The Strait of Hormuz as a Critical Energy Corridor: A Technical Review of Electricity Generation, Fuel Supply, and Energy Supply Security

Mehmet Rida Tur
Department of Electrical and Electronic Engineering
Faculty of Engineering
Batman University, Batman, Turkey
mrida.tur@batman.edu.tr

Ramazan Bayindir
Department of Electrical and Electronic Engineering
Faculty of Technology
Gazi University, Ankara, Turkey
bayindir@gazi.edu.tr

***Abstract*— The Strait of Hormuz is one of the most critical chokepoints in the global energy system due to its central role in the transportation of crude oil, petroleum products, and liquefied natural gas. In the literature, the Strait of Hormuz is generally discussed in relation to geopolitical risks, maritime security, and international energy trade. However, its implications for electricity generation, fuel supply continuity, and power system reliability are also of considerable technical importance. In electricity systems that depend heavily on imported natural gas and oil, any disruption in the Strait of Hormuz may directly affect fuel costs, thermal power plant generation capacity, reserve power requirements, electricity market prices, and overall energy supply security. From an electrical engineering perspective, this study examines the Strait of Hormuz in terms of its technical effects on the fuel supply chain, continuity of electricity generation, and security of supply. The study also evaluates the role of alternative routes, such as Gwadar Port, the Saudi Arabia East–West Pipeline, the Abu Dhabi Crude Oil Pipeline, and the proposed Arab Energy Corridor, in strengthening energy supply security. The findings indicate that the Strait of Hormuz should not be regarded solely as a geopolitical maritime passage, but also as a critical risk factor for electricity generation planning and power system reliability.**

Keywords*— *Strait of Hormuz, energy supply security, electricity generation, fuel supply, power system reliability, energy corridor

I. INTRODUCTION

Energy supply security is one of the fundamental components of modern electric power systems [1]. The security of electricity supply is not limited to the adequacy of installed generation capacity; it also includes the continuity, accessibility, affordability, and reliability of the primary energy sources used in electricity generation [2]. Therefore, the supply security of natural gas, oil, coal, nuclear fuel, and renewable energy resources is directly linked to the security of electricity generation. The Strait of Hormuz is a strategic maritime passage located between Iran and Oman, connecting the Persian Gulf to the Gulf of Oman and the Arabian Sea [3]. A significant share of the oil and LNG exported from Gulf countries reaches global markets through this narrow chokepoint [4]. For this reason, any military, political, logistical, or commercial disruption in the Strait of Hormuz has the potential to affect not only oil markets, but also electricity generation costs and energy supply security. From an electrical engineering perspective, the importance of the Strait of Hormuz can be examined in three main dimensions. The first concerns the uninterrupted supply of fuels used in electricity generation. The second is related to the operational continuity and cost structure of natural gas- and oil-fired power plants. The third is associated with power system reliability, reserve capacity requirements, generation adequacy, and supply security indicators such as expected energy not served. This study aims to evaluate the Strait of Hormuz not only as a maritime trade route or geopolitical chokepoint, but also as an energy infrastructure element that creates indirect yet critical impacts on electricity generation systems.

A. Strategic Energy Importance of the Strait of Hormuz

The Strait of Hormuz is widely regarded as one of the most important maritime chokepoints in the global energy system [5]. Its strategic significance stems from the concentration of oil and LNG flows within a narrow and sensitive region that is highly exposed to geopolitical tensions. Major hydrocarbon-producing countries such as Saudi Arabia, Iran, Iraq, Kuwait, Qatar, and the United Arab Emirates play a central role in global energy supply, and a substantial share of their exports is transported through the Strait of Hormuz [6]. When an energy transit route becomes a strategic chokepoint, it creates a single point of vulnerability within the global energy system. The closure, partial restriction, or even a heightened perception of risk in the Strait of Hormuz could affect tanker traffic, insurance costs, freight rates, spot LNG markets, and oil prices [7]. These effects may subsequently be reflected in electricity generation costs, fuel procurement schedules for power plants, and electricity market prices. The critical importance of the Strait of Hormuz is not limited to full closure scenarios. In modern energy systems, risk perception can be as influential as physical disruption. Military tensions, tanker attacks, naval mines, sanctions, disruptions in port operations, or insurance-related restrictions in the region may affect both the cost and reliability of energy flows [8]. Therefore, the Strait of Hormuz should be considered not only as a physical transit route, but also as a key element in the pricing of risk in global energy markets.

II. THE RELATIONSHIP BETWEEN FUEL SUPPLY AND ELECTRICITY GENERATION

The security of electricity supply cannot be explained solely by the installed capacity and technical availability of power plants [9],[10],[11], [12]. In countries that are highly dependent on imported natural gas and oil, the continuity of electricity generation is directly linked to the reliability of the fuel supply chain. For this reason, strategic energy transit points such as the Strait of Hormuz represent an indirect but critical source of risk for electric power systems. Any disruption in oil and LNG flows through the Strait of Hormuz may first affect fuel markets, then the generation costs of thermal power plants, and ultimately the reliability of the power system.

