. To meet demand for traffic between cities and within cities and their suburbs, urban air mobility (UAM) systems³ will also spread in areas lacking public transportation networks, with support from Europe and China. Autonomous driving will be easily introduced for the main roads of new cities for the transportation of both goods and people, but the scopes of the introduction will vary depending on the economic powers of cities.
- As for automobiles, BEVs will be the main choice in combination with the supply of zero-emission electricity amid the enhancement of climate change measures, with technological options limited. In ASEAN as well as other regions, the transition to BEV cars will progress

³ Urban air mobility may be introduced in the United States, China, and ASEAN, where public transportation is not in place (Europe is focusing on standardization). Since UAM is premised on electrification, it will be introduced in Scenarios 1 and 4, where climate change measures will be strengthened. Scenario 1 is more likely to involve government intervention, so the deployment of UAM will also be more advanced. In addition, it is assumed that short-distance: automobile (autonomous driving), medium-distance (about 100 km): UAM, long-distance: railway / aircraft. UAM is expected to travel about 100 km due to current capability, but development is also underway for intercity travel of 300 km.

from the perspective of regional industrial development. On the other hand, large vehicles, such as trucks and buses, will mainly use biofuels. Competition between food and biofuels, a matter of concern regarding biofuels, will not arise in countries where plants for food are produced separately from those for biofuels.

- In Scenario 1, energy demand will remain flat due to sluggish economic growth and strong climate action. As a result of the lowest oil demand among the four scenarios, oil prices will be weak (at \$64 per barrel in 2020 prices). As decarbonization efforts accelerate, electricity prices will increase by an average of 50%, but government intervention will keep them low for the industry sector. Under these circumstances, the status of BEVs will be established in the ASEAN region, benefitting from tax incentives. Gasoline will be subjected to high taxes from the perspective of climate change measures, despite sluggish crude oil prices. Biofuels will be used to the fullest, but supply (capacity) will be limited. So, natural gas vehicles may be reviewed (promoted) in ASEAN.
- As for the energy system, ASEAN will first pursue thorough energy conservation, accelerating natural gas use and energy efficiency improvement. Gas and ammonia co-firing as transitional technology will progress. From the viewpoint of energy security, the distribution of hydrogen and ammonia in the region will be pursued. (Since energy affordability is highly important for the region, profit sharing through the production and distribution of blue and green hydrogen in the region will be sought.) ASEAN will seek to achieve gradual decarbonization by co-firing coal with ammonia and using carbon capture and storage (CCS) technology for gas. With support from Europe and the United States, renewable energy (mainly solar photovoltaics) will expand while depending on domestic or regional technologies.

4. Scenario 2 overview: Economic security will be enhanced while climate action stalls

4.1. Society & economy

- As countries focus on economic security, the global economy will split into blocs. This framework will deviate from a world pursuing economic efficiency and minimized costs, leading growth markets to be locked up and thereby making strategically important goods costly. As the global market size shrinks, markets that companies belonging to a certain bloc can access will be limited. As a result, annual global economic growth will slow down to 1.5%. In this scenario in which the world will be divided into blocs, ties between China and Russia will be strengthened in terms of security and energy (fossil fuel) supply over the long term (structurally).
- In ASEAN, structural economic and social transformation will fail to progress, leaving current challenges to remain (or worsen). ASEAN will tend to follow the countries that will supply cheap energy sources (as it is basically difficult for ASEAN to achieve self-sufficiency even if regional energy development is promoted). Instead of actively participating in one of the blocs, however, ASEAN will choose to deal with any bloc in a manner to benefit most from it.
- Regarding climate change, low-carbonization will progress slowly, with the world failing to achieve the 2°C target. As it becomes clear that climate action will not lead to economic growth,

emerging economies will strongly oppose the enhancement of climate change measures led by developed countries, making the COP (Conference of Parties to the United Nations Framework Convention on Climate) framework unsustainable. Due to the collapse of the international framework, even funds for adaptation to climate change will fail to circulate sufficiently. Climate change measures in this scenario will be the most inferior among the four scenarios. As bloc leaders seek to win over developing countries, bilateral funding will increase for Southeast Asia, South Asia, and Africa. The position of climate change action as a social value that should be shared by the world will fade away, leaving each country or bloc to choose economically rational energy sources.

