TRILATERAL ENERGY SECURITY COMMITTEE

CHANGING THE GAME: ENERGY SECURITY AND GEOPOLITICAL ALLIANCES

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Energy security plays a pivotal role in sustaining the economic growth and geopolitical stability of nations. This is especially true in the context of South Korea and Japan, both of which rely heavily on imported energy resources due to their limited domestic energy supply. This dependence significantly influences their strategic alliances and security dynamics, particularly regarding their relationships with the United States as a key ally in the region. Disruptions in energy supplies stemming from geopolitical tensions could severely undermine the economic health and democratic integrity of these nations, threatening U.S. interests in the Western Pacific. South Korea, Japan, and the U.S. (hereafter referred to as the Triad) need to work closely together on energy security to protect their shared interests and maintain stable energy supplies in the face of global challenges. Their long-term partnership should include shared investments, diversification of energy portfolios, and collaborative efforts to enhance both national and regional security interests especially as geopolitical tensions continue to shift.

Our research contributes to better understanding these issues using a mixed methods approach. So far, our research has worked to outline the energy security risks faced by the Triad, and our initial research demonstrated the need for diversification. However, as we further investigated alternatives to current energy sources, especially those that would reduce carbon output and are therefore aligned with Japan and South Korea's net zero goals, we found several promising options that unfortunately have very uncertain timelines. When considering the risks to energy security, and the ramifications for energy failures, we argue that continued cooperation on fuels such as LNG will continue to be necessary.

In this document we first introduce our research team, goals, and approach. Second, we present the preliminary findings of our research in the context of identified energy security risk and the current state of energy supply options. Third, we summarize the policy solutions that our research points to and conclude with our roadmap for future research.

Trilateral Energy Security Committee

The Trilateral Energy Security Committee (TESC) is a collaborative effort led by experts from the Hamm Institute for American Energy, the Korea Energy Economics Institute (KEEI), and the Institute of Energy Economics, Japan (IEEJ). The TESC's goal is to assess holistically the current state of energy resources, dependence, and vulnerabilities, to address the energy security risks impacting South Korea, Japan, and the United States, and provide policy recommendations to help mitigate those risks.

Why this Triad?

Both South Korea and Japan are heavily reliant on imported energy, with over 90 percent of their energy resources sourced externally, which significantly impacts their energy security. Both countries also have ambitious decarbonization goals and are striving to diversify energy sources by enhancing their renewable energy capacity and utilizing nuclear power. To accomplish this, they will need strong alliances with reliable partners. The U.S. is positioned to be a vital partner for South Korea and Japan's energy security goals.

Through advancements in technology, strategic exploration, and policy reforms, the U.S. has emerged as a net exporter of liquefied natural gas (LNG) and crude oil (see Figure 1). By fortifying energy ties with South Korea and Japan, the U.S. can enhance not only its role as a key energy supplier but also strengthen its strategic alliances, contributing to regional stability and security in an increasingly complex geopolitical landscape.

