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IEEJ Outlook 2025: How to Deal with Uncertainties Regarding Energy Transition

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On October 18, the Institute of Energy Economics, Japan, held its 448th forum on research works to announce "IEEJ Outlook 2025." This is our original outlook for global energy supply and demand through 2050, being positioned as our flagship publication. We publish the annual outlook every October, providing a long-term energy supply and demand analysis in the form of an annual regular exercise and special analyses on up-to-date topics. In addition to the Reference Scenario and the Advanced Technologies Scenario for the annual regular exercise, the latest IEEJ Outlook features special analyses on how to deal with uncertainties regarding the energy transition, as indicated by the subtitle. The following summarizes the key points of the latest IEEJ Outlook.

The IEEJ Outlook depicts how global energy supply and demand will change toward 2050 under two future scenarios, the Reference Scenario and the Advanced Technologies Scenario. These scenarios take a forecast approach projecting global energy supply and demand under various assumptions on future changes, based on changes to date. The forecast approach contrasts with the backcast approach that the International Energy Agency has adopted for an analysis of global carbon neutrality to consider how global energy supply and demand should change for the achievement of the global carbon neutrality goal. While the backcast analysis normatively shows how the world must change, the forecast analysis predicts how the world will change. Both are useful tools for future analysis. However, it should be noted that they have different significances and challenges, based on their different characteristics.

In the IEEJ Outlook's Reference Scenario in which current trends will be sustained, global primary energy demand will steadily increase under sustained economic growth, posting a 14% rise from 2022 to 17.0 billion tons of oil equivalent in 2050. The increase will be driven by emerging markets and developing economies, including India and the Association of Southeast Asian Nations, which will account for 81% of the global increase. In China, which has led global energy demand growth, demand in 2050 will decline by 11% from 2022 due to the falling population and decelerating economic growth. As natural gas and oil demand increase steadily, despite a decrease in coal demand, fossil fuels will continue to account for the dominant part of the global energy demand, capturing 73% of the global energy demand in 2050.

In the Advanced Technologies Scenario in which advanced energy technologies will be assumed to spread to the maximum extent to enhance climate change prevention and energy security measures, primary energy demand in 2050 will be 18% less than in the Reference Scenario due to powerful progress in energy efficiency improvement. Demand will sharply grow for non-fossil energy sources such as renewable energy and nuclear, while slackening for fossil fuels. Coal demand will decrease substantially due to a decrease in demand for power generation. Oil demand will also plunge as the electrification of vehicles makes progress. Natural gas demand will level off in the 2030s before decreasing moderately. As a result, global energy-related CO_2 emissions in 2050 will decline by as

much as 62% from 34.1 billion tons in 2022 to 12.9 billion tons in 2050. In order to achieve this substantial reduction in CO_2 emissions, the world will have to mobilize all options, including three major ones: (1) energy efficiency improvement that will make particularly significant progress from 2030 due to the "stock effect", (2) solar photovoltaics, wind power, and other renewables that will account for 60% of the world's power mix, and (3) CCUS (carbon capture, utilization, and storage) that will be introduced in the power generation and industry sectors, particularly after the second half of the forecast period. Overall, however, decarbonizing the non-electricity sector will not be easy. Particularly, decarbonization will be a great challenge in non-OECD countries. Even in the Advanced Technologies Scenario, fossil fuels will remain an important energy source, accounting for 54% of global primary energy demand as of 2050. How to stabilize the fossil fuel market and secure a stable supply of fossil fuels will remain an important global challenge.

The first special analysis in the latest IEEJ Outlook takes up liquefied natural gas, which is expected to continue playing an important role in the progress of global energy transition in the future. In the energy transition, which aims to achieve both decarbonization and enhanced energy security, LNG is attracting renewed attention worldwide as a realistic and reliable solution. In the Reference Scenario, global demand for LNG in 2050 will increase by 74% from 2022. In the Advanced technologies Scenario, global LNG demand will expand until around 2040 and gradually decrease later to reach the present level in 2050. Emerging markets such as Southeast Asia will be at the center of LNG demand growth. LNG will play a particularly important role in the energy transition in these markets. In order to support the expansion of the LNG market, it will be important to secure supply by implementing sufficient investment. Given the natural decline of existing LNG supply capacity, it will be necessary to expand LNG supply capacity by an average of 10 million to 20 million tons per year until 2050 and realize investment to achieve it. In order for LNG to continue to play its expected role, it is essential to develop cleaner LNG and decarbonize the entire LNG supply chain. In order to achieve this, all the policy, industry, and research stakeholders in the fields of LNG will have to strengthen their respective efforts.

The second special analysis covers energy security risk scenarios. It highlights five risk factors: (1) underinvestment in fossil fuels, (2) geopolitical risks, (3) destabilization of electricity supply, (4) supply of critical minerals, and (5) cybersecurity. With regard to the first factor, it is pointed out that if sufficient investment fails to be implemented in fossil fuels, which will continue to play an important role in the energy transition pathway, their prices will rise to the heavy disadvantage of vulnerable developing countries and social strata. The second factor of geopolitical risks will remain important in the future as in the past. Among them, the destabilization of the situation in the Middle East is serious and important today. Attention should also be paid to the risk of unexpected significant policy changes in major countries. As for the third factor, how to secure a stable electricity supply has become a major challenge due to a decrease in surplus power generation capacity and difficulties in securing a sufficient supply amid a substantial rise in naturally variable renewable energy's share of the electricity mix and electricity market liberalization, at a time when the expansion of generative artificial intelligence and data centers is expected to boost electricity demand further. With regard to the fourth factor, the concentration of critical mineral supply sources in specific countries such as China is attracting global attention as a potential risk factor, while demand for critical minerals is expected to increase significantly due to the promotion of the energy transition. In addition, attention should be paid to issues such as intensifying global competition for resources and the rise of resource nationalism. Regarding the fifth factor, the analysis notes that the risk of cyberattacks on energy infrastructure as the foundation of national and economic management and livelihoods is increasing. It is necessary to pay attention to the potential "weaponization" of energy interruption by cyberattacks in connection with geopolitical risks.

In the latest IEEJ Outlook, several box analyses cover such as a life cycle cost analysis (LCA) of automobiles regarding greenhouse gas emissions, the outlook and challenges for energy efficiency improvement regarding the importance of the “stock effect”, rising electricity demand from data centers and stable electricity supply, and the feasibility of achieving the 1.5°C global warming target from the perspective of the residual carbon budget. As an example, the automobile life cycle cost analysis indicates that GHG emissions from internal combustion engines, hybrid, plug-in hybrid, and electric vehicles differ by country, depending on the power supply mix, and energy resource endowment and availability. It is important to make choices and judgments regarding automobiles from a comprehensive perspective covering the use of critical minerals and total vehicle use costs for consumers, in addition to the GHG emission levels based on LCA.

Any long-term global energy outlook is fraught with great uncertainties, making it difficult to envision the future. Even so, however, it is important to analyze the future potential of the world. The IEEJ would like to continue to contribute to solving energy problems through the IEEJ Outlook.

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