

REQUIREMENTS FOR ESTABLISHING ENERGY HUBS: PRACTICAL PERSPECTIVE

Mahmoud A. Hammad^{1*}, Sara Elgazzar², Borut Jereb³
and Marjan Sternad⁴

¹⁾²⁾ Arab Academy for Science, Technology and Maritime Transport, Alexandria,
Egypt.

¹⁾³⁾⁴⁾ University of Maribor, Celje, Slovenia.

Please cite this article as:

Hammad, M.A., Elgazzar, S., Jereb, B. and Sternad, M., 2023. Requirements for Establishing Energy Hubs: Practical Perspective. *Amfiteatru Economic*, 25(64), pp. 798-812.

DOI: <https://doi.org/10.24818/EA/2023/64/798>

Article History

Received: 12 March 2023

Revised: 30 May 2023

Accepted: 26 June 2023

Abstract

The global economy has barely begun to recover from the effects of the COVID-19 pandemic, only to be thrown into a new crisis because of the Russian-Ukrainian war. The war exacerbated the energy problem by causing a shortage of energy supplies for the EU and other countries, affecting quality of life. As a result, establishing energy hubs for collecting, processing, storing, and transiting energy resources between producing and consuming countries has become imperative to manage energy supplies efficiently. However, previous studies have not yet addressed the requirements for setting up energy hubs from a practical point of view. Therefore, this paper investigates the requirements for the establishment of energy hubs, particularly for oil and gas, from a practical perspective. The researchers conducted 13 semi-structured interviews with different energy stakeholders. Using the SWOT analysis matrix tool, the findings assessed the current state of the global oil and gas market, and the main practical requirements for the establishment of energy hubs were identified, along with the elements for implementation. Furthermore, the article highlighted the most pressing practical issues confronting the establishment of energy centres. Finally, the paper laid out a comprehensive practical framework based on the industry practitioners' views to help establish energy hubs. The framework provides a possible guide for countries to establish energy hubs based on the main requirements outlined in this study. It can also improve the diversity, flexibility, and security of energy supply, especially for countries that rely on sole suppliers, such as the EU.

Keywords: Energy hubs, energy stakeholders, diversification of energy supplies, security and sustainability of energy supply, European Union countries, Russian-Ukrainian war.

JEL Classification: O13, P18, P48, Q42

* Corresponding author, **Mahmoud A. Hammad** – e-mail: m.hammad@aast.edu



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. © 2023 The Author(s).

Introduction

The Russian-Ukrainian war has greatly affected the global energy market. The war created risks for energy supply and a sharp increase in energy prices around the world, especially in the European Union (EU), which is heavily dependent on hydrocarbon sources from Russia (Bella et al., 2022). This prompted the EU to urgently look for new strategies and plans to deal with the shortage of supplies and reduce dependence on Russia by diversifying its sources of supplies in the European Council (European Council, 2022; Grybaite et al., 2022). Establishing energy hubs is one of the proposed solutions that can eliminate the dependence of the EU on Russia and achieve the overall efficiency of the global energy supply chain (Coşkun and Carlson, 2010; Hammad et al., 2022). An energy hub can be defined as a place or spot in energy crossing routes connecting energy exporting and importing countries. This energy hub serves as a market for energy trade, where energy resources can be imported, processed, stored, transported, and exported (Vieira, Catapan and Luna, 2016). Thus, energy hubs in the energy pathways can significantly smooth the flows and security of the energy supplies (Pourghasemi and Akhbari, 2018; Hammad, Elgazzar and Sternad, 2021). However, the establishment of an energy hub is not an easy task and requires a lot of requirements, such as; infrastructure and logistics facilities, huge investments, stable political and economic environments, well-developed financial and legal regimes, and international cooperation (Altundeğer, 2015; Yilmaz-Bozkus, 2019; Hammad, Elgazzar and Sternad, 2021).