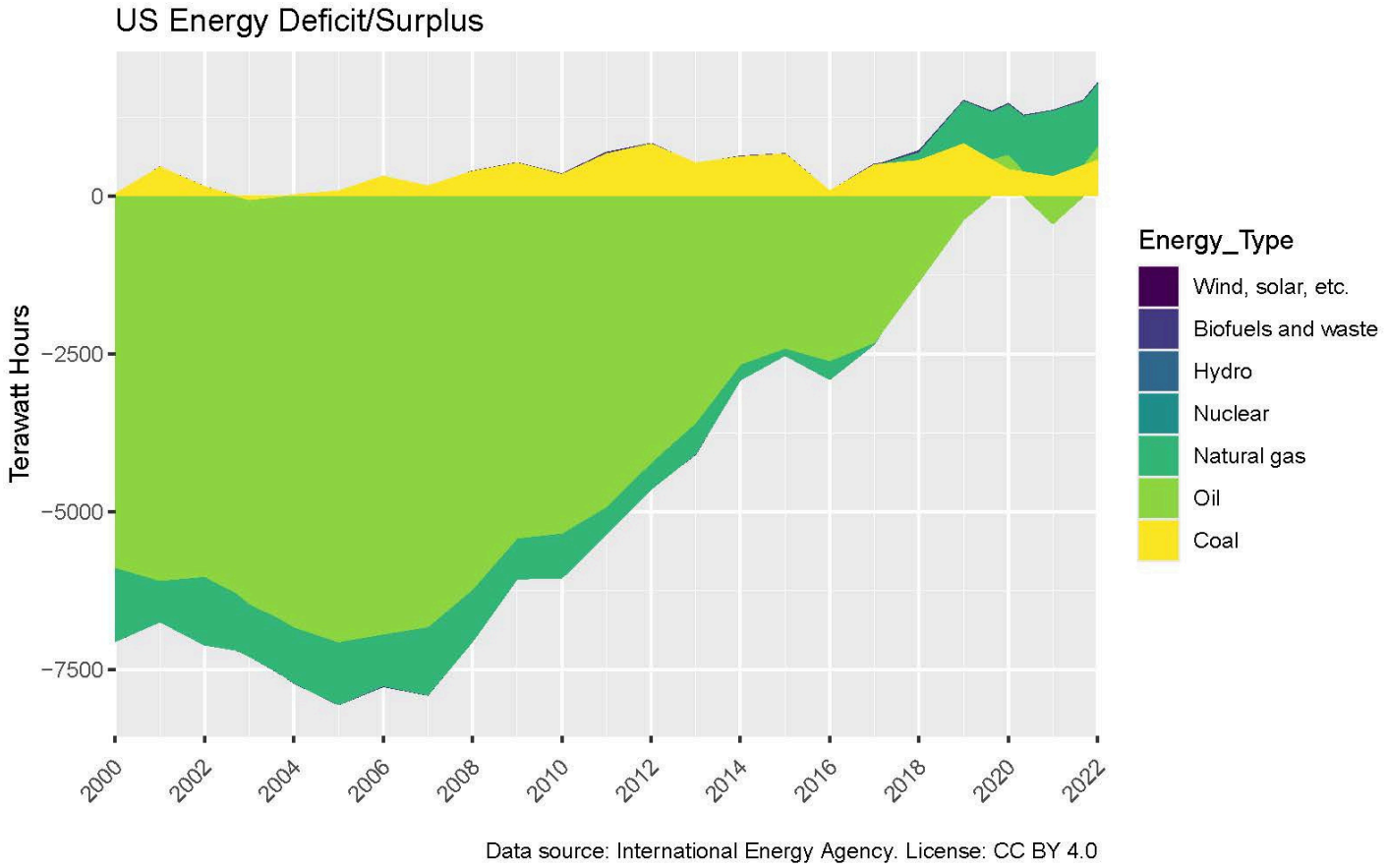


Figure 1 U.S. Energy Profile

Methodological Approach

The TESC employs two different methodological approaches. In the first, we use a combination of secondary research and interviews with experts from a myriad of domains to inform our discussion of policy solutions. This contribution matters because it incorporates diverse perspectives, enhances credibility, and leverages existing knowledge to address complex issues.

The second approach is quantitative. We are developing a novel ensemble approach that employs groundbreaking machine learning methodologies to provide useful, predictive scenario analysis, especially as it relates to the impact of disruptions. In the first step we mapped out descriptive statistics of observed energy commodity trade networks, including LNG, coal, oil, and uranium, and past disruptions of these networks (see Figure 2 for a sample output from this stage). We also examined how the energy trade network behaves compared to overall trade to better understand which economic theories were and were not applicable to energy trade.

In second step of the quantitative approach, we developed a social network analysis approach for scenario simulations using an existing inferential model known as additive and multiplicative effect network model or AMEN for short. The third and last step is combining the output from the AMEN model with a more common simulation methodology known as a CGE or computable general equilibrium model. So far, step 1 and step 2 have been completed. We are currently limiting the scenario simulations to LNG trade markets until we are finished validating the approach. We discuss below the insights from these steps.

