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IEEJ Outlook 2026: Deepening Uncertainties Surrounding the Challenges of Energy Transition: A Widening Gap Between the Ideal and the Reality

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On October 17, our institute convened the 451st Regular Research Briefing Session, during which we presented the "IEEJ Outlook 2026" (hereinafter referred to as "the Outlook"). The Outlook represents our proprietary long-term global energy supply and demand forecast extending to the year 2050, and is positioned as the flagship output of our research activities. Our institute has consistently released the IEEJ Outlook each October, providing a long-term energy supply and demand analysis in the form of an annual regular exercise. In addition to these foundational analysis, we also conduct special analyses that address pressing and timely themes of global significance. The current Outlook comprises two core scenario analyses—namely, the "Reference Scenario" and the "Advanced Technology Scenario"—which serve as the basis for our regular analytical exercise. Furthermore, in alignment with the subtitle of this year's Outlook, we have undertaken three special analyses that explore the deepening uncertainties surrounding the energy transition, particularly in light of the widening gap between idealistic aspirations and practical realities. Below, the author presents an overview and key highlights of the Outlook and its constituent analyses.

In the Outlook, global energy supply and demand trajectories toward 2050 are depicted under two future scenarios: the "Reference Scenario" and the "Advanced Technology Scenario." These projections are constructed as "forecast-type" outlooks, which extrapolate future developments based on observed historical trends and incorporate a range of assumptions regarding potential changes moving forward. This approach stands in contrast to "backcast-type" analyses, such as the Net Zero Emissions (NZE) Scenario presented in the International Energy Agency's World Energy Outlook. In backcasting, a normative future endpoint is first established—such as achieving global net-zero emissions by a specified year—and the analysis then explores the transformations required to reach that target. While both forecast-type and backcast-type methodologies serve as valuable tools for future-oriented energy analysis, it is essential to recognize the fundamental differences in their nature. Each possesses distinct implications and limitations, which must be carefully considered when interpreting their findings and applying them to policy or strategic planning.

In the Reference Scenario of the Outlook, which assumes the continuation of the ongoing trends for policy and technology, global primary energy demand is projected to grow steadily under sustained economic expansion, reaching 173 billion tons of oil equivalent by 2050—an increase of 14% compared to 2022. The principal source of this growth lies in emerging and developing economies, with India and the ASEAN region serving as the primary engines of demand expansion. The incremental demand from these regions accounts for approximately 89% of the total global increase projected through 2050. China, which has historically been the central driver of global energy demand growth, is expected to see a 12% decline in energy consumption in 2050 relative to 2023. This decline is attributed to demographic contraction and a slowdown in economic growth. From the perspective of energy sources, fossil fuels are projected to retain their dominant position in the global energy

supply mix through 2050. While coal demand is expected to decline, both natural gas and oil are forecast to experience steady growth. Consequently, fossil fuels will continue to constitute the majority of global energy supply, with their share reaching 72% in 2050.

In the "Advanced Technology Scenario"—where it is assumed that advanced energy technologies are deployed to their maximum extent in response to the growing urgency of climate change and the need to strengthen energy security—global primary energy demand in 2050 is projected to be 17% lower than in the Reference Scenario, driven by significant progress in energy efficiency.
Non-fossil energy sources such as renewables and nuclear power are expected to expand substantially, while demand for fossil fuels declines. Coal consumption is projected to fall sharply due to reduced demand for power generation, and oil demand is expected to decline significantly as vehicle electrification advances. Natural gas demand is anticipated to remain roughly flat through the 2030s, followed by a gradual decline thereafter. Global energy-related CO_2 emissions are projected to decrease markedly—from 346 billion tons in 2023 to 141 billion tons in 2050—representing a 59% reduction. However, decarbonization of the non-power sectors remains a formidable challenge, and regionally, the decarbonization of non-OECD countries poses a particularly critical issue. It is noteworthy that even under the Advanced Technology Scenario, fossil fuels are projected to account for 55% of global primary energy supply in 2050, underscoring their continued role as a vital energy source. Ensuring market stability and securing reliable supply of these fuels will remain key global challenges.