In this sense, various studies have tackled the requirements of establishing energy hubs from different perspectives; geopolitics (Pourghasemi and Akhbari, 2018; Stratakis and Pelagidis, 2018, Yilmaz-Bozkus, 2019, Ersen and Celikpala, 2019); legal (Doulah and Shafee, 2016; Mustafayev, 2016), security (Kakachia, 2011; Misiągiewicz, 2012; Iseri, 2015; Ibrayeva et al., 2018), and logistics (Essaadi, Grabot and Féniès, 2019; Maharjan and Hanaoka, 2019; Maharjan and Hanaoka, 2020; Shahparvari et al., 2020; Zhang et al., 2021). However, few studies have addressed the requirements of establishing energy hubs thoroughly.

A comprehensive framework has been proposed by Hammad, Elgazzar and Sternad (2021) that presents the requirements needed to establish the energy hub. The framework has considered most of the variables and determinants required for the establishment of energy hubs, but its applicability from a practical perspective has not yet been assessed. Consequently, this paper aims to bridge this knowledge gap by verifying to what extent the proposed framework can be applied in the practical context by conducting interviews with key energy stakeholders focused on the oil and gas market. It also seeks to provide a comprehensive practical framework that can be used to establish energy hubs, thus achieving smooth flows of energy.

The remainder of this paper is structured as follows. Section 1 reviews the relevant scientific literature on the economic impact of the energy supply shortage in the EU, the importance of energy hubs and the requirements for the establishment of energy hubs. The research methodology and data sources are described in Section 2, Section 3 presents and discusses the results obtained, and the conclusion is provided in the last part.

1. Review of the scientific literature

Our life is unimaginable without energy, especially in oil and gas (Horváth et al., 2022). Energy is obtained from many sources, mainly from oil and gas. Recently, the world has been

witnessing a significant energy crisis in terms of the shortage of oil and gas supplies (Rokicki and Perkowska, 2021), the increase in energy prices, and the operational and logistic challenges related to border crossings and other restrictions (European Council, 2022). Perhaps the Russian-Ukrainian conflict is one of the main reasons and factors that exacerbated the problem. The war has become a source of tension for the entire world and the EU, as the crisis went beyond the political arena to become an economic crisis (Acevedo and Lorca-Susino, 2021).

1.1. The economic repercussions of the Russian-Ukrainian war on the EU

According to the World Bank and the European Commission, the war has had extremely heavy impacts on human life and the economy. This unprecedented crisis has had ramifications for consumers and governments, limiting fiscal affordability, firm productivity, and household welfare. The war has harmed the global economy by causing significant trade disruptions and food and energy price shocks, all of which contribute to high inflation. The EU is one of the most vulnerable economies because it is dependent on Russian imports and proximity to the conflict. The economies of EU countries are expected to contract further as a result of the destruction of productive capacity and significant reductions in the Russian energy supply. It is expected to enter a technical recession this winter, with weak growth returning in the spring as inflation gradually eases its grip on the economy. Inflation in the EU is expected to increase by 9.3% this year before falling to 7.0% in 2023. Furthermore, GDP in the EU is expected to grow by 3.3% in 2022, while GDP growth in 2023 is expected to be 0.3%, as shown in Figure 1. The deficit is expected to fall to 3.4% of GDP this year before rising to 3.6% in 2023. As a result, we can conclude that the EU economy has reached a tipping point.

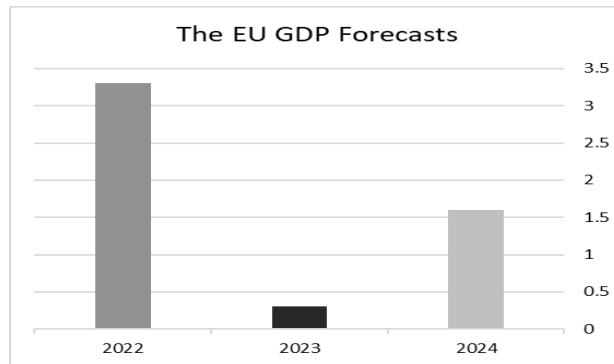


Figure no. 1. GDP Forecasts for the EU

Source: Economic forecast of the European Commission in 2022

Until 2021, the EU imported approximately 90% of its total gas consumption, with Russia accounting for approximately 45% of these imports, 25% of its oil imports, and 45% of its coal imports (Zgurovsky et al., 2022). As a result, EU countries must diversify their energy suppliers and reduce their dependence on Russian imports.