The importance of the Strait of Hormuz for electricity generation can be explained through three main links [13]. The first is associated with gas turbines and combined-cycle power plants that depend on natural gas and LNG supply [14]. The second concerns island systems, isolated grids, emergency generators, and peak-load power plants that use petroleum products. The third relates to the reflection of rising oil and LNG prices on electricity market prices and generation costs. Therefore, risks originating from the Strait of Hormuz should be assessed not only from the perspective of energy trade, but also in terms of electricity generation planning and power system operation.

A. Quantitative Overview of Energy Flows Through the Strait of Hormuz

The Strait of Hormuz is a highly concentrated transit point in global oil and LNG trade [15]. The attached studies indicate that, during the 2024–2025 period, approximately 20 million barrels per day of oil passed through the Strait, corresponding to nearly 20% of global petroleum liquids consumption [16]. A significant share of LNG trade is also carried through this route. This concentration makes the Strait of Hormuz a critical factor in securing the fuels used for electricity generation [17] shown in Table 1.

TABLE 1. KEY INDICATORS OF ENERGY SUPPLY SECURITY IN THE STRAIT OF HORMUZ.

Indicator	Value	Significance in terms of electricity generation
Daily oil transit volume	Approximately 20 million barrels/day	High impact on oil prices and fuel costs
Share in global petroleum liquids consumption	Approximately 20%	Creates systemic risk in the global energy market
Share in global LNG trade	Approximately 25–30%	Critical supply risk for gas-fired electricity generation
Share of exports to Asia	More than 80%	High dependence on importers such as China, India, Japan, and South Korea
Share of China, India, Japan and South Korea	Approximately 69%	High sensitivity in terms of fuel security in Asian electricity systems
Approximate length of the strait	90 miles	Long and strategic transit route
Narrowest transit width	Approximately 2.5 miles	Critical bottleneck in terms of maritime traffic and security risk

As shown in Table 1, the Strait of Hormuz is a strategic transit point not only for oil trade, but also for LNG supply and the electricity generation that depends on it. In particular, the role of gas-fired power plants in power systems—such as balancing, load following, and frequency control—indicates that LNG supply security is directly linked to power system reliability [18].

B. Assessment of Oil Flows in Terms of Electricity Generation Equivalent

An approximate energy-equivalent calculation can be made to illustrate the scale of oil flows through the Strait of Hormuz from the perspective of electricity generation. In the technical literature, the energy content of one barrel of crude oil is generally accepted as approximately 5.8 MMBtu, corresponding to nearly 1.7 MWh of thermal energy. Accordingly, an oil flow of 20 million barrels per day is equivalent to approximately 34 TWh per day of thermal energy shown in Table 2. Assuming an average thermal power plant efficiency of 40%, this amount corresponds to nearly 13.6 TWh per day of electrical energy, or an average power equivalent of approximately 567 GW [19].

TABLE 2. APPROXIMATE ENERGY EQUIVALENT OF OIL FLOW THROUGH THE STRAIT OF HORMUZ.

Parameters	Value	Description
Daily oil flow	20 million barrels/day	Strait of Hormuz transit volume
Energy equivalent of 1 barrel of oil	Approximately 1.7 MWh thermal	Approximate conversion coefficient
Daily thermal energy equivalent	34 TWh/day	20 million × 1.7 MWh
Default power plant efficiency	40%	Average thermal cycle assumption
Energy equivalent of electricity	13.6 TWh/day	Theoretical electricity generation equivalent
Average power equivalent	Approximately 567 GW	13.6 TWh / 24 hours

This scale indicates that the Strait of Hormuz has strategic significance not only for oil markets, but also for the overall adequacy of energy systems. The purpose here is not to assume that all oil passing through the Strait is used for electricity generation. Rather, the aim is to translate the magnitude of fuel flows associated with the Strait of Hormuz into a scale that is more understandable from an electrical engineering perspective.

C. LNG Supply and Gas-Fired Electricity Generation

One of the most critical aspects of the Strait of Hormuz in terms of electricity generation is LNG supply. In many countries, LNG is one of the main fuels used for power generation in combined-cycle natural gas power plants. Natural gas-fired power plants play a strategic role in power systems due to their fast start-up capability, operational flexibility, relatively short construction period, and ability to balance fluctuations in renewable energy generation. Any disruption in LNG flows through the Strait of Hormuz could disturb the fuel procurement schedules of combined-cycle natural gas power plants, increase spot LNG prices, raise the marginal generation cost of gas-fired power plants, and force system operators to dispatch more expensive or higher-emission alternative generation units. It could also reduce the system's ability to balance uncertainties in renewable energy generation and increase the need for reserve capacity. This situation is particularly important for Asian countries that depend heavily on LNG imports. A large share of energy exports passing through the Strait of Hormuz is directed toward Asian markets. The high share of China, India, Japan, and South Korea in crude oil flows originating from the Strait of Hormuz indicates that these countries are highly sensitive to developments in the Strait in terms of both electricity generation and industrial energy security in Table 3.