Another key driver of global energy demand growth is the rising demand for electricity. In response to this trend, global power generation is projected to expand significantly—by 66% under the Reference Scenario and by 92% under the Advanced Technology Scenario—by the year 2050. Enhancing electricity supply security amid sharply increasing demand has emerged as one of the foremost global challenges.

As the first special analysis in the Outlook, an in-depth examination is conducted on the integration costs associated with the large-scale deployment of variable renewable energy (VRE)—such as solar and wind power—which are expected to expand significantly in the future global energy mix. Due to the inherent variability and intermittency of VRE supply, additional measures such as battery storage installation, grid expansion, and thermal power backup become necessary. These measures contribute to what is termed the "integration cost," which in turn raises the total cost of the power system. In the case of ASEAN, the Outlook demonstrates that when pursuing an energy transition toward carbon neutrality, optimizing the system with integration costs taken into account results in the lowest overall system cost when the share of VRE reaches approximately 30% in total power mix in ASEAN. In contrast, if the VRE share were to rise to 80%, the cumulative additional cost across ASEAN from 2030 to 2060 would amount to approximately 1.3 trillion USD. Furthermore, due to differences in VRE supply potential/endowment and other regional factors, the burden of these additional costs would vary significantly among ASEAN member states. Therefore, as countries advance their energy transitions through the expansion of VRE, it becomes increasingly important to complement national efforts with regional and international energy cooperation frameworks.

The second special analysis addresses the critical importance of setting climate goals and pursuing adaptation strategies grounded in realism. While numerous countries have declared ambitious decarbonization targets, global greenhouse gas (GHG) emissions continue to rise in reality. The remaining carbon budget for 1.5°C target—defined as the total allowable future CO_2 emissions to limit global temperature rise to 1.5°C with a 50% probability—is rapidly diminishing. According to the latest assessments, the remaining budget from 2025 onward is estimated at approximately 130 $GtCO_2$,

equivalent to only four years' worth of current global emissions. Based on this analysis, the attainment of the 1.5°C target is considered virtually unfeasible. Notably, the CO_2 emissions trajectory under the Advanced Technology Scenario presented in the Outlook aligns broadly with the objective of limiting temperature rise to 2°C with a 50% probability. In light of these realities, it is imperative to continue striving toward the goals of the Paris Agreement while simultaneously acknowledging the constraints imposed by current global trends. Furthermore, the importance of "adaptation"—the process of managing and mitigating the direct and indirect negative impacts of climate change on our societies—is growing. As efforts to reduce and control GHG emissions through "mitigation" continue, achieving an appropriate balance between mitigation and adaptation will become increasingly essential.

The third special analysis addresses the future implications of artificial intelligence (AI) on energy demand. As noted earlier, the most pronounced trend in global energy consumption is the rapid increase in electricity demand. While this is partly driven by rising power demand in industrial sector as well as heating and cooling needs in residential sectors—particularly in emerging and developing economies—a major contributing factor is the accelerating spread of AI and the associated expansion of data centers, which underpin this new wave of the information revolution. Under the Reference Scenario, global electricity demand from data centers is projected to rise from 497 TWh in 2025 to 1,080 TWh by 2035, representing a 2.1-fold increase over a decade. In the context of this rapidly evolving information revolution, the challenge of supplying electricity that is stable, competitively priced, and environmentally sustainable has become critically important. On the other hand, this surge in electricity demand from data centers may be mitigated through advances in energy efficiency. In the Advanced Technology Scenario, the Outlook suggests that the power demand for data centers could be reduced by 20% in 2035 compared to the Reference Scenario. Moreover, the potential for further energy savings through the application of AI itself has been estimated across various sectors. The key issue, however, lies in how these energy-saving potentials can be effectively realized.

Long-term global energy outlooks are inevitably accompanied by considerable uncertainty, making the depiction of future scenarios a complex and challenging endeavor. Nevertheless, even under such conditions, it remains critically important to analyze the range of possible futures for the global energy system. Through continued publication and refinement of the IEEJ Outlook, our institute remains committed to contributing to the resolution of energy-related challenges and to supporting informed decision-making in the energy policy domain.

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