1.2. The EU Strategies to Reduce Russian Dependence

The EU has implemented common energy strategies in the short and long term for energy independence and has gradually evolved affordable, secure, competitive, and sustainable energy. The key elements of these strategies are based on diversifying energy supply routes

and sources, regional cooperation, an integrated internal energy market, and the development of the energy infrastructure (Rokicki and Perkowska, 2021; Zgurovsky et al., 2022). Short-term strategies for households and firms included; saving energy, boosting energy savings, energy efficiency enhancement, and implementation of quota / rationing plans. Meanwhile, long-term strategies focus on diversifying energy supply sources and expanding the use of alternative energy sources, such as renewable energy sources. The EU puts these strategies at the top of its agenda, but both are lengthy, costly, and require several requirements. They should also be built on long-term vision and strategic partnership to ensure sustainable and reliable energy sources for EU countries and thus prevent cuts or disruptions in energy supplies in the future (European-Council, 2022; Popa et al., 2022). Consequently, this requires the existence of energy hubs linking EU countries as consumption countries with countries of production and transit. The establishment of energy hubs, whether for conventional or renewable energy sources, provides diversified sources of energy supply and, therefore, can guarantee a secure and sustainable flow of energy supplies to the EU countries (Hammad, Elgazzar and Sternad, 2021).

1.3. The role of the energy hub in achieving the EU's strategies

An energy hub is a geographical location or marketplace that facilitates energy exchange between supply and demand, where multiple participants trade energy (Lynx, 2019). Energy hubs provide many benefits and advantages to all participants and stakeholders (Yilmaz-Bozkus, 2019). Additionally, the host country of the energy hub can achieve several benefits, such as economic and financial profits from; trading activities, value-adding industries, and job opportunities, as well as increasing its geopolitical role (Ersen and Celikpala, 2019; Yilmaz-Bozkus, 2019). According to Bjørnmoose et al. (2009), energy hubs have an essential role in establishing both security of supply and stimulating competition in the energy market. Thus, developing energy hubs should be considered to achieve the diversity, flexibility, and security of supply, especially for countries that rely on sole suppliers. However, establishing energy hubs is not an easy task, as it takes time and has many requirements (Altundeđer, 2015; Hammad et al., 2022).

1.4. Requirements for establishing energy hubs

Several requirements are essential to establish an energy hub. Most of these requirements have been addressed in some previous works such as; Altundeđer (2015), Yilmaz-Bozkus (2019), Hammad et al. (2022) and Hammad, Elgazzar and Sternad (2021).

Establishing an energy hub requires extensive infrastructure and logistics investments that can be used to import, export, store, and transport energy. Energy hubs also require a sophisticated financial system to allow prices to develop without interference in a competitive and transparent environment. Additionally, a well-developed legal and regulatory framework is needed to govern the physical side of the business. These cannot be achieved without political will, international cooperation, and energy partnerships.

Field Hammad, Elgazzar and Sternad (2021) presented a comprehensive framework for establishing energy hubs. The framework considered the different points of view and captured most of the requirements and determinants needed for to establish energy hubs from the previous literature and success stories. It also clearly presented the relationships between the participating parties and stakeholders in one framework. The framework consists of the four parties of the oil and gas supply chain: the suppliers, the consumers, the transit, and the hub countries; all are surrounded by an ecosystem that can influence the decisions and

behaviour of all these parties, representing the internal and external environmental factors. The internal factors are long-term agreements, investments, and the level of domestic consumption. At the same time, external factors include oil and gas stockholders, market uncertainty, legal and regulatory framework, international energy market, energy charter treaty, environmental concerns, and information sharing. Furthermore, the figure shows the required requirements to establish and operate the global energy hub country, namely; the geographical location of the country, the required infrastructure and facilities, the political and economic environment of the country, the geopolitical position of the country, cooperation and interrelationships between the hub country and other countries, and the level of competitiveness and market liberalisation of the country, as shown in Figure No. 2.