TESC's focus is to deliver actionable recommendations that promote cooperative strategies, enhancing energy supply security through policy coordination and diversified investments. We have two primary goals for our research. First, we aim to strengthen economic and geopolitical resilience in the region, forging strategic partnerships that mitigate vulnerabilities and promote stable energy flows among the nations involved. Second, we are developing a robust approach to analyzing energy security, enabling us to scale our research to better understand the scenarios facing allies outside of the Triad as well as global energy security at large.

Energy Security Risks and Challenges

To better understand how to improve energy policies we identified three categories of potential disruptive events:

- **Policy Shifts**: Changes in energy export policies are increasingly driving trade flows and can directly reduce the diversification of import portfolios for countries which in turn raises the likelihood of policy-driven disruptions in trade flows.

- **Military Conflicts**: Tensions in the region, particularly influenced by geopolitical rivals, can pose threats to shipping routes and access to energy resources, affecting energy security.

- **Natural Disasters**: Events such as earthquakes and typhoons can disrupt both logistics and energy supply chains, emphasizing the geographic vulnerabilities of these nations.

Insights from Network Mapping and Scenario Analysis

The initial descriptive mapping of energy trade networks and past disruptions showed that disruptions tend to be very concentrated and that demand for different energy inputs is inelastic, suggesting that when disruptions occur, targeted policy measures are needed to address specific commodities and economies. The observations also point to a relatively volatile market when compared to trade in other goods, indicating the need for robust preventive policy measures that ensure supply and price stability. When crafting policy, the Triad must not only take into consideration known geopolitical issues but also create the most secure policy path to deal with future developments.

Three scenarios were chosen for testing to compare some of the most pressing current issues without making the investigation prohibitive. The first scenario simulated a reduction in exports from Russia to any country that participated in introducing sanctions against Russia after the invasion of Ukraine, including the EU, the U.S., and several Western Allies.

The second involved a reduction in exports from Middle East producers, chosen based on the possibility of conflict-induced disruptions, including Qatar, U.A.E., and Egypt. The last scenario modeled a reduction in exports from the U.S., based on the possibility of policy changes that limit exports.

Our simulations for these scenarios show that the disruptions in energy trade networks, even limited ones, can lead to unexpected trade reorientations that significantly affect countries that are less centrally positioned within these networks, making them more susceptible to import challenges. We visually demonstrate this in Figure 2, which shows a reduction in the diversification of import portfolios and a contracted network with much less evenly distributed trade flows. To bolster energy security and mitigate potential shocks, it is crucial for countries to engage in comprehensive cooperation, focusing on supply chain management. This strategic approach is crucial for enhancing overall system resilience, allowing countries like South Korea, Japan, and the United States to navigate the complexities of global energy interdependence effectively.

Base Network (non-zero μ = 282M USD) **Disrupted network (non-zero μ = 470M USD)**

