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Original Article

Investigating the Strategic Cooperation for a Greener Tomorrow in Saudi Aramco's Liquefied Natural Gas (LNG) Pathway to Sustainable Energy

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Abstract: Petroleum has long served as the cornerstone of global industrialization and the backbone of Saudi Arabia's economy. However, the rising global demand for energy, coupled with increasing environmental concerns, underscores the urgent need to diversify energy sources towards more sustainable alternatives. In this context, this study examines the role of Saudi Aramco's international collaborations in advancing Liquefied Natural Gas (LNG) initiatives as part of the transition toward a low-carbon energy future. Employing a qualitative exploratory methodology, the research draws upon secondary data from academic journals, books, industry reports, and official publications to assess the strategic partnerships and technological advancements underpinning these efforts. The findings highlight that Saudi Aramco, in alliance with global energy leaders such as Abu Dhabi National Oil Company (ADNOC), PTT Public Company Limited (PTT PCL), and China Petroleum & Chemical Corporation (SINOPEC), has made significant strides in leveraging its natural gas resources for LNG development. These collaborations have facilitated the deployment of low-emission technologies and the integration of green innovations—most notably Carbon Capture, Utilization, and Storage (CCUS), as well as the incorporation of renewable energy into LNG production systems. By aligning with international partners, Saudi Aramco is not only broadening its participation in the global energy market but also reinforcing its commitment to environmental sustainability. The study concludes by recommending increased investment in clean energy technologies and deeper international cooperation to ensure the long-term viability and ecological integrity of LNG projects.

Keywords: Liquefied Natural Gas (LNG); Saudi Aramco; Energy Diversification; International Cooperation; Green Technologies.

1. Introduction

Fossil fuels, particularly oil, have played a pivotal role in driving industrialization and global trade. Petroleum has been supporting the industrial revolution since the late 19th century. It serves as the backbone of Saudi Arabia's economy, which is recognized as one of the world's largest oil producers. Saudi Arabia controls some of the largest oil

reserves globally, with Saudi Aramco as the state-owned oil company playing a crucial role in oil exploration, production, and export (Zalwa Apriliana Sesa, Baginda Goldy Hamonangan, Najla Ramadhanthi Yuristiannisa, 2021). The increasing energy consumption driven by economic growth, population expansion, and industrialization has led to a rising demand for energy to support development and economic progress (Pangestu & Soesanto, 2023). While the use of fossil fuels can stimulate economic growth, it also significantly impacts on the environment. The Saudi government launched a program to collect associated gas from oil and its valuable by-products (Al-Falih, 2004). The goal of this program was to protect the environment by eliminating gas flaring and preserving valuable gas resources for industrial purposes (Younis, 2022).

This initiative, known as the Master Gas System (MGS), includes a collection system, processing plants, fractionation plants, storage facilities, transmission pipelines, and export terminals. Following the launch of the Master Gas System, aimed at collecting and utilizing associated gas, Saudi Aramco began exploring and developing non-associated gas reserves unrelated to oil production. This development enabled Saudi Aramco to process the gas into Liquefied Natural Gas (LNG) (Pio & Salzano, 2018). Although Saudi Aramco excels as the largest oil supplier globally, it lacks experience in developing LNG projects. Thus, the company needs to seek qualified partners to assist in LNG project development through investment and collaboration to achieve mutual goals. Saudi Aramco faces several technical and commercial challenges, including identifying strategic locations for international market activities and ensuring infrastructure security and technology to position LNG in the global arena.

The urgency of this research lies in understanding and developing effective collaborative strategies for LNG project development by Saudi Aramco to meet the needs of a sustainable energy economy. The use of LNG, representing a transition from non-renewable to sustainable and environmentally friendly energy sources, can reduce carbon emissions and air pollution in power generation and industrial sectors (Çengel, 2020). This aligns with Islamic principles, emphasizing humans' duty to manage the environment responsibly to meet human needs without causing destruction. Surah Al-A'raf verse 56, interpreted by the scholar Ibn Kathir, highlights the prohibition against actions that harm the Earth's preservation and stability (Katsir, 2015). The author analyze the collaboration undertaken by Saudi Aramco to achieve environmentally friendly energy economy goal. Saudi Aramco continues to enhance its technology and production capabilities through LNG processing by collaborating with technology and energy companies from other countries (Demirbas et al., 2016). International cooperation enables Saudi Aramco to adopt advanced technologies and improve efficiency in implementing sustainable energy through LNG projects.

2. Literature Review

The first discussion concerns on Saudi Arabia’s policy on importing LNG to meet domestic needs. Through the study conducted by Rami Shabaneh and Maxime Schenckery titled “Assessing Energy Policy Instruments: LNG Imports into Saudi Arabia”, it is explained that Saudi Arabia utilized LNG to support a more efficient and economical energy mix transition from oil dependency compared to relying solely on liquid fuels. The use of LNG for power generation also helps Saudi Arabia achieve environmental and air quality targets (Shabaneh & Schenckery, 2020). The second discussion highlights the role of natural gas in Saudi Arabia to fulfill energy needs and achieve significant economic growth. In the study by Ayhan Demirbas, Hemaid Alsulmi, and Abdul-Sattar Nizami (2016) by titled “The Natural Gas Potential of Saudi Arabia” it is noted that importing LNG can push companies towards more robust market-based energy pricing within the electricity supply mix. Several LNG facilities, such as Jum’aymah and Yanbu plants, are set for operational expansion, where LNG pipelines connect two major centers between the Arabian Gulf and the Red Sea. These initiatives are supported by the government in promoting sustainable energy efficiency projects in industrial, transportation, and residential sectors (Demirbas et al., 2016).

The third discussion addresses the technologies employed in LNG processing. The study titled “The Future Role of Natural Gas in Saudi Arabia” by Mohamed Morsy Elgohary and Captain Khalil Hemida introduces the launch of Floating Liquefied Natural Gas (FLNG) technology capable of producing, storing, and transferring LNG. FLNG technology operates offshore, allowing the production, liquefaction, storage, and transfer of LNG directly at sea (Elgohary, 2013). The fourth discussion explores the use of LNG to reduce carbon emissions and establish environmentally friendly oil companies. In the study by Hussein Al-Yafei, Saleh Aseel, Murat Kucukvar, et al. (2021), titled “A systematic Review for Sustainability of Global Liquified Natural Gas Industry: A 10-year Update” it is revealed that LNG serves as a sustainable energy alternative that can significantly reduce greenhouse gas emissions over the past decade (2010–2020) in several LNG-utilizing countries (Al-Yafei et al., 2021).

The fifth discussion examines LNG transformation into renewable energy. In the study by Haoshui, Truls Gundersen, and Emre Gencer (2021), titled“Optimal Liquefied Natural Gas (LNG) Cold Energy Utilization in Allam Cycle Power Plant with Carbon Capture and Storage” the cold energy of LNG is used in Allam cycle power plants to reduce energy penalties in carbon capture or compression processes for recycled exhaust gas (Yu et al., 2021). The final discussion involves Ahmad Al-Douri, Abdulrahman S.A., and Margau (2022), in their study “Greenhouse Gases Emissions in Liquified Natural Gas as a Marine Fuel: Life Cycle analysis and reduction potential”. It emphasizes LNG’s potential as a marine fuel and its innovative solutions, such as decarbonization in liquefaction processes, to reduce

greenhouse gas emissions (Al-Douri et al., 2022). This research introduces the novelty discussion on Saudi Aramco's cooperation in LNG development. Using a qualitative method with study case approach and analyzing relevant documents, reports, and articles, this study aims to examine Saudi Aramco's partnerships with other oil and gas companies, such as ADNOC (Abu Dhabi), SINOPEC (China), and PTT (Thailand), in fostering a sustainable energy economy through LNG projects.

2.1. Conceptual Framework

2.1.1. International Cooperation

According to K.J. Holsti in his book *International Politics: A Framework for Analysis*, international cooperation is a process wherein interconnected states work together to find solutions to shared problems. This process involves approach by conducting negotiations and identifying technical factors to find solutions to meet the goals. Similarly, Charles Armor McClelland, in his book *Theory and International System* (1966), defines international cooperation as various forms of interaction between individuals or groups within a society through their respective states.(McClelland, 1966) Such cooperation can occur through governments or directly by individuals as citizens. One of the reasons countries are engaged to enhance economic prosperity by reducing production costs, which might otherwise burden the country due to limited resources. Saudi Aramco, as a state-owned enterprise contributing to Saudi Arabia's economic growth, collaborates with global oil companies to achieve shared goals and interests. Holsti identifies cooperation can be conducted when: (1) two or more countries share common interests, values, and goals to promote mutually beneficial outcomes; (2) each country anticipates that the policies enacted by other states will help to achieve their respective goals and interests; (3) it involves formal or informal rules, including written agreements, to regulate interactions on the way to achieve common objectives; (4) agreements or treaties often address relevant issues such as trade, environmental protection, human rights, security, and technology. The goal of Saudi Aramco's cooperation in LNG development aligns with Holsti's first principle, wherein each participating country shares a common objective to achieve mutual benefits.(Holsti, 1967).

The concept of international cooperation applied by national oil and gas companies, including Saudi Aramco and other renowned companies such as ADNOC (Abu Dhabi), SINOPEC (China), and PTT PCL (Thailand), involves routine interaction to establish efficient oil and gas operations while ensuring environmental sustainability. LNG project requires consistentcy in production, distribution, and the use of advanced technology to guarantee efficiency and sustainability. Through international cooperation, all parties involved in LNG projects obtain benefits from the cooperation. The imported nations gain access for cleaner and more stable energy resources, while at the same time the producing countries like Saudi Aramco expand their market to reach and increase revenue.

2.1.2. Green Industry

Green industry is based on four key principles that support industrial transformation toward sustainability. First, technology innovation is central to green industry, where clean technologies are employed to replace industrial processes with high pollution levels. Mechanism of carbon capture and utilization low-emission production methods, and renewable energy sources like solar and wind power, enable carbon footprint reduction while improving energy efficiency across various industrial sectors. Second, resource efficiency emphasizes optimizing raw material usage in a sustainable manner. Industries are encouraged to minimize waste, recycle materials, and reduce ecological pressures. Thus, it is also lowering operational costs and the risk of environmental harm at the same time (Ashford & Hall, 2011). Third, green industry aims to integrate economic growth with environmental preservation. Implementations on supporting policies such as tax incentives for green technology, carbon trading mechanisms, and strict regulations on pollution. Calls for, social justice and community empowerment form an integral part of the transition toward green industry. The dimension involves creating decent job opportunities and empower meet on communities to ensure benefits of industrial development are equitably distributed among all stakeholders. Saudi Aramco's LNG development project can be seen as concrete implementation of the principles of green industry. LNG, as a cleaner fuel compared to coal and petroleum, served as a solution to reduce carbon emissions and other pollutants. This aligns with global efforts to combat climate change while enhancing air quality. Within the framework of green industry, LNG development involves efficient technological innovations, to lower carbon emission.

3. Materials and Methods

3.1. Design of Study

This research employs a case study method to analyze the development of Liquefied Natural Gas (LNG) projects by Saudi Aramco to meet sustainable energy. According to Yves-Chantal Gagnon, a case study method involves observing and analyzing a single phenomenon using a holistic approach. This method is not only produces a detailed

description of the analyzed situation and events but also provides an in-depth understanding of the actors involved and their interactions (Bakry, 2016). The case study approach will involve secondary data analysis, including LNG production and consumption data, investment figures, and economic indicators related to the development of a sustainable energy cooperations. The data is analyzed to measure the economic impact of LNG projects, energy efficiency, and their contribution to reducing carbon emissions. This research focuses on problem analysis using a naturalistic paradigm and concepts relevant to the research questions.

3.2. Research Object

This research focuses on the initiatives and strategies employed by Saudi Aramco in developing LNG projects, including technology, investment, and project management. It also examines how this collaboration contributes to global energy needs and supports sustainable energy goals. The geographical scope of this research encompasses Saudi Aramco's operational areas in Saudi Arabia and partner countries. The analysis is focused on specific aspects such as LNG liquefaction, infrastructure, supportive government policies, and environmental impacts involving three companies collaborating with Saudi Aramco: ADNOC in Abu Dhabi, PTT in Thailand, and SINOPEC in China.

3.3. Data Collection Techniques

This research utilizes document-based data collection techniques, including literature studies and secondary data collection to access relevant information. The literature review includes data from various sources such as academic journals, books, websites, e-books, newspaper articles, reports, and official documents. Other secondary data sources include academic publications, company annual reports, government policies, and relevant news articles (Abdussamad, 2021). Additionally, the researcher collects data from various official documents and industry reports related to Saudi Aramco's LNG projects. After collecting the data, a filtering and selection process is carried out, followed by categorizing the data into discussion phases. This research aims to provide a comprehensive overview of how Saudi Aramco and its partners collaborate in developing sustainable LNG projects and their impact on the global energy economy.

3.4. Data Analysis Techniques

The data analysis technique employed in this research follows the Miles and Huberman model. This model involves three stages: data reduction, data display, and conclusion drawing verification. In the first stage, the researcher gathers data from various documents such as academic journals, reports, relevant books, websites, e-books, and news articles (Sugiyono, 2020). After collecting extensive data, the researcher reduces or selects data focusing on aspects significant to the research. The next stage is presenting the reduced data in descriptive paragraphs, followed by data verification and conclusion to address the research questions.

4. Results

4.1. Implementation of International Cooperation

4.1.1. Common Interest

A. ADNOC in Abu Dhabi

The Abu Dhabi National Oil Company (ADNOC) is one of the largest national energy companies in the United Arab Emirates (UAE), headquartered in Abu Dhabi. Since its establishment in 1971, ADNOC has played a crucial role in managing the UAE's oil and gas resources, directly contributing to the national Gross Domestic Product (GDP). As a state-owned company, ADNOC has full responsibility for managing oil and gas reserves, covering exploration, production, processing, distribution, and international trade (Kolsi et al., 2022).

Figure 1. Saudi Aramco and ADNOC MoU

This strategic role positions ADNOC as a key pillar of economic stability and energy security in the UAE.ADNOC operates across the entire energy supply chain, from upstream and downstream sectors to international trade. In the upstream sector, ADNOC has a significant crude oil production capacity, with a target of reaching 5 million barrels per day (bpd) by 2030. To achieve this goal, ADNOC is developing various exploration and production projects, both onshore and offshore.(Tordo et al., 2011) Meanwhile, in the downstream sector, ADNOC operates several refining facilities, such as the Ruwais Refinery, which has a processing capacity of over 900,000 bpd, making it one of the largest processing complexes in the world. Through the diversification of downstream products such as petrochemicals and value-added fuels, ADNOC enhances resilience against global oil price volatility.(Jones et al., 2023).

B. PTT PCL in Thailand

The cooperation between Saudi Aramco and PTT PCL is rooted in shared interests, values, and goals to ensure energy security and support sustainable economic growth. As a country highly dependent on energy imports, Thailand requires a strategic partner that can guarantee a long-term energy supply, while for Saudi Aramco, this partnership provides an opportunity to expand its market share in Southeast Asia. This common interest has driven both companies to strengthen their relationship, not only in crude oil trade but also in downstream sectors and clean energy development.(Termpittayapaisith & Dixon, 2011)

C. SINOPEC in China

Saudi Arabia, as the world's largest oil exporter, plays a strategic role in meeting China's energy needs, which is one of the largest energy consumers globally.(*Case Study Report on China Petroleum & Chemical Corporation (Sinopec Corp .)*, 2019) This relationship is strengthened through agreements and strategic cooperation between state-owned energy companies, aiming to ensure a stable energy supply for China while enhancing Saudi Arabia's position in the Asian market. More than 25% of China's crude oil imports came from Saudi Arabia, making it the primary energy supplier for the largest economy in Asia. Saudi Arabia's dependence on oil exports to China reflects Riyadh's efforts to expand markets and reduce reliance on traditional markets such as the United States and Europe. Therefore, Saudi Arabia is implementing a long-term strategy to deepen ties with Asian countries as the global economic growth centre shifts to the region.

Sinopec Limited, or China Petroleum and Chemical Corporation, is one of the world's largest energy and petrochemical companies operating globally. Founded in 2000, it is fully state-owned and plays a strategic role in managing energy and petrochemical resources both domestically and internationally. As an integrated energy company, Sinopec oversees all aspects of the energy industry, including exploration, production, processing, and distribution of oil and natural gas, as well as the manufacturing of petrochemical products.(Nolan & Zhang, 2002). The cooperation between Saudi Aramco and Sinopec is an example of international collaboration based on key indicators. First, both countries share common interests, values, and goals, particularly in ensuring energy security, enhancing economic growth, and developing refining and petrochemical industries. This mutual interest has led to significant joint investments in oil refining and chemical manufacturing, such as the Yanbu Aramco Sinopec Refining Company (YASREF) in Saudi Arabia.(Sheng, 2020)

4.1.2. Policy

A. ADNOC in Abu Dhabi

Both companies have aligned objectives in ensuring a stable LNG supply and developing more environmentally friendly energy technologies. This partnership allows both countries to share resources, technology, and expertise to achieve mutually beneficial outcomes. Furthermore, each country anticipates that the energy policies implemented by its partner will help achieve its national interests. The UAE and Saudi Arabia strive to secure LNG supplies for domestic needs and exports while strengthening their positions in the global market. In this context, each country's policies on energy diversification and low-carbon technology development support their shared goal of enhancing regional energy security.(Eldeen et al., 2023)

B. PTT PCL in Thailand

This collaboration is also motivated by the expectation that each party's policies will support the achievement of their respective goals. Thailand's energy import policies aim to maintain economic and industrial stability, while Saudi Aramco leverages these policies to increase its crude oil exports and expand its involvement in Thailand's downstream projects, such as the Rayong refinery. Through this cooperation, both parties can ensure a stable and mutually beneficial supply and distribution of energy.

C. SINOPEC in China

Saudi Arabia and China anticipate that the policies enacted by each party will help achieve their respective energy security and economic diversification goals. For Saudi Arabia, working with Sinopec aligns with its Vision 2030 strategy to diversify its economy beyond crude oil exports. For China, securing a stable oil supply from Saudi Arabia helps sustain its industrial and economic expansion. the cooperation involves formal and informal rules, including written agreements that regulate their interactions. Saudi Aramco and Sinopec have signed multiple agreements that establish frameworks for joint ventures, technology sharing, and research collaborations. These agreements ensure smooth operations and facilitate long-term commitments to energy production and petrochemical processing.

The inauguration of Yanbu Aramco Sinopec Refining Company in December 2015 coincided with the official visit of Chinese President Xi Jinping to Saudi Arabia, marking a significant milestone in the relationship between the two countries. This initiative reflects Saudi Aramco's vision to strengthen the company's image in the global market by diversifying its downstream portfolio. Saudi Aramco aims to increase the added value in the global energy supply chain and maximize the utilization of crude oil resources. For Sinopec, participation in the YASREF project offers strategic benefits, including guaranteed access to a stable supply of crude oil from Saudi Arabia. Furthermore, both companies are committed to integrating the hydrocarbon value chain comprehensively, by exploration, refining, and distribution of energy products. This project not only strengthens bilateral relations in the energy sector but also creates a synergistic model that combines the technological, operational, and economic strengths of both entities.(Zeng et al., 2022)

4.1.3. Agreement

A. ADNOC in Abu Dhabi

This collaboration also involves formal regulations outlined in a written agreement, as evidenced by the signing of a framework agreement on November 12, 2018, at the Abu Dhabi International Petroleum Exhibition and Conference (ADIPEC). This agreement serves as a regulatory foundation for both companies, governing the mechanisms of cooperation, joint investments, and technologies used in LNG production. Clear regulations ensure structured and effective interactions between the two parties. this agreement addresses key issues such as trade and environmental protection. ADNOC and Saudi Aramco are committed to reducing the carbon footprint in LNG production by implementing Carbon Capture, Utilization, and Storage (CCUS) technology. This technology helps reduce carbon emissions by up to 90%, aligning with global trends in developing cleaner energy.(Martín et al., 2021) Consequently, this collaboration not only brings economic benefits but also supports sustainable environmental policies.

B. PTT PCL in Thailand

In its implementation, this partnership is governed by formal regulations in the form of written agreements, including the Memorandum of Understanding (MoU) signed on May 11, 2022. The MoU reflects a long-term commitment across various areas, from crude oil trading to the development of blue and green hydrogen and other renewable energy initiatives. By establishing structured agreements, business interactions between Saudi Aramco and PTT PCL become more organized and effective in achieving shared energy sector objectives.

Figure 2. Aramco and PTT Deepen Energy Cooperation

Source: Aramco (2022)

C. SINOPEC in China

YASREF or Yanbu Aramco Sinopec Refining Company, which served as a tangible representation of the strengthening economic and energy relations between Saudi Arabia and China. YASREF was officially established on January 14, 2012, as a joint venture with a shareholding distribution of 62.5% owned by Saudi Aramco and 37.5% by Sinopec. Located in the Yanbu Industrial Area on the western coast of Saudi Arabia, it has a capacity to process up to 400,000 barrels of heavy Arabian crude oil per day. This project is designed to produce more than 13.5 million gallons of environmentally friendly transportation fuels, including high-octane gasoline and clean diesel fuel. YASREF manufactures a variety of high-value refined products that meet global environmental standards, supporting efforts toward sustainable energy transition.

4.1.4. Environmental Protection

A. ADNOC in Abu Dhabi

This agreement serves as a regulatory foundation for both companies, governing the mechanisms of cooperation, joint investments, and technologies used in LNG production. Clear regulations ensure structured and effective interactions between the two parties. This agreement addresses key issues such as trade and environmental protection. ADNOC and Saudi Aramco are committed to reducing the carbon footprint in LNG production by implementing Carbon Capture, Utilization, and Storage (CCUS) technology. This technology helps reduce carbon emissions by up to 90%, aligning with global trends in developing cleaner energy.(Martín et al., 2021) Consequently, this collaboration not only brings economic benefits but also supports sustainable environmental policies.

B. PTT PCL in Thailand

Beyond trade cooperation, this partnership also demonstrates a commitment to addressing global issues such as trade and environmental protection. With the growing demand for green energy, investments in hydrogen and clean energy technologies highlight that both companies are not only focused on economic gains but are also adapting to global trends toward decarbonization. This reinforces the notion that the collaboration between Saudi Aramco and PTT PCL has a far-reaching impact, both in international trade and in supporting sustainable environmental policies.(Public Company Limited, 2022)

C. SINOPEC in China

Through the establishment of the Yanbu Aramco Sinopec Refining Company (YASREF), Saudi Aramco has successfully expanded its access to Asian markets, with a particular focus on China, one of the world's largest energy consumers. In this joint venture, Sinopec serves as a key partner, ensuring the distribution of YASREF's refined products to the Chinese market. This collaboration not only strengthens bilateral economic relations between Saudi Arabia and China but also enhances Saudi Aramco's influence in the increasingly competitive global energy market. By leveraging China's strategic position as an industrial and energy consumption hub, the project opens significant market opportunities for Saudi Aramco amidst the dynamics of the international energy market.

4.2. Implementation of Green Industry

4.2.1. Technology Innovation

A. ADNOC in Abu Dhabi

Technological innovation is central to the Ruwais LNG Project, ensuring that production processes align with sustainability goals. Both ADNOC and Saudi Aramco are committed to deploying cutting-edge technologies to enhance the efficiency and environmental performance of LNG production. The use of artificial intelligence (AI) and automation plays a crucial role in optimizing gas liquefaction processes, reducing energy consumption, and detecting potential inefficiencies before they impact operations.(Asiva Noor Rachmayani, 2015) Moreover, carbon capture and storage (CCS) technology is integrated to significantly lower greenhouse gas emissions, capturing CO_2 released during the liquefaction process and either storing it or repurposing it in other industrial applications. By leveraging AI and CCS, the Ruwais LNG facility aims to become one of the most technologically advanced and environmentally sustainable LNG projects globally.

B. PTT PCL in Thailand

Technology innovation is central to the green industry, and both companies are investing heavily in research and development to enhance clean energy production. In the case of blue hydrogen, Saudi Aramco and PTT are deploying advanced Carbon Capture and Storage (CCS) technology to minimize carbon emissions. CCS enables the capture and storage of CO2 generated during hydrogen production, reducing environmental impact and ensuring compliance with global sustainability goals.(Sebbagh et al., 2024) For green hydrogen, both companies are utilizing cutting-edge water electrolysis technology powered by renewable energy sources such as wind and solar, ensuring zero carbon emissions

in the process.(APEC, 2018) This technological advancement strengthens their position as leaders in the sustainable energy economy.

C. SINOPEC in China

YASREF employs cutting-edge technology in its refining processes to optimize the efficiency and quality of the final products. The technologies used include hydrocracker distillation and hydrotreater units, which allow the conversion of heavy crude oil into clean transportation fuels and high-value products. Additionally, the refinery is equipped with a continuous catalytic reformer designed to produce high-octane gasoline that meets international standards. These technical advantages make YASREF one of the most innovative and technologically advanced refineries in the world. The application of technology as only enhances the economic value of the products but also ensures sustainability and operational efficiency in the production process. Recognition of this excellence was achieved through the Construction Project of the Year award at the 2015 Platts Global Energy Awards.(Wurster, 2013)

YASREF uses Sulfur Recovery Units (SRUs) with a capacity of up to 1,200 tons per day. This technology enables the separation and utilization of sulfur from waste gases produced during the crude oil refining process, reducing harmful sulfur oxide (SOx) emissions. YASREF's distillation units are designed to improve energy efficiency during the separation of crude oil fractions. This technology minimizes energy consumption of processed oil, thereby reducing the overall carbon footprint.

4.2.2. Resource Efficiency

A. ADNOC in Abu Dhabi

Resource efficiency is emphasized through the optimization of raw material usage, ensuring sustainable management of energy resources. The collaboration between ADNOC and Saudi Aramco focuses on maximizing the utilization of natural gas while minimizing waste and emissions.(Singh et al., 2023) This includes improving heat recovery systems, optimizing fuel consumption, and implementing energy-efficient liquefaction units. By enhancing operational efficiency, both companies reduce the environmental footprint of LNG production while maintaining high output levels. This resource efficiency strategy not only supports cost-effectiveness but also aligns with the global push toward reducing reliance on high-carbon energy sources.(CIEL, 2022)

B. PTT PCL in Thailand

Resource efficiency is a crucial factor in optimizing the use of raw materials in a sustainable manner. Saudi Aramco and PTT are focusing on maximizing energy yield while minimizing waste. In LNG production and distribution, they are implementing energy-efficient storage and transportation systems, reducing methane leakage, and improving fuel conversion efficiency. Additionally, for hydrogen production, both companies are utilizing by-products from refining and petrochemical operations to enhance resource utilization. These efforts ensure that energy production.(Insight et al., 2024)

C. SINOPEC in China

The inauguration of Yanbu Aramco Sinopec Refining Company in December 2015 coincided with the official visit of Chinese President Xi Jinping to Saudi Arabia, marking a significant milestone in the relationship between the two countries. This initiative reflects Saudi Aramco's vision to strengthen the company's image in the global market by diversifying its downstream portfolio. Saudi Aramco aims to increase the added value in the global energy supply chain and maximize the utilization of crude oil resources. For Sinopec, participation in the YASREF project offers strategic benefits, including guaranteed access to a stable supply of crude oil from Saudi Arabia. Furthermore, both companies are committed to integrating the hydrocarbon value chain comprehensively, by exploration, refining, and distribution of energy products. This project not only strengthens bilateral relations in the energy sector but also creates a synergistic model that combines the technological, operational, and economic strengths of both entities.(Zeng et al., 2022).

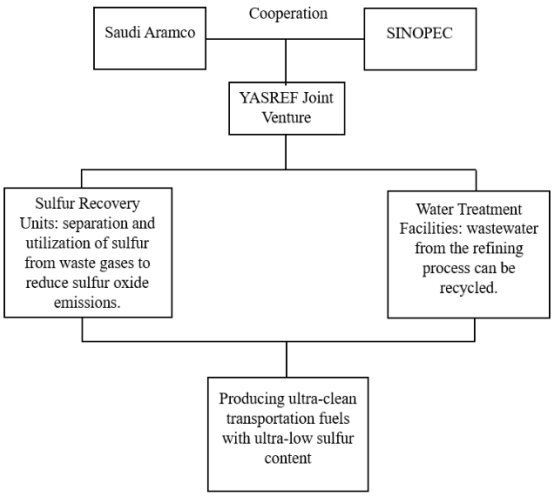

Figure 3. Implementation of the Cooperation between Saudi Aramco and SINOPEC

4.2.3. Economic Growth

A. ADNOC in Abu Dhabi

The Ruwais LNG Project, currently being developed by the Abu Dhabi National Oil Company (ADNOC) in collaboration with Saudi Aramco, represents a key initiative in advancing the sustainable energy economy in the Middle East and North Africa (MENA) region.(Abo-Khalil, 2024) This project, with a total capacity of 9.6 million tons per annum (mtpa), integrates three fundamental green industry indicators: technological innovation, resource efficiency, and the balance between economic growth and environmental preservation. The Ruwais LNG Project integrates economic growth with environmental preservation, reinforcing a sustainable energy economy. Both ADNOC and Saudi Aramco recognize the increasing global demand for low-carbon LNG and are developing infrastructure that meets international environmental standards while ensuring economic viability.(International Renewable Energy Agency (IRENA), 2023) Through strategic market expansion, the project aims to strengthen LNG exports to key regions such as Asia and Europe, where demand for cleaner energy alternatives is rising. By leveraging existing port infrastructure and establishing long-term agreements with LNG-importing countries, ADNOC and Saudi Aramco ensure a steady supply of LNG while maintaining competitive pricing. Simultaneously, their commitment to reducing emissions and incorporating sustainable practices enhances their reputation as leaders in green energy solutions.

B. PTT PCL in Thailand

The integration of economic growth with environmental preservation is a fundamental goal of this partnership. Saudi Aramco and PTT are committed to long-term investments in clean energy that drive economic expansion while minimizing ecological harm. By establishing large-scale green hydrogen production facilities, they are not only creating new business opportunities but also supporting global decarbonization initiatives.(Roucham et al., 2025) The development of green hydrogen as a clean fuel alternative enhances industrial sustainability and supports Thailand's vision of becoming a regional hub for low-carbon energy solutions. Additionally, their investments in renewable energy infrastructure, such as solar and wind farms, further contribute to economic and environmental resilience. From an economic perspective, this collaboration brings significant benefits to both parties. For Saudi Aramco, the partnership with PTT provides broader access to the rapidly growing Southeast Asian market. By leveraging PTT's well-established infrastructure and distribution networks, Saudi Aramco can strengthen its presence in the region, reduce dependence on traditional markets such as North America and Europe, and adjust its export strategy to the ever-changing dynamics of the global energy market. Meanwhile, for PTT, this partnership ensures a stable and diverse energy supply, allowing Thailand to meet its growing energy needs while accelerating the transition to cleaner energy sources.

C. SINOPEC in China

YASREF was established with a commitment to operational efficiency and environmental responsibility. The refinery integrates advanced technologies designed to optimize energy processing while minimizing greenhouse gas emissions and other pollutants. This initiative aligns with global efforts to mitigate the environmental impact of industrial activities and transition toward more sustainable energy sources. As a result, YASREF complies with international sustainability standards and contributes to reducing the carbon footprint in the energy sector. It serves as a model for modern energy industries that other refineries can emulate to minimize environmental harm. This approach to operational efficiency and environmental sustainability aligns with Islamic principles that emphasize humanity's responsibility as stewards (khalifah) of the Earth. From an Islamic perspective, partnerships between companies or

countries in economic ventures can be seen as a manifestation of the principles of *mu'amalah* in trade and resource management. Islam emphasizes on *ta'awun*, described as the importance of fair and mutually beneficial cooperation aimed at collective well-being (Aulia et al., 2024). The principle of justice in trade, or *al-adl fi tijarah*, encourages economic actors to engage in activities that not only yield material benefits but also contribute to the welfare of global society. By the means, diversification the market demand and expand on Asia through China market, Saudi Aramco is not only capitalizing on economic opportunities but also supports the equitable distribution of energy resources to meet global energy demands. In Islam, humans are entrusted to maintain the balance of nature, as highlighted in Surah Ar-Rahman, verse 7:(*Al-Qur'an*)

وَالسَّمَاءَ رَفَعَهَا وَوَضَعَ الْمِيزَانَ (٧)

According to the commentary of Buya Hamka, the term mizan or "balance" refers to the equilibrium that Allah SWT has established in the universe. Hamka explains that the order of nature, such as the fixed positions of stars that never collide despite existing for millions of years, reflects this divine balance. The verse teaches humanity to utilize natural resources responsibly and equitably. Unsustainable exploitation or neglecting the needs of future generations is considered an injustice to what Allah has created.(Amrullah, 1989). Overall, this verse urges importance of maintaining balance in all aspects of life, including the management of natural resources. LNG projects represent a form of energy transition toward cleaner energy sources aimed at reducing global carbon emissions while meeting global energy demand. Collaboration among multinational companies in these projects demonstrates humanity's efforts to create a just system where the energy produced benefits not just one party but is distributed fairly and efficiently across societies. The development of LNG projects by oil and gas companies through collaborations such as Saudi Aramco's partnerships with ADNOC, PTT PCL, and Sinopec can be linked to the concepts of international cooperation and the green economy. These cross-border partnerships are not only designed to meet global energy demands but also aim to support the transition to a cleaner and more sustainable energy economy. The collaboration in energy development is the example of how multilateral cooperation, whether between nations or state-owned enterprises is fostering an energy economy oriented toward energy-based sustainability and global balance.

5. Conclusions

Saudi Aramco's international cooperation in the development of Liquefied Natural Gas (LNG) projects marks a significant strategic advancement toward fostering a sustainable global energy economy. By forming strategic alliances with leading energy corporations such as ADNOC in the United Arab Emirates, Sinopec in China, and PTT PCL in Thailand, Saudi Aramco has effectively harnessed technological innovations and optimized the use of vast natural resources to strengthen and diversify LNG supply chains across international markets. These collaborative ventures not only contribute to meeting the growing global demand for energy but also play a pivotal role in accelerating the global shift toward cleaner and more sustainable energy solutions. The development of LNG infrastructure aligns with the broader goals of the green economy and reinforces global commitments to reducing carbon emissions and promoting environmental sustainability. Through these partnerships, Saudi Aramco has expanded its production capacity, improved operational efficiency, and ensured greater energy security and resilience in a volatile global energy landscape. This approach highlights the critical importance of international synergy and strategic cooperation in addressing the intertwined challenges of energy access, economic development, and climate change. Ultimately, Saudi Aramco's LNG initiatives serve as a model of how global collaboration can drive meaningful progress toward a cleaner, more secure, and sustainable energy future.

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