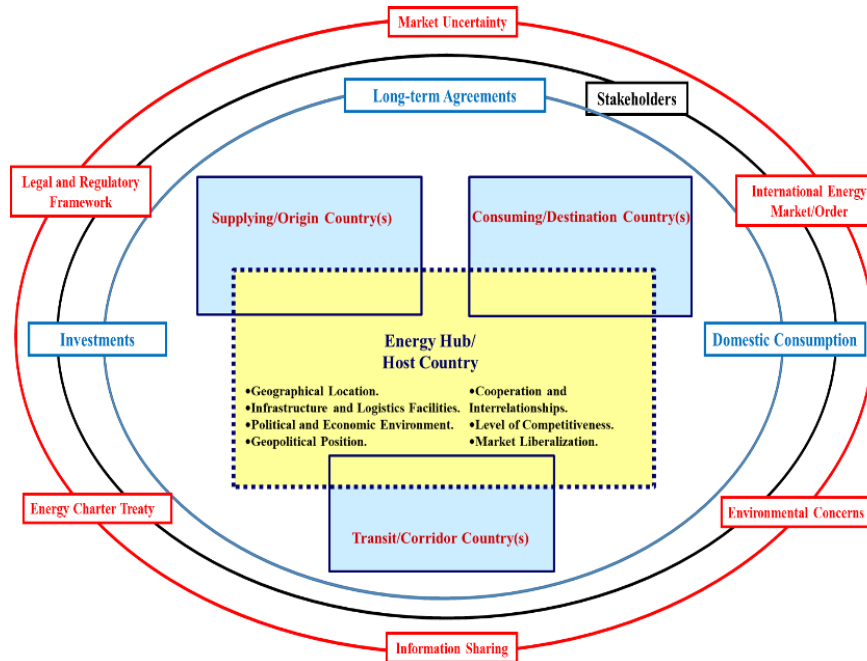


Figure no. 2. The theoretical framework for establishing energy hubs

Source: Hammad, Elgazzar and Sternad (2021)

Field Hammad, Elgazzar and Sternad (2021) show that these variables can be the main determinants for establishing energy hubs. This theoretical framework should be tested from a practical perspective to verify its applicability. Therefore, the central proposition of this article is to assess to what extent this framework can be applied in the practical context by conducting an empirical study with different stakeholders and practitioners in this industry.

2. Research methodology

To test the study proposition that was previously presented in Section 1 of “*assessing to what extent the theoretical framework proposed by Hammad, Elgazzar and Sternad (2021) can be applied in the practical context*”, the following two research questions have been addressed:

- RQ1: How is the global energy (oil and gas) market currently performing?

- RQ2: How can the theoretical framework proposed by Hammad, Elgazzar and Sternad (2021) be applied in practice?

The study research methodology used secondary and primary data to answer these two questions. Secondary data on the global oil and gas market have been compiled by reviewing the literature and recent reports. The primary data were extracted from interviews with key stakeholders and experts in the oil and gas industry.

The researchers chose the stakeholders indicated by Mustafayev (2016) as the target population for the interviews. Stakeholders invited to participate in the interviews, namely; governments and regulators of countries, investors, finance and lending agencies, owners and operators of pipeline and gas liquefaction plants, international authorities and organisations, and oil and gas companies (Mustafayev, 2016). Researchers also used the purpose-sampling technique to select participants in semi-structured interviews because it is typically appropriate for qualitative studies like this one (Etikan, 2016). This purposive sample representing different stakeholders was chosen on the basis of accessibility. Furthermore, researchers selected participants with prior experience and knowledge of the research topic, which allowed them to answer the research questions better and understand the various aspects of that topic (Creswell and Clark, 2017). As a result, the researchers conducted thirteen (13) separate semi-structured interviews with key stakeholders and professionals in the oil and gas industry. Ten (10) interviewees from the oil and gas sector and three (3) from the financial and lending sectors were interviewed. Face-to-face, phone, and Zoom sessions were used to conduct the interviews, depending on the convenience and schedule of the interviewees. All interviews were experienced and from the highest levels of management and from a variety of areas and backgrounds, including CEOs, planning and performance managers, plant managers, quality managers, drilling managers, and purchasing managers. Branch managers, credit managers, and investment sector managers were interviewed from financing and lending agencies. Interviews were conducted between July 2022 and October 2022.