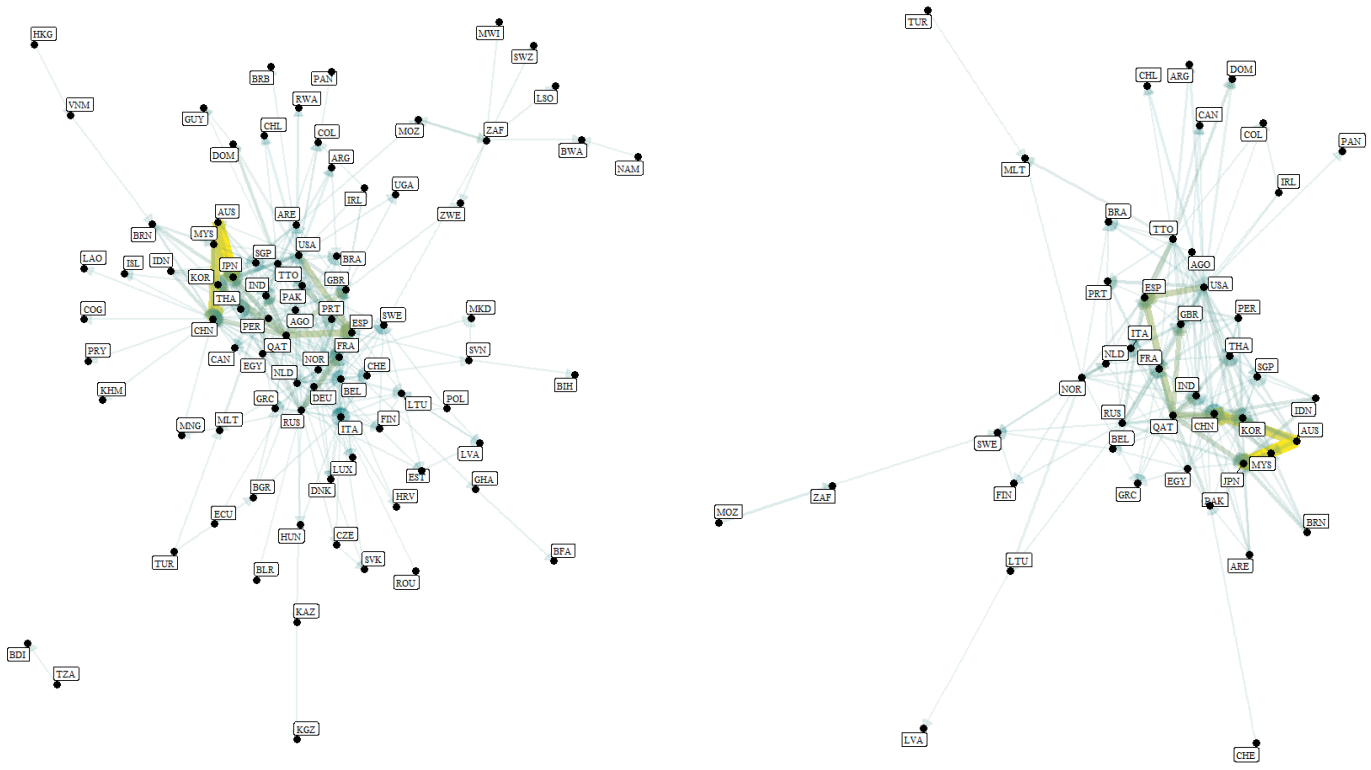


Figure 2 Network Projections of LNG Trade

Projections are force-directed, meaning nodes closer to the center are more central to the network and those on the periphery are less central. The disruption is simulating a 50 percent reduction in exports from Russia to any country that participated in introducing sanctions against Russia after the invasion of Ukraine. This includes the EU, U.S., and several Western Allies.

Figure 3 shows that in the simulations a country's total market share of LNG trade did not consistently predict a greater resilience post-disruption in the scenarios. For example, in the Middle East disruption scenario, France has a market share of six percent, which is much smaller than East Asian countries, but because of its stronger position relative to non-Middle Eastern exporters, the network effects predict an increase in total imports when the market reaches a new equilibrium. It is also evident that regardless of market share, when only a small amount is disrupted, countries are less likely to recover the simulated trade volume lost from the disruption. These preliminary findings from scenario modeling highlight that a country's position within global energy networks, rather than its market share, is pivotal in determining its vulnerability to disruption and reveals the necessity of strategic positioning and maintaining diverse trading partnerships to minimize systemic vulnerabilities.

One shortcoming worth reiterating is that in this stage of developing a predictive model, the simulations only account for network position and so some changes may be unrealistic. Moving forward we will be adding other variables such as infrastructure, contract limitations, and price shifts to the simulations.

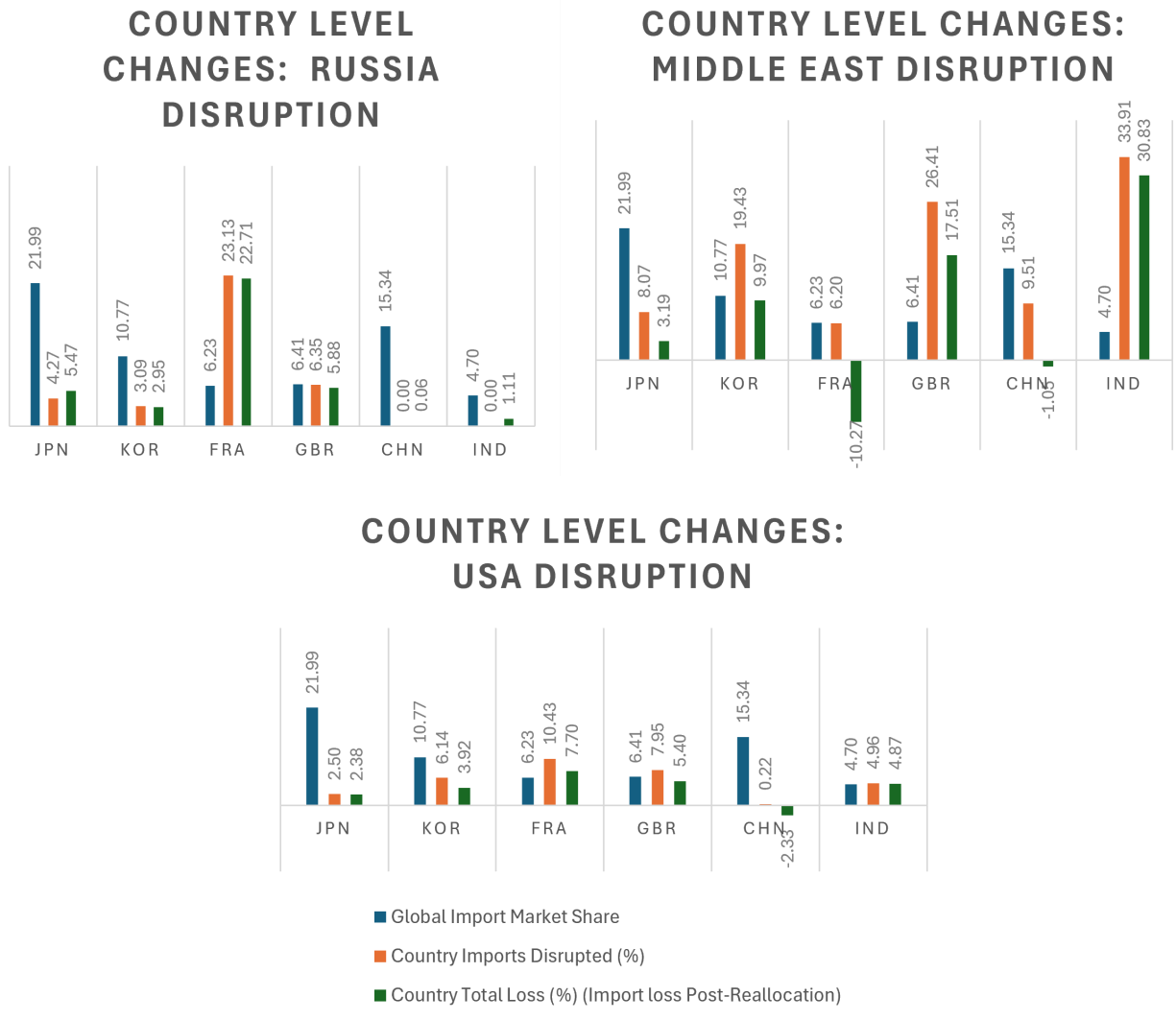


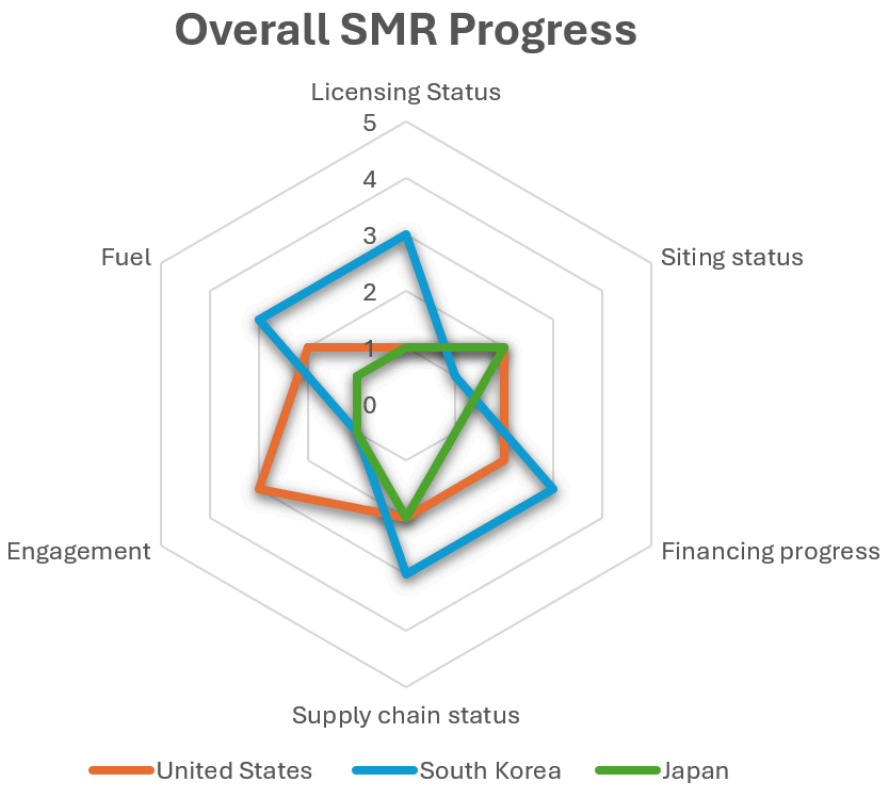
Figure 3 Country Level Changes: Disruption scenarios

Exploration of Alternative Energy Sources

As part of a broader diversification strategy, alternative energy sources were explored to address the energy security challenges facing South Korea and Japan. Advancement in nuclear, hydrogen, and ammonia technologies present opportunities to diversify energy sources and align with decarbonization goals. Trilateral collaboration among South Korea, Japan, and the United States is essential to advancing these technologies, reducing costs, and expanding markets. While these alternatives hold promise, development timelines remain uncertain. Furthermore, renewables such as solar and wind are reliant on intermittent inputs and their power supply is variable. Therefore, LNG is anticipated to play a significant role in meeting energy needs for the foreseeable future. LNG is a critical baseload energy source, and when utilized along with carbon capture technology, LNG use can reduce carbon emissions by replacing coal and oil while ensuring a reliable power supply that supports the transition to lower-carbon alternatives.

Development of Small Modular Reactors

While conventional nuclear reactors are still being newly built and restarted, they require substantial capital and land. Small Modular Reactors (SMRs) offer innovative nuclear energy solutions that address geographic and import limitations of conventional nuclear reactors and are increasingly seen as a key solution for enhancing energy stability, especially for South Korea and the United States. Collaborative efforts in advancing SMR technologies, focusing on design standardization and improving uranium supply chains, are crucial for ensuring sustainable and reliable nuclear energy production.



Data Source: NEA 2024

Figure 4 SMR Progress in the Triad

While SMRs can provide stable baseload power and contribute to carbon reduction goals, their development faces challenges such as complex supply chains and diverse reactor designs. The United States leads in SMR technology development with substantial government support, but it still lacks operational units, unlike Russia and China, which have deployed projects. Moving forward, SMR development must prioritize standardization of designs and securing uranium supply chains to achieve cost optimization, to enable broader implementation, it is essential to harmonize safety regulations internationally, validate them, and establish public acceptance. These collaborative initiatives highlight a shared commitment to creating a secure energy future that addresses rising demands.

Figure 4 visually depicts the relative progress of each country in the Triad along various dimensions required for successful SMR development where a rating of five indicates development is ready for implementation.

Hydrogen and Ammonia Technology Collaboration

This report does not cover all hydrogen derivatives in development. However, hydrogen and ammonia are currently leading in development and interest. Cooperation on hydrogen and ammonia technologies among the Triad is critical for enhancing energy security and fostering economic opportunities in the region. Continued research and development are crucial to enhance the efficiency and scalability of hydrogen, making it a viable long-term option. Establishing international standards and regulations for carbon emissions per kilogram of hydrogen and ammonia is essential for consistency, environmental sustainability, and facilitating global trade. South Korea, the United States, and Japan can form strategic alliances in hydrogen development, supported by incentives like those included in the U.S. Inflation Reduction Act, Japan's Green Transformation funds, and Korea's Clean Hydrogen Power Generation Bidding System. Such cooperation can stimulate demand to develop and expand the hydrogen market, accelerate the transition to clean energy, reduce carbon emissions, and enhance energy security.