4.2. Mobility

- As the global economy's split into blocs limits economic development potential, the current urban structure of ASEAN will remain fixed. In order to improve the economic efficiency of large cities, the development of public transportation networks (railways, subways, and buses) will be pursued. ASEAN will consider the introduction of autonomous driving for the distribution of goods on main roads around new cities that have already been developed.
- The global economy's split into blocs will reduce the global auto market size. As climate change measures weaken, ICE vehicles and hybrid electric vehicles (HEVs) will continue to be used. Against this backdrop, the automotive industry in ASEAN will promote regional sales and exports focusing on ICE vehicles under government industrial policy.
- In Scenario 2, energy demand will remain flat due to stagnant economic growth. Oil demand will be maintained mainly in emerging and developing countries under weaker pressure from climate change measures. As the international market is divided, crude oil and other fossil fuels will have multiple prices (\$100/bbl for 2050 in 2020 prices). Electricity prices will rise moderately despite cost hikes resulting from greater dependence on fossil fuels, as energy demand is suppressed. In ASEAN, gasoline prices will range from the current level to higher levels, with electricity prices being relatively high. Due to the weakening of climate change measures, the use of biofuels will not progress so much. Biofuel production will depend only on surplus crops. On the other hand, the use of natural gas vehicles will expand.
- ASEAN's energy system will give top priority to promoting energy efficiency. Coal-fired power plants will remain the main power source. Decarbonization measures for these plants will be limited to co-firing ammonia and biofuels with coal. Since energy affordability is emphasized in this region, deployment of renewable energy will be limited to the extent where energy affordability is maintained. The deployment of renewable and nuclear energy for the purpose of improving energy self-sufficiency will fail to progress. As the decarbonization of power sources makes little progress, the electrification of automobiles will fail to progress.

5. Scenario 3 overview: Economic security concerns will wane while climate measures stall

5.1. Society & economy

- The global free trade system will be firmly maintained, and economically optimal supply chains will be developed under the division of labor. Climate measures will be given low priority, with fossil fuels continuing to be used. The current situation in which resource-rich countries and emerging economies are driving economic growth will be maintained. Consumers will have many choices for technologies and goods, with vigorous consumption continuing. The global economy will slow down until around 2030 due to the aftereffects of current inflation and the economic failure of green investment. Later, however, the global economy will return to a solid growth path led by emerging economies due to the restoration of the free trade system and the reduction of constraints related to climate change measures. Economic growth will accelerate to 2.5%.
- ASEAN will establish its position as the world's factory comparable to China. As the political system differs from country to country, however, political control will remain weaker than in China. If a new economic and trade framework that includes ASEAN works, the region's economic power will increase.
- From the perspective of climate change, the world will fail to achieve the 2°C target, though with the temperature rise around 2100 limited to about 2.6°C (in line with the STEPS (Stated Policies Scenario) in the International Energy Agency's World Energy Outlook 2021). Emerging economies will strongly oppose the enhancement of climate change measures led by developed countries, which will fail to lead to economic growth. As climate change progresses, however, mainly emerging economies will become more oriented toward adaptation to climate change. The COP framework will be maintained as geopolitical conflicts are managed or mitigated, but COP discussions will focus on adaptation rather than mitigation.
- In ASEAN, climate change policy will fail to make progress. Increasing climate impacts will lead ASEAN to request more funding from developed countries.

5.2. Mobility

- As population concentration in large cities and depopulation in their neighbors continue globally, ASEAN will see population concentrating in large cities and functional problems (such as sanitation deterioration and rich-poor gaps) arising in the rising number of cities. Some new cities will be developed but fall short of being smart cities (distributed cities optimized by digital technology). Thus, the number of conventional cities will increase.
- Global demand will be high for vehicles, including those used in urban areas. Thanks to weak climate-related restrictions and the demonstration of innovation in a globalized market, the range of automotive technology options will be the widest among the four scenarios, including BEV and ICE vehicles. The wide range of automotive technology options will support the expansion of the automotive market in developing countries. As population concentration in cities continues in ASEAN, vehicle demand will change from two-wheelers to three/four-wheelers. As traffic congestion and air pollution become more serious, efforts will be made to develop and promote public transportation, with political priority given to public transportation rather than private transportation. However, public transportation capacity will remain insufficient. Public transportation in ASEAN will include not only high-volume transportation but also small-scale

vehicle sharing. The diffusion of BEV vehicles will progress to combat air pollution and reduce oil imports (for example, in Indonesia). As transportation volume increases, freight and passenger transportation services will make progress and develop into businesses. Under these circumstances, ASEAN will promote the automotive industry's expansion of ICE and other vehicle exports to developing countries under its industrial policy, as China has done.

- In Scenario 3, oil prices will be relatively high (at \$88/bbl for 2050 in 2020 prices) due to growing oil demand. Electricity prices will rise due to the remaining dependence on fossil fuels, of which prices will increase. In ASEAN, gasoline prices will stand at the current or higher levels. Electricity prices will also be relatively high. Due to the weakening of climate change measures, the use of biofuels will fail to progress. Biofuel production will depend only on surplus crops. On the other hand, the use of natural gas vehicles will expand.
- In ASEAN's energy system, existing coal-fired power plants will continue to be used. As the use of cheap gas is promoted, LNG demand will increase.

6. Scenario 4 overview: As economic security concerns wane, climate action will accelerate

6.1. Society & Economy

- The global free trade system will be firmly maintained, and economically optimal supply chains will be built under the global division of labor. As green investment leads to economic growth, both developed and developing countries will take advantage of clean energy sources to expand their markets and achieve economic growth. Among the four scenarios, global economic growth will be the highest (at 3%).
- As for the balance of power in the world economy, the status of fossil fuel-rich countries will relatively decline, leading Europe, the United States, and China to benefit the most from green growth. Demand for energy will increase in line with global economic growth, but investment in fossil fuels will not progress.
- The world will achieve the 1.5°C target. In global rulemaking on climate change, global standards will be created under the leadership of Europe. Financial contributions and technology transfers will be made to developing countries within a global support framework. The COP framework will continue to function. On the financial front, climate change pressures are also strong, with green investment being prioritized more globally (prioritization will vary from country to country).
- Against this backdrop, ASEAN will aim to replace China as the world's factory. As the emphasis is placed on climate change measures, the selection of partners for technical assistance will grow important, leading ASEAN to increase its economic and policy dependence on foreign countries. In addition, the cost of living will rise due to the higher cost of climate action.

6.2. Mobility

- From the perspective of climate change measures (including decarbonization and efficient energy

use), the development of smart cities (distributed cities optimized by digital technology) will make strong progress. Based on the belief that the centralization of cities has a high environmental load, smaller cities will be distributed under the smart city approach. In ASEAN, urban development will stagnate in existing large cities due to delays in environmental measures, while the development of new cities (distributed smart cities) around large cities will make progress. Until 2050, however, ASEAN will pursue large-sized cities.

- New cities in ASEAN will have well-developed roads, making progress in the diffusion of autonomous driving for not only the distribution of goods but also human transportation. Automobiles will be converted into BEVs, with vehicle-sharing services using autonomous driving becoming more widespread. UAM systems based on the standards of the United States, Europe, and China and supporting the construction of new cities will be introduced as an option for medium-distance transportation.
- The global automotive industry will expand BEVs' share of production in conjunction with an increase in zero-emission electricity to fight against climate change. Since the range of BEV technology options is limited, making it difficult to differentiate BEVs, automakers will differentiate themselves in regard to services and contents. Thanks to its production and market sizes, China will become the center of BEV production. Against this backdrop, the automotive industry in ASEAN will promote BEVs in passenger car production for industrial development purposes. In Indonesia and Thailand, biofuels will be used as one fuel option.
- In Scenario 4, a virtuous cycle will be created in which the widespread adoption of renewable energy will lower costs, leading renewable energy to become the center of energy supply. As an early exit of coal-fired power generation is realized in both developed and developing countries, short-term supply-demand imbalances and subsequent fluctuations in fossil fuel prices are likely to occur during the transition period. As a result of Scenario 4, oil prices will stand at \$24/bbl (in 2020 prices) in 2050. Amid decarbonization efforts, electricity prices will increase significantly, posting an average increase of 50%. The hydrogen supply price will be 30 yen per normal cubic meter or less in 2030 and 20 yen/Nm³ or less in 2050, achieving the targets of the Japanese government. In ASEAN, the status of BEVs in short- and medium-haul travel will be established, leading them to be treated favorably in taxation. Electricity will be subject to higher prices and taxes. As fossil fuel prices fall, gasoline prices will decrease. However, higher taxes will be levied on gasoline from the perspective of climate change measures. Although the use of biofuels will be maximized in the region, absolute consumption will be limited due to supply constraints. As hydrogen supply prices decline significantly, the use of hydrogen in the transportation sector will be promoted.
- In the ASEAN energy system, coal-fired power generation will be forced to retire early and be replaced by renewable energy power generation. Decarbonization pressure will increase on gas-fired power generation, requiring gas and hydrogen co-firing and the installation of CCS systems at gas-fired plants. With support from Europe and the United States, the use of renewable energy, such as solar power, will expand. The use of hydrogen and ammonia with support from Japan will become marginal.

7. Summary

In this paper, we have drawn a picture of the energy supply structure and mobility in 2050, mainly for ASEAN. Even amid population and economic growth, ASEAN will be required to promote decarbonization efforts. Although decarbonization efforts differ by scenario, the electrification of passenger cars will progress in all scenarios. Particularly in a scenario in which the decarbonization of power sources progresses, the electrification of passenger cars may be actively pursued from the perspective of regional industrial promotion.

At the same time, the development of public transportation will play a major role in ASEAN. Although the urban structure differs from scenario to scenario, it is expected that public transportation systems, such as railways, subways, and buses, will be developed to contribute to decarbonization in new small cities and to efficient large-scale transportation and the mitigation of traffic congestion and air pollution in large cities.

As noted above, when the energy supply structure and the automobile industry in ASEAN are considered, affordability (reasonable prices) is important. While some countries in the region have set out carbon neutrality and other ambitious climate targets, the importance of a realistic energy transition is growing further. There are multiple paths to energy transition, indicating that a wide range of technologies will be required in the field of mobility. In particular, the use of biofuels and natural gas is conceivable for large vehicles, which are difficult to electrify. Various technologies will contribute to the decarbonization of the transportation sector in the region.

8. Conclusion

The trend of climate change measures, such as those to achieve carbon neutrality, has been coupled with Russia's invasion of Ukraine, making the global situation and direction regarding energy and mobility more uncertain and unclear. Therefore, we conducted a scenario analysis using two driving forces – whether climate change measures will be enhanced (in each country) by 2030 and whether each country will strengthen its policies that emphasize economic security by 2025 to 2030. The two driving forces allow us to draw different pictures of the future world and regions. As mentioned above, the scenarios indicate that the future of mobility and relevant energy in ASEAN could vary depending on the driving forces.

Given the world, with its high degree of uncertainty, we should pay close attention to which of the scenarios depicted in this paper will be realized and implement a strategy responding to the realized scenario flexibly and without delay.

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