Accordingly, the research was divided into two phases, as follows:

- To answer the first research question, both secondary data and interview questions were sent to stakeholders to analyse the current state of the global oil and gas industry from both internal and external perspectives. The market strengths, weaknesses, opportunities, and threats (SWOT) analysis was used as an analysis technique. Strengths and weaknesses represent the internal environment, while opportunities and threats represent the external environment.

- To address the second question of the study, the stage was carried out to validate the theoretical framework for establishing energy hubs and their requirements. At this point, the researchers relied heavily on primary data from interviews with essential stakeholders and oil and gas industry specialists. The interview questions were designed to fit the study objectives and divided into three portions. The first phase of the interview consisted of standard demographic questions about the interviewee, such as job title and specialisation, qualifications, and years of experience. The second portion asked the interviewees various questions concerning the current state of the global oil and gas market, including the following:

- The main activities of the company of the interviewee.
- The direct or indirect role of the company in the oil and gas industry.

- A general overview of the global oil and gas sector.
- The current situation of the global oil and gas sector.
- The main strengths, weaknesses, opportunities, and threats of the global oil and gas market (SWOT analysis).

The questions in the third section focused on the main requirements for establishing energy hubs and verifying how these requirements are practically executed by asking about the following:

- Their opinion on the parties of the energy supply chain; exporting countries, importing countries, and transit countries.
- The role of the hub country in achieving linkage and cooperation between exporting, importing, and transiting countries.
- What is their view on the requirements and ecosystem stipulated in the theoretical framework?
- Other practical requirements or factors that could be considered for the establishment of energy hubs.

However, the questions in the third portion have been modified based on the industry and expertise of the target stakeholders; for example, in the case of financing and lending institutions, the questions focused on the following:

- The status of investments and investment returns for investors in the oil and gas industry.
- If they see the oil and gas sector as an attractive/promising sector for investors, then why.

The researchers used a question-by-question qualitative content analysis to analyse the results of the interviews, and then an aggregated analysis for the interviews was performed. The analysis findings were very important in understanding the research topic, exploring the global oil and gas industry using SWOT analysis, and modifying the practical framework for the establishment of energy hubs. Consequently, the conclusions of the methodology regarding SWOT analysis and the construction of the practical framework will be described in the next part.

3. Results and discussion

This section discusses the findings and results of the literature review and interviews to answer the following research questions.

3.1. Assessment of the current situation of the global oil and gas market

The researchers gained a thorough understanding of the current situation, as well as the factors involved in planning and decision-making in the global oil and gas market, through the analysis of the literature review and the responses of the interviewees, which resulted in the following SWOT analysis.

- *Strengths*

About 85% of the interviewees agreed that one of the most important strengths of the oil and gas industry is its well-educated and trained human competencies. Because the oil and gas

industry is a complex and ever-changing industry that requires highly qualified and trained human resources to operate at the highest level, companies always provide training and education programmes to their employees to meet the demands of jobs. The industry is also distinguished by large budgets and financial resources, which allow it to develop and invest in new technologies and innovations in all operations.

• *Weaknesses*

On the other hand, approximately 77% of the respondents believed that the global oil and gas industry has some weak factors, the most significant of which is that the industry faces the risk of depletion of reserves. Additionally, despite constant efforts to reduce costs through modern technologies, the industry suffers from high exploration, drilling, and production costs. This high cost also contributed significantly to the decline in oil and gas production and the faltering of revenues and financial performance. Moreover, there is a need for technology and knowledge transfer between companies and countries, particularly developing countries, despite these countries having the majority of the oil and gas resources.