TABLE 3. TECHNICAL EFFECTS OF FUEL SUPPLY DISRUPTION ON THE ELECTRICITY GENERATION SYSTEM.

Fuel supply risk	Affected production sources	Technical consequences	Systemic impact
LNG delivery delay	Combined cycle natural gas power plants	Disruption in production schedule	Increased need for backup capacity
LNG price increase	Gas power plants	Increased marginal production cost	Increased electricity market price
Oil supply risk	Oil-fired power plants and generators	Increased fuel cost and inventory risk	Increased emergency production cost
Increased insurance and freight costs	Entire imported fuel chain	Increased fuel delivery cost	Puts pressure on consumer tariffs
Partial sea transit restrictions	LNG and oil transportation	Longer delivery times	Increased importance of fuel stocks
Severe disruption	Thermal production portfolio	May reduce available capacity	EENS and LOLE may increase

D. The Impact Mechanism from the Fuel Supply Chain to the Electricity System

The impact of a potential risk in the Strait of Hormuz on the electricity system emerges gradually through several stages. In the first stage, maritime transportation and insurance costs are affected. In the second stage, prices increase in oil and LNG markets. In the third stage, the generation costs of natural gas- and oil-fired power plants rise. In the fourth stage, electricity market prices, reserve capacity requirements, and overall system reliability are affected.

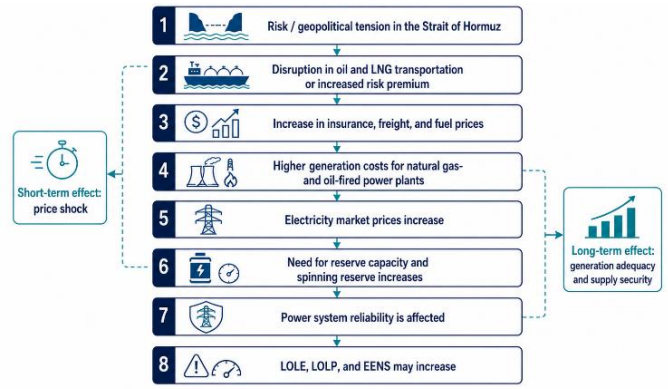

Fig. 1. The transfer mechanism of fuel supply risk originating from the Strait of Hormuz to electricity generation costs.

E. The Importance of Alternative Route Capacities for Fuel Supply Security

Pipelines and alternative ports developed to reduce dependence on the Strait of Hormuz can strengthen the resilience of the fuel supply chain. However, the capacity of the existing alternatives is not sufficient to fully substitute the total volume of energy flows passing through the Strait of Hormuz. Therefore, these infrastructures should not be considered complete replacements for the Strait of Hormuz, but rather complementary options that enhance supply security in Table 4 [20].

TABLE 4. SOME ALTERNATIVE ENERGY ROUTES AND CAPACITIES TO THE STRAIT OF HORMUZ.

Infrastructure / Route	Country / Region	Approximate capacity	Abqaiq–Yanbu	Role in terms of energy supply security
Saudi Arabia East-West Pipeline	Saudi Arabia	Approximately 5 million barrels/day	Habshan – Fujairah	Hormuz bypass possibility via the Red Sea
Abu Dhabi Crude Oil Pipeline	UAE	Approximately 1.5 million barrels/day	Abqaiq – Duqm	Access to the Arabian Sea without entering the Strait of Hormuz
Proposed Arab Energy Corridor	Saudi Arabia + Gulf	Approximately 2.5 million barrels/day + gas	Goreh–Jask	Land-based corridor with multiple energy flows
Goreh–Jask Pipeline	Iran	Approximately 300 thousand barrels/day	Gwadar – Kashgar	Exports outside the Strait of Hormuz via the Gulf of Oman
Gwadar Connection	Pakistan / China	Depending on project and capacity	Abqaiq–Yanbu	Land-sea based supply diversification for China

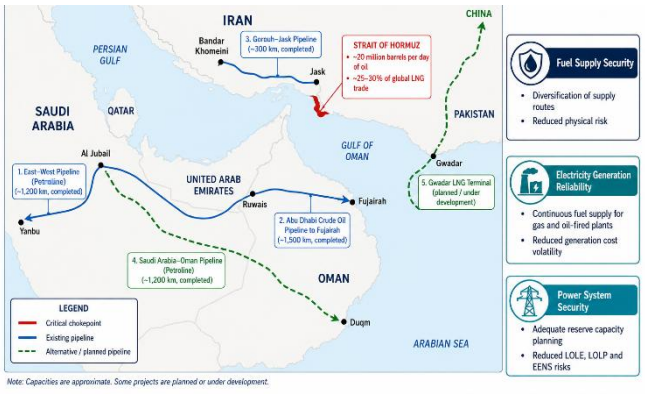

Fig. 2. Diagram showing the relationship between the Strait of Hormuz, alternative pipelines, and electricity generation security.

F. Risk Level Matrix in Terms of Electricity Generation

The impact of fuel supply interruptions on the electricity system varies depending on the duration and severity of the interruption. Short-term and low-severity risks mainly result in price increases, while long-term and high-severity interruptions can directly affect power plant availability and system reliability.

The numerical data clearly demonstrate the concentrated role of the Strait of Hormuz in the global energy system. The passage of approximately 20 million barrels of oil per day through the Strait, corresponding to nearly one-fifth of global oil consumption, together with the fact that roughly one-quarter to one-third of global LNG trade is associated with this route, makes the Strait of Hormuz critical from the perspective of electricity generation as well. Considering the role of natural gas-fired power plants in system flexibility, balancing, and meeting peak demand, any disruption in LNG supply may affect not only fuel markets, but also power system operation in Table 5 [20].

TABLE 5. IMPACT OF FUEL SUPPLY RISK FROM THE STRAIT OF HORMUZ ON ELECTRICITY GENERATION.

Risk level	Fuel market impact	Impact on electricity production	System reliability impact	Proposed measures
Low	Limited price increase	Production continues	Reliability impact is low	Fuel price monitoring
Medium	Increase in LNG and oil prices	Production costs of gas power plants increase	Backup capacity needs may increase	Fuel stock management
High	Delivery delays	The production schedule of some power plants may change	LOLE and EENS may increase	Alternative fuel and demand-side management
Very high	Serious supply disruption	Thermal capacity may be restricted	Risk of unmet energy needs increases	Strategic reserve, emergency production, and load management

Therefore, risks originating from the Strait of Hormuz should be incorporated into electricity generation planning together with fuel price scenarios, LNG delivery delays, power plant availability rates, reserve capacity requirements, and reliability indicators such as EENS. Such an approach moves energy supply security beyond a purely geopolitical discussion and places it within a technical analytical framework based on electrical engineering.

III. TECHNICAL IMPACTS ON POWER SYSTEM SECURITY

A supply risk in the Strait of Hormuz may affect power system security through several mechanisms. The first impact is related to fuel availability. In the event of delays or reductions in fuel deliveries, thermal power plants may be technically available but unable to operate at full capacity due to insufficient fuel supply. This situation reduces the available generation capacity of the system. The second impact is on generation costs. An increase in oil and LNG prices raises the marginal generation cost of natural gas- and oil-fired power plants. In liberalized electricity markets, this may lead to higher market clearing prices. In regulated markets, it may create pressure on public budgets, subsidies, or consumer tariffs. The third impact is the growing need for reserve capacity. When uncertainty in fuel supply increases, system operators may need to maintain higher levels of spinning reserve, fast-start capacity, or alternative generation resources. This issue becomes particularly important in power systems with a high share of renewable energy, since natural gas-fired power plants play a critical role in balancing and frequency control. Therefore, the fuel security of these plants is also essential for system flexibility. The fourth impact is the deterioration of reliability indicators. In power system reliability studies, power plant outage rates and demand uncertainty are generally taken into account. However, in systems that depend on imported fuels, fuel supply disruptions should also be modeled as a factor that reduces plant availability. In this context, supply risks associated with the Strait of Hormuz may affect reliability indicators such as LOLE, LOLP, and EENS.

A. Scenario-Based Technical Assessment

The impact of the Strait of Hormuz on electricity supply security should not be evaluated only in terms of the possibility of a physical closure. It should also be assessed together with fuel price increases, LNG and oil shipment delays, insurance and freight costs, thermal power plant availability, reserve capacity requirements, and reliability indicators. For this reason, four main scenarios are developed in this study: normal operation, risk premium, partial disruption, and severe disruption. In these scenarios, the daily oil flow through the Strait of Hormuz is assumed to be approximately 20 million barrels per day. It is also assumed that one barrel of oil contains approximately 1.7 MWh of thermal energy and that the average efficiency of a thermal power plant is 40%. Under these assumptions, an oil flow of 1 million barrels per day corresponds to approximately 0.68 TWh per day of electricity equivalent, or about 28.3 GW of average power. This value does not imply that all oil is used for electricity generation; rather, it is used only to express the scale of energy flow in a form that is comparable from an electrical engineering perspective.

B. Scenario Assumptions

Four different cases are compared in the scenario analysis. The normal operation scenario represents the uninterrupted continuation of existing energy flows. In the risk premium scenario, no physical disruption occurs, but geopolitical tension leads to increases in fuel prices, insurance costs, and freight rates. In the partial disruption scenario, energy flows through the Strait of Hormuz are assumed to decrease by 25%. In the severe disruption scenario, transit capacity is assumed to decrease by 50% in Table 6.

TABLE 6. BASIC ASSUMPTIONS USED IN SCENARIO ANALYSIS.

Parameters	Value	Description
Strait of Hormuz oil transit volume	20 million barrels/day	Basic reference flow
Share in global petroleum liquids consumption	Approximately 20%	Global systemic risk indicator
Share of exports directed to Asia	More than 80%	Demand-side dependency
Share of China, India, Japan and South Korea	Approximately 69%	High sensitivity for Asian electricity and industrial systems
Energy equivalent of 1 barrel of oil	Approximately 1.7 MWh thermal	Energy conversion coefficient
Average thermal power plant efficiency	40%	Assumption for electricity equivalent calculation
Electricity equivalent of 1 million barrels/day	0.68 TWh/day	1.7 MWh × 40% × 1 million
Average power equivalent of 1 million barrels/day	28,3 GW	0,68 TWh / 24 saat

C. Numerical Comparison of Scenarios

The scenarios were compared in terms of the rate of decrease in energy flow, daily affected oil volume, electrical energy equivalent, average power equivalent, fuel price effect, and potential consequences on the electricity system.

As shown in Table 7, even in the absence of a physical disruption, the risk premium scenario increases electricity generation costs. In the partial disruption scenario, a flow loss of 5 million barrels per day corresponds to approximately 3.4 TWh per day of electricity equivalent. In the severe disruption scenario, this value rises to 6.8 TWh per day. These figures indicate that a supply shock originating from the Strait of Hormuz should be taken into account not only in relation to oil markets, but also in electricity generation planning [21].

TABLE 7. NUMERICAL COMPARISON OF SCENARIOS ORIGINATING FROM THE STRAIT OF HORMUZ.

Scenario	Flow reduction	Affected oil volume:	Electrical energy equivalent	Average power equivalent	Fuel price impact	Impact on the electricity system
Normal operation	0%	0 million barrels/day	0 TWh/day	0 GW	Reference level	Normal production planning
Risk premium	0%	0 million barrels/day	0 TWh/day	0 GW	+10–15%	Production costs increase
Partial interruption	25%	5 million barrels/day	3.4 TWh/day	141.5 GW	+25–40%	Fuel constraints and cost pressures arise
Severe interruption	50%	10 million barrels/day	6.8 TWh/day	283 GW	+60–100%	Power plant availability and supply security risks increase

D. *Impact of the Scenarios on Electricity Generation Costs*

A fuel cost index was developed to illustrate the impact of Strait of Hormuz-related risks on electricity generation costs. The normal operation scenario was taken as the baseline and assigned a value of 100. Under the risk premium scenario, the fuel cost index is assumed to increase to the range of 110–115. In the partial disruption scenario, it may rise to the range of 125–140, while in the severe disruption scenario it may reach the range of 160–200.

TABLE 8. IMPACT OF FUEL COST AND ELECTRICITY GENERATION COST ACCORDING TO SCENARIOS.

Scenario	Fuel cost index	Impact on gas power plants	Impact on petroleum-fueled production	Potential impact on electricity market price
Normal operation	100	Normal operation	Normal operation	Reference market price
Risk premium	110–115	Marginal costs increase	Emergency production costs increase	Limited price increase
Partial interruption	125–140	Fuel supply planning becomes more difficult	Inventory utilization increases	Moderate-high price increase
Severe interruption	160–200	Production constraints may occur in some plants	Emergency production costs rise significantly	High price shock

This comparison shows that electricity generation costs are sensitive not only to the physical availability of fuel, but also to the perception of risk. In power systems where natural gas-fired power plants operate as marginal generation units that determine market prices, an increase in LNG prices may be directly reflected in electricity market prices.

E. *EENS Comparison Based on a Sample Power System*

A sample electricity system is assumed in order to illustrate the impact of the scenarios on power system reliability. In this system, it is assumed that there is 10 GW of natural gas- and oil-fired generation capacity that is sensitive to fuel supply risks originating from the Strait of Hormuz. The duration of critical supply stress is taken as 12 hours. In the partial disruption scenario, 25% of this capacity is assumed to become unavailable, while in the severe disruption scenario, the unavailable share is assumed to increase to 50%. For the EENS calculation, the following approach is used: "EENS = unavailable capacity × critical duration."

TABLE 9. COMPARISON OF EENS SCENARIOS IN THE EXAMPLE POWER SYSTEM.

Scenario	Capacity sensitive to the Strait of Hormuz	Capacity constraint rate	Unavailable capacity	Critical time	Approximate EENS
Normal operation	10 GW	0%	0 GW	12 hours	0 GWh
Risk premium	10 GW	0%	0 GW	12 hours	0 GWh
Partial interruption	10 GW	25%	2.5 GW	12 hours	30GWh
Severe interruption	10 GW	50%	5 GW	12 hours	60 GWh

The values presented in Table 9 were calculated for a sample power system and are intended to demonstrate the potential impact of fuel supply risks originating from the Strait of Hormuz on power system reliability. In the risk premium scenario, no EENS occurs because there is no physical loss of generation capacity; however, generation costs increase. In the partial disruption scenario, a risk of 30 GWh of unserved energy emerges, while in the severe disruption scenario this risk rises to 60 GWh.

F. *Impact of Alternative Corridors on the Scenarios*

Although alternative pipelines and energy corridors cannot completely eliminate the risks associated with the Strait of Hormuz, they can improve system resilience under disruption scenarios. Existing and proposed infrastructures may allow a certain share of flows that depend on the Strait of Hormuz to be redirected through other routes. In this context, the Saudi Arabia East–West Pipeline, the Abu Dhabi Crude Oil Pipeline, the Goreh–Jask Pipeline, the Gwadar connection, and the proposed Arab Energy Corridor can be considered complementary solutions for strengthening supply security.

This table shows that alternative routes become particularly important under partial and severe disruption scenarios. However, considering the approximately 20 million barrels per day of flows passing through the Strait of Hormuz, the existing bypass capacities remain far from sufficient to offset the total risk. Therefore, alternative corridors should not be considered sufficient on their own; they should be assessed together with strategic fuel storage, LNG supply diversification, renewable energy investments, battery storage, demand-side participation, and reserve capacity planning.

TABLE 10. MITIGATION EFFECT OF ALTERNATIVE ROUTES ACCORDING TO SCENARIOS.

Alternative route / infrastructure	Approximate capacity	Role in normal operation	Role in partial disruption	Role in severe disruption
Saudi Arabia East-West Pipeline	Approximately 5 million barrels/day	Export diversification	Directing a portion of the oil flow	Critical bypass capacity
Abu Dhabi Crude Oil Pipeline	Approximately 1.5–1.8 million barrels/day	Exit via Fujairah	Flexibility for UAE exports	Export support outside the Strait of Hormuz
Goreh–Jask Pipeline	Approximately 300 thousand barrels/day	Limited alternatives	Low-scale bypass	Limited mitigation effect
Gwadar connection	Project-based	Strategic alternatives	Supply diversification for China	Long-term land-sea option
Arab Energy Corridor	1.5 million barrels/day single line; 2.5 million barrels/day + gas	Regional corridor	Resilience in fuel flow	Strategic support through multiple energy flows

G. General Comparison of the Technical Outcomes of the Scenarios

When the technical impacts of the scenarios are evaluated together, it can be seen that the risk is reflected in the electricity system through three main stages. The first stage is the economic impact, in which fuel prices, insurance costs, and freight rates increase. The second stage is the operational impact, where the generation scheduling of gas- and oil-fired power plants becomes more difficult. The third stage is the reliability impact, in which available capacity decreases, the need for reserve capacity increases, and reliability indicators such as EENS and LOLE may deteriorate.

TABLE 11. GENERAL COMPARISON OF THE SCENARIOS IN TERMS OF ELECTRICITY SUPPLY SECURITY.

Scenario	Fuel supply risk	Production cost risk	Capacity adequacy risk	EENS/LOLE effect	Overall risk level
Normal operation	Low	Low	Low	None / negligible	Low
Risk premium	Low	Medium	Low	None / limited	Medium
Partial interruption	Medium	High	Medium	Increase begins	High
Severe interruption	High	Very high	High	Significant increase	Very high

The numerical comparisons show that the effects of Strait of Hormuz-related risks on the electricity generation system emerge at two different levels. The first level is the price effect. In this case, even if there is no physical supply disruption, the generation costs of natural gas- and oil-fired power plants increase, creating upward pressure on electricity market prices. The second level is the physical fuel supply constraint, which directly reduces available generation capacity. In the partial disruption scenario, the affected flow of 5 million barrels per day corresponds to approximately 3.4 TWh per day of electricity equivalent. In the severe disruption scenario, a flow loss of 10 million barrels per day reaches approximately 6.8 TWh per day of electricity equivalent. Based on the calculation carried out for a sample 10 GW fuel-dependent generation capacity, the risk of EENS may reach 30 GWh under the partial disruption scenario and 60 GWh under the severe disruption scenario during a 12-hour period of critical supply stress. As a result, scenario analyses related to the Strait of Hormuz should include fuel supply security, generation costs, reserve capacity, and system reliability dimensions together from an electrical engineering perspective. This approach moves the discussion of energy supply security beyond a purely geopolitical assessment and places it within a quantitative, technical, and power system-oriented analytical framework.

IV. ALTERNATIVE ENERGY CORRIDORS AND SUPPLY RESILIENCE

Due to the structural risk posed by the Strait of Hormuz, many countries and regional actors have sought to develop alternative energy routes. In this context, the Saudi Arabia East–West Pipeline and the Abu Dhabi Crude Oil Pipeline are among the existing bypass infrastructures. Although these pipelines reduce the dependence of some oil exports on the Strait of Hormuz, they do not have sufficient capacity to fully substitute total Gulf energy exports. Gwadar Port is considered a strategic alternative, particularly for China's long-term energy security. Within the framework of the China–Pakistan Economic Corridor, Gwadar is intended to provide a land–sea connection between the Arabian Sea and China's western regions. The main advantage of this route is its potential to reduce China's dependence on vulnerable maritime chokepoints for energy imports. However, the realization of this potential depends on the completion of infrastructure investments, pipeline capacity, regional stability, and economic feasibility. The Arab Energy Corridor can be evaluated as a land-based energy infrastructure approach aimed at connecting Gulf production centers to Duqm Port in Oman. Such a corridor could bypass the Strait of Hormuz and provide direct access to the Arabian Sea. From the perspective of electricity generation, these alternative routes could contribute to the operational security of thermal power plants by improving the continuity of fuel supply.

A. Evaluation from the Perspective of Electrical Engineering and Energy Policy

The technical analysis of the Strait of Hormuz reveals important implications for both electrical engineering and energy policy. First, fuel supply security should be considered an integral part of electricity supply security. Electricity generation planning should not be limited to installed capacity, demand growth, and renewable energy integration; it should also take into account the geopolitical and logistical reliability of fuel supply chains. Second, countries that depend on LNG imports should strengthen fuel diversification. Long-term LNG agreements with different suppliers, floating storage and regasification units, underground natural gas storage facilities, strategic fuel reserves, and flexible supply mechanisms are important for improving supply security. Third, non-fuel-dependent sources of flexibility should be increased in electricity systems. Renewable energy, battery energy storage systems, pumped-storage hydropower plants, demand-side participation, and interconnection capacity can

reduce dependence on imported fossil fuels. However, the contribution of these resources to system reliability should be supported by technical planning and adequacy analyses. Fourth, fuel supply risk should be incorporated into power system reliability models. Traditional reliability analyses are generally based on generation unit outages and demand uncertainty. However, in countries with high dependence on imported fuels, fuel delivery risk should also be modeled as a variable that affects power plant availability. Finally, energy corridors should be evaluated not only in terms of transportation cost, but also in terms of the supply security value they provide. An infrastructure investment that may appear costly under normal conditions can become strategically rational when the economic losses prevented during large-scale supply disruptions are taken into account. Therefore, the concept of an energy security premium can be used as an important criterion in the assessment of energy infrastructure investments.

V. CONCLUSION

The Strait of Hormuz is not merely a maritime passage; it is a critical infrastructure component for global energy supply security and the continuity of electricity generation. The dependence of a significant share of oil and LNG trade on this chokepoint makes the Strait of Hormuz a strategic risk factor in terms of electricity generation costs, fuel supply security, and power system reliability. From an electrical engineering perspective, the main issue is not only whether oil or LNG shipments continue. The more important issue is how uncertainty in fuel supply affects generation planning, power plant operation decisions, reserve capacity requirements, electricity market prices, and reliability indicators. Since natural gas- and oil-fired power plants are sensitive to fuel supply conditions, risks originating from the Strait of Hormuz should be incorporated into power system planning. Alternative routes such as Gwadar Port, the Saudi Arabia East–West Pipeline, the Abu Dhabi Crude Oil Pipeline, and the Arab Energy Corridor can improve supply resilience. However, these alternatives should be regarded as complementary solutions that reduce existing dependence rather than as complete substitutes for the Strait of Hormuz. Therefore, energy-importing countries should address route diversification, fuel storage, renewable energy investments, grid flexibility, demand-side management, and reliability-based planning approaches together. In conclusion, the security of the Strait of Hormuz should not be evaluated solely as a geopolitical or maritime trade issue. It should be considered as an integrated technical problem linked to the fuel supply chain, electricity generation, and power system reliability. This approach can contribute to a more comprehensive and engineering-based analysis of energy supply security.

REFERENCES

[1] J. M. Łukasiak, J. Paś, and A. Rosiński, 'Selected Reliability Aspects Related to the Power Supply of Security Systems', *Energies*, vol. 17, no. 15, p. 3665, Jul. 2024, doi: 10.3390/en17153665.

[2] M. Rele and D. Patil, 'Enhancing Safety and Security in Renewable Energy Systems within Smart Cities', in *2023 12th International Conference on Renewable Energy Research and Applications (ICRERA)*, Oshawa, ON, Canada: IEEE, Aug. 2023, pp. 105–114. doi: 10.1109/ICRERA59003.2023.10269395.

[3] G. Bahgat, 'Crisis in the Strait of Hormuz: What Lies Ahead?', *Middle East Policy*, vol. 33, no. 2, pp. 72–84, Jun. 2026, doi: 10.1111/mepo.70083.

[4] E. Eiran, 'Why do some limited regional conflicts in the maritime domain have global consequences? Evidence from two Middle Eastern wars', *Front. Polit. Sci.*, vol. 8, p. 1741706, Mar. 2026, doi: 10.3389/fpos.2026.1741706.

[5] U. Egwuatu, 'The Strait of Hormuz as a Strategic Maritime Chokepoint: Implications of Escalating Geopolitical Tensions for Global Shipping', 2026, *SSRN*. doi: 10.2139/ssrn.6563258.

[6] M. G. Kassim and A. I. Osman, 'The impact of Bab al-Mandab and the strait of Hormuz on Somalia's ports and maritime security', *J. Transp. Secur.*, vol. 19, no. 1, p. 7, Dec. 2026, doi: 10.1007/s12198-026-00330-5.