While hydrogen is a valuable low-carbon solution, the prohibitive cost of seaborne hydrogen transportation makes ammonia a more practical alternative at present. To fully harness ammonia's potential for reducing carbon emissions in energy production, several challenges must be addressed. First, the number of commercial cargo ships specifically designed to transport ammonia is insufficient for large-scale shipping. Second, ammonia requires specific safety measures, trained personnel, and specialized infrastructure due to its toxicity. These costs will need to be brought down via technological advancement and economies of scale. Third, standardizing efficient production is necessary due to the variance in production technologies and prices. Co-firing ammonia in coal-fired power plants presents a promising transitional solution to reduce emissions, though high production and transport costs require increased carbon pricing or additional subsidies to be economically viable. The long-term competitiveness of co-firing will depend on policy support, technological advancements, and market dynamics. Ammonia is low carbon and is not variable, which could position it as a long-term power source alongside variable renewable energy sources, such as wind and solar, when they cannot meet energy demand.

LNG with Carbon Capture Utilization and Storage (CCUS)

LNG is a viable near-term solution for the U.S., Japan, and South Korea, particularly for co-firing in coal or oil power plants and as maritime fuel.

Using LNG in place of oil and coal offers a more economical short-term option by using existing infrastructure and still substantially reduces CO2 emissions. CCUS technologies can further cut emissions of LNG, however their cost-competitiveness depends on carbon pricing and CCUS is currently seen as cost-prohibitive in countries with limited land, such as Japan and South Korea. Despite strong interest in these technologies, implementation of CCUS will likely occur only in the U.S. until research and development reduce costs for Japan and South Korea. The U.S. stands to cement itself as a leader in developing CCUS technology that can be shared with its allies and in the short-term the U.S. can use LNG with CCUS to produce energy commodities such as hydrogen and ammonia that will help Japan and South Korea meet their net-zero goals.

As energy security and geopolitical stability remain closely intertwined, the ability of the Triad to navigate these challenges together will be essential in shaping future energy strategies. While LNG serves as a critical near-term solution, long-term energy security will require a broader approach that integrates supply chain investments, diversification of energy sources, and strengthened trade networks.

Navigating Challenges to Fortify Energy Security

Given their limited capacity for domestically sourcing energy inputs, South Korea and Japan will need reliable trading partners, and the U.S. should take an active policy role as one of those partners. Three key policy areas have been identified, incorporating both initial recommendations and a framework for future research: cooperative investments in the supply chain, energy portfolio diversification and transition, and ensuring robust trade networks and shipping lanes.

Cooperative Investments in the Supply Chain: This involves joint investments in energy infrastructure and supply chains to ensure stable and reliable energy supplies. By pooling resources and sharing risks, countries can reduce transaction costs and uncertainties. Examples include investments in infrastructure for natural gas, such as quickly scalable shipping terminals and backup storage facilities in the U.S., as well as collaborative projects in nuclear energy and critical mineral supply chains.

Energy Portfolio Diversification and Transition: Given that coal and oil still play a significant role in the energy mix of the Triad economies, cleaner transition fuels such as nuclear, hydrogen, and ammonia offer viable long-term pathways to reducing carbon emissions (See figure 5). LNG, often viewed as a transitional fuel, can facilitate a quicker shift away from coal. Enhancing energy security and meeting decarbonization goals can be achieved through the diversification of energy sources and suppliers, and the adoption of flexible contract terms. Just as portfolio diversification mitigates risk in financial markets, energy diversification allows economies to adjust purchases in response to supply disruptions. Future analysis will explore how policy frameworks, infrastructure investments, and international partnerships can support a balanced transition while maintaining energy security.

Ensuring Robust Trade Networks and Shipping Lanes: Securing trade networks and shipping lanes is essential for stable energy supplies, especially amid rising geopolitical tensions in key routes like the South China Sea.

A major disruption could have severe economic consequences, as seen in the impact of the Suez Canal blockage or the conflict in Ukraine. Beyond geopolitics, piracy and infrastructure vulnerabilities also pose risks. The Triad should pursue binding agreements to protect energy trade routes and critical infrastructure, strengthen international cooperation to safeguard maritime routes, and work with Southeast Asian partners to align security strategies with economic incentives.

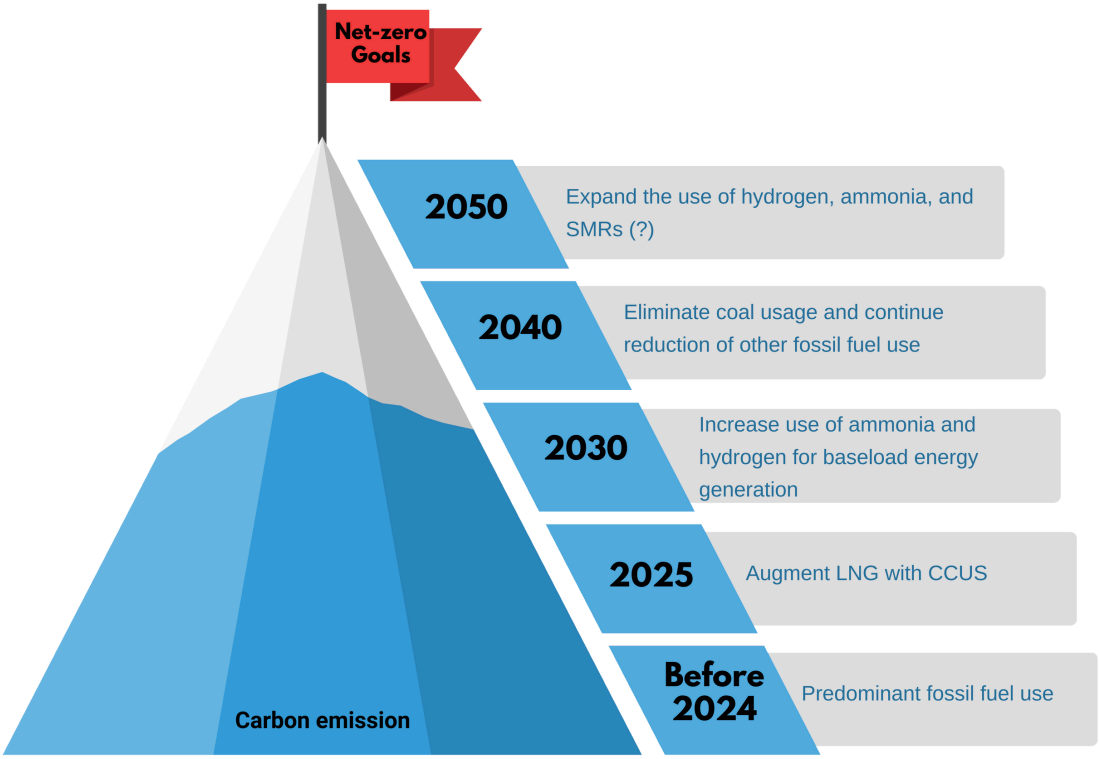


Figure 5 Pathways to Net Zero: Diversifying Energy Sources

TESC Research Roadmap

The next research phase aims to build on the foundational research work by addressing key economic, policy, and technological questions. This phase will refine models, analyze policy impacts, and explore infrastructure opportunities to provide actionable insights for strategic investment decisions and policymaking. As global energy demands grow and the urgency to reduce carbon emissions intensifies, LNG is seen as a critical bridge between traditional fossil fuels and emerging low-carbon technologies. Given the significant challenges in SMRs and deploying low-carbon hydrogen and ammonia, such as producing them economically, transporting and storing them safely, and building the necessary infrastructure, LNG serves as a practical, lower-carbon alternative to coal and oil, especially when used with CCUS. TESC's research agenda includes enhancing our quantitative approach using AMEN and CGE modeling, analyzing global LNG market risks, and investigating the impacts of potential policy shifts in the U.S., South Korea, and Japan. Specifically, this includes evaluating the feasibility of expanding LNG export infrastructure and understanding the long-term impacts of potential Trump administration policies on the energy security of the Triad.