• *Opportunities*

According to 92% of the interviewees, we can conclude that although efforts and attempts have been made in the field of renewable energy sources that could replace traditional sources, there are no reliable renewable sources to replace oil and gas. This can be an opportunity for the oil and gas industry, especially with increasing global demand. With the enormous technological development that the world is witnessing in all sectors, the oil and gas industry has benefited significantly from these technologies and innovations to reduce costs and improve operations.

• *Threats*

Despite the opportunities listed above, the global oil and gas industry faces several threats and challenges. According to 85% of those polled, one of the most severe threats is the constant fluctuation of oil and gas prices, particularly during economic, political, and health crises that disrupt the global energy supply chain. Another threat is the increased use of renewable and environmentally friendly energy sources because of the negative environmental impact of oil and gas and the preparation for the post-oil and gas depletion era. The following matrix (Table no. 1) summarises the internal and external environment analysis of the global oil and gas industry.

Table no. 1. Summary of the internal and external environment (SWOT) analysis for the global oil and gas market

Strengths	Weaknesses
<ol style="list-style-type: none"> 1. The oil and gas industry is a long-established industry with decades of knowledge and experience. 2. The active contribution of industry to the global economy. 3. Human competencies in the oil and gas industry that are well educated and trained. 4. The industry is well-known for its large budgets and resources. 5. Growing reliance on technology, information systems, and innovation. 	<ol style="list-style-type: none"> 1. The risk of reserve depletion. 2. Expensive exploration and drilling. 3. Lack of technology transfer between companies and countries. 4. Financial performance insecurity.

Opportunities	Threats
<ol style="list-style-type: none"> 1. Increased global demand. 2. The global lack of reliable alternative energy sources to replace oil and gas. 3. Use cutting-edge technologies to accelerate production growth and process efficiency. 4. The development of new technologies and innovations. 	<ol style="list-style-type: none"> 1. Volatility of the prices and downturns. 2. Adoption of alternative and renewable energy sources. 3. The perception that oil and gas operations are fundamentally opposed to environmental issues and increasing environmental protection regulations such as; sustainability, decarbonisation, climate change, etc. 4. Global economic threats and exchange rate fluctuations. 5. Changes in global politics and geopolitics. 6. Global energy supply chain disruption and confusion caused by wars, epidemics, cyberattacks on infrastructure, leaks, and instability.

Source: Developed by the authors on the basis of literature and interviews

3.2. The practical requirements for establishing energy hubs

The researchers were able to draw the following conclusions from their interviews. The interviewees agreed that the global oil and gas market had faced many challenges and problems during the last period, the latest of which is the Russian-Ukrainian war, which raises fears of “global energy starvation”. Therefore, there is an urgent need for great moves and efforts at the international level to improve energy cooperation, particularly for the EU, to diversify energy sources and secure their supplies. Some interviewees believe that many actions have been taken in this regard, while others believe that more actions are required. They also think that energy hubs along transit routes can alleviate such issues.

Furthermore, the interviewees agree that the establishment of energy hubs is one of the most important strategies that can be used to manage and balance the flow of energy between the production and consumption countries. Energy centres can also achieve resilience or the ability to recover quickly from unexpected circumstances and events in the future. However, the interviewees believe that establishing energy hubs requires significant investment in infrastructure and international cooperation.

Putting the theoretical framework proposed by Hammad, Elgazzar and Sternad (2021) into practice. All interviewees showed that their acceptance of the theoretical framework is adequate, complete, and includes all requirements. They unanimously also affirmed that the energy supply chain consists of three major parties are; the supplying, consuming, and transit countries, with the energy hub country connecting them all. Regarding the requirements for establishing energy hubs, 85% of those interviewed had no objections and accepted them. While 15% believe that the human element must be included in the framework because only human resources can accomplish something. Concerning the ecosystem, 92% of the interviewees confirmed all the listed requirements and emphasised their importance because they cover all aspects that must be considered. Almost 77% of them suggested that the first level directly impacts the requirements. On the other hand, the third level tends to be broader, as it includes external environmental factors.