[7] S. Sangwa, N. Kabanyana, and E. Murungu, 'Strait of Hormuz Disruption, Africa–Asia Trade Linkages, and Policy Options for African States', Mar. 30, 2026, *Business, Economics and Management*. doi: 10.20944/preprints202603.2257.v1.

[8] D. Icaza and D. Borge-Diez, 'Potential Sources of Renewable Energy for the Energy Supply in the City of Cuenca-Ecuador with Towards a Smart Grid', in *2019 8th International Conference on Renewable Energy Research and Applications (ICRERA)*, Brasov, Romania: IEEE, Nov. 2019, pp. 603–610. doi: 10.1109/ICRERA47325.2019.8997114.

[9] M. R. Tur and R. Bayindir, 'The Impact of Variable Renewable Energy on Spinning Reserve Requirements: A Case Study of the Spanish Power System', in *2025 13th International Conference on Smart Grid (icSmartGrid)*, Glasgow, United Kingdom: IEEE, May 2025, pp. 822–829. doi: 10.1109/icSmartGrid66138.2025.11071780.

[10] M. R. Tür, 'Energy Supply Security and Artificial Intelligence Applications', *Insight Turk.*, pp. 213–233, Aug. 2022, doi: 10.25253/99.2022243.13.

[11] R. Temiz and M. R. Tür, 'Investment technique for ensuring energy supply continuity in ring grids', *Turk. J. Eng.*, vol. 8, no. 2, pp. 186–195, Apr. 2024, doi: 10.31127/tuje.1357643.

[12] E. Kazanecka, A. Gucwa, A. Wyrwa, A. Higler, and E. Unsal, 'Scenario Analysis for Balancing Renewable Energy Intermittency-A Comperative Study for Netherlands and Poland', in *2025 14th International Conference on Renewable Energy Research and Applications (ICRERA)*, Vienna, Austria: IEEE, Oct. 2025, pp. 1125–1130. doi: 10.1109/ICRERA66237.2025.11284119.

[13] M. H. Shahzad, B. B. Liaqat, and I. Wakil, 'Maritime Stability of Strait of Hormuz: A Critical Analysis', *Glob. Polit. Rev.*, vol. X, no. II, pp. 41–49, Jul. 2025, doi: 10.31703/gpr.2025(X-II).04.

[14] L. Chai, Z. Huo, X. Zhang, Y. Han, Y. Huang, and H. Mei, 'Multi-objective optimization of a hybrid gas turbine combined cycle system with LNG cold energy integration', *Energy*, vol. 353, p. 140916, Jun. 2026, doi: 10.1016/j.energy.2026.140916.

[15] H. Mansour, 'Maritime Transport Disruptions and Oil Price Volatility: A GARCH-MIDAS Scenario Analysis of Strait of Hormuz Closure', 2026, *SSRN*. doi: 10.2139/ssrn.6422678.

[16] G. Saif Al-Kuwari, 'Oil as a Tool for Political Influence: Opportunities and Risks', *QScience Connect*, vol. 2026, no. 1, p. 6, May 2026, doi: 10.5339/connect.2026.6.

[17] S.-J. Lee, J. Kim, and H.-S. Yun, 'How Sustainable Is Arctic Route Diversification? Economic Losses, SDG Trade-Offs, and Supply Chain Resilience in the 2026 Hormuz Crisis', *Sustainability*, vol. 18, no. 9, p. 4318, Apr. 2026, doi: 10.3390/su18094318.

[18] A. Fereidunian, A. Hajizadeh, P. Salyani, H. Shahinzadeh, and M. Roscia, 'Integrated Planning of the Electricity-Gas-Water Nexus for Smart City Infrastructure', in *2025 14th International Conference on Renewable Energy Research and Applications (ICRERA)*, Vienna, Austria: IEEE, Oct. 2025, pp. 1936–1941. doi: 10.1109/ICRERA66237.2025.11283675.

[19] G. Villines, 'Petroleum Inventory Trajectories Under the 2026 Strait of Hormuz Closure: A Mass-Balance Forecast Model with Sensitivity Analysis and Falsifiable Predictions', 2026, *SSRN*. doi: 10.2139/ssrn.6737518.

[20] R. Ramadhani and A. Marzaman, 'MARITIME STABILITY IN THE STRAIT OF HORMUZ: CHALLENGES, GLOBAL IMPACTS, AND MULTILATERAL DIPLOMACY', *HYPOTHESIS Multidiscip. J. Soc. Sci.*, vol. 3, no. 02, pp. 81–96, Dec. 2024, doi: 10.62668/hypothesis.v3i02.1293.

[21] Mohamed Buheji and Kongkiti Phusavat, 'From Reactive Survival to Generative Resilience- Double-Loop Learning as a Strategic Imperative for GCC Societies in the 2026 War on Iran', May 2026, doi: 10.5281/ZENODO.20122271.