As a result, the researchers can conclude that the proposed framework by Hammad, Elgazzar and Sternad (2021) is highly applicable in real life based on interviews with stakeholders in

the global oil and gas industry. However, the following are some suggestions and recommendations to help implement it in real life.

- *Economic and financial requirements*

The main challenge in establishing energy hubs remains the economic and financial requirements. To provide value-added activities and operate properly, the energy hub country requires various necessary and adequate infrastructure and facilities such as pipelines, storage facilities, and transportation systems such as roads and ports. As a result, establishing energy hubs requires significant investment in existing and new infrastructure and facilities, which is difficult given the current global economic conditions and high prices. As a result, the energy hub country must implement policies to attract and secure investments. Additionally, more international cooperation and synergy in is required the energy sector to develop common plans to adopt and transition to safe and sustainable energy sources. Developing energy hubs requires cooperation between production, transit, and consumption countries to achieve mutual benefits.

- *Management and regulatory requirements*

Another critical issue is the need to plan and control energy consumption levels, as nothing can be achieved if energy consumption continues to increase. Thus, all countries should work together to reduce energy consumption rates and dependence through energy efficiency programmes and diversify their energy portfolio. In addition, qualified and well-trained human resources are essential for the establishment and operation of energy centres. Long-term contracts with producers are also necessary to ensure an affordable and reliable oil and natural gas supply. Once an energy hub is established, it will be critical to ensure that local businesses have easy access to affordable and reliable energy sources. Furthermore, the energy hub country must liberalise the energy market and align its regulations and laws with international standards. It should also have good relations with its neighbours.

- *Technological requirements*

Sharing energy technology among countries, especially the developing ones, is important for increasing energy production and improving energy efficiency. In addition, digitisation and information technology are important in energy hubs. To ensure a transparent and regulated energy trading environment, energy hubs should have a platform or commodity exchange (virtual market). In addition, there is an urgent need to capitalise on new technologies to increase oil and gas exploration while reducing operating costs.

Based on the foregoing, the researchers have developed the updated framework derived from Hammad, Elgazzar and Sternad (2021) after considering the practical aspects extracted from the responses and analysis of the interviewees, as shown in Figure no. 3.

Human resources have been highlighted and added as a critical requirement to consider in the establishment of energy hubs. These human resources must be qualified and well trained to handle the various operations they perform. Furthermore, there are the following aspects that have been added to the framework:

- Economic and financial requirements are critical for establishing energy hubs to build the infrastructure and facilities required to provide logistics operations and value-added activities.

- Management and regulatory requirements: Managing energy hubs requires several managerial requirements to achieve effective operations.
- Technological requirements and sharing of energy technology: Technology is critical for the oil and gas industry, and sharing this technology among partners can result in significant financial and technical benefits.
- Reduce costs: To generate additional revenue, all partners must work together to reduce costs, particularly those associated with exploration and operations.
- Establishing a commodity exchange: A commodity exchange can stabilise oil and gas prices while facilitating transparency.

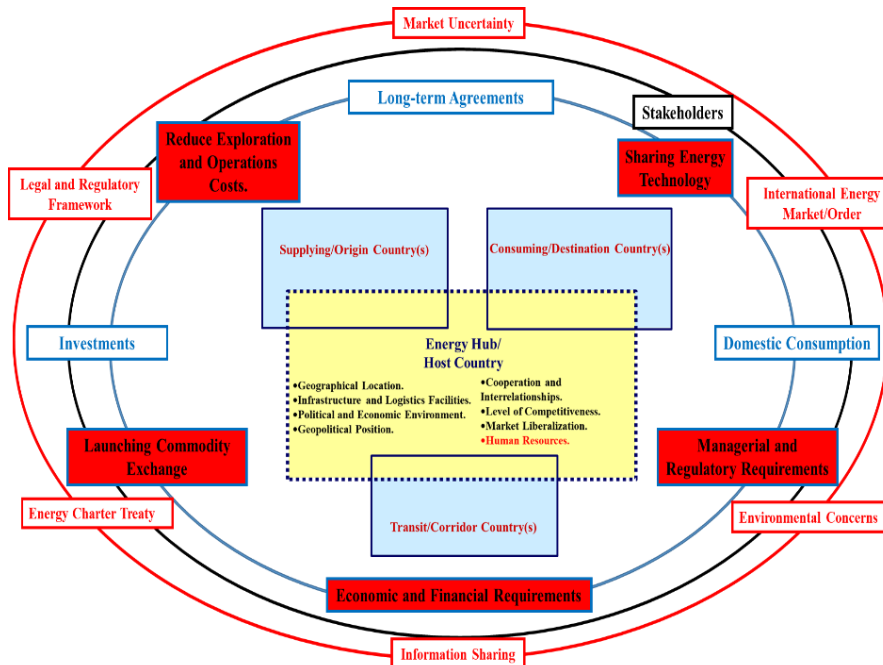


Figure no. 3. The practical framework for establishing energy hubs

Source: Developed by researchers based on interviews

Conclusions

The main goal of this study was to investigate the effects of establishing energy hubs on the security and diversification of energy supplies to eliminate recurring energy interruptions, focussing on EU countries in the aftermath of the Russian-Ukrainian war. The study shed light on the practical requirements for establishing energy hubs from the perspectives of various stakeholders in the oil and gas industry. The main advantage of the research framework developed is that, unlike previous studies, it considered the practical aspects of establishing such energy hubs.

The study revealed the importance of establishing and having energy hubs. The analysis provided researchers with a complete understanding of the current state of the global oil and gas market and the most significant challenges it faces. Among the challenges are global

energy scarcity, high costs, lack of technology transfer, financial performance instability due to price volatility and economic threats, geopolitical changes, and supply chain disruptions. Due to the impact on human life, disruption of energy supply chains can be regarded as the most severe challenge. As a result, the establishment of energy hubs improves the overall efficiency of the global energy supply chain.

The study conducted a review of the literature and interviews with key stakeholders in the oil and gas industry to assess the global oil and gas market and identify practical requirements for the establishment of energy hubs. The results of the interviews were subjected to a SWOT and qualitative analysis.

According to the interviews, the theoretical framework proposed by Hammad, Elgazzar and Sternad (2021) is widely accepted by industry experts because it considers all the requirements for establishing energy hubs. Consequently, we believe that the establishment of energy hubs could be a critical solution to ensure sustainable and diverse energy supplies to EU countries. We also concluded that the theoretical framework can be applied in real life. However, some economic, managerial, technological, and other requirements can improve the implementation of the framework. Among these requirements is the attraction of significant investments in infrastructure and logistics facilities, which can be accomplished through coordinated international efforts. The international community should also focus on energy efficiency and behaviour change programmes to reduce energy consumption. Furthermore, countries around the world need to share technology and knowledge, whether in the fields of energy exploration and production or energy conservation. Moreover, one of the fundamental requirements for the success of establishing energy hubs is qualified human capital.

The findings are also significant for the policymakers of countries to work on the liberalisation of the energy market and the establishment of a commodity exchange to ensure a transparent market. In addition, it must modify its rules and legislation to meet international standards. Moreover, it must establish good relations with other countries and pursue balanced foreign policies. As a result, the paper adds to the literature on the practical aspects of establishing energy hubs. It also provides a comprehensive framework for establishing energy hubs that can be used by countries such as the EU to improve the diversity and security of the energy supply.

The study, like any other research study, has some limitations. The energy hub countries were studied rather than the transit, corridor, or center countries. Only oil and gas energy resources were addressed among the energy resources. Furthermore, the proposed framework in this study approached the establishment of energy hubs from a strategic and not a technical point of view. Additionally, qualitative rather than quantitative analysis was used. Therefore, future research can investigate the technical requirements for establishing energy hubs and to what extent this can improve energy flow and sustainability and test its applicability in a country. In addition, the research can be used to develop criteria and key performance indicators (KPIs) to assess and evaluate the performance of energy hubs. More research is needed to develop and adapt the proposed framework for other energy sources, particularly renewable ones.

References

- Acevedo, R.A. and Lorca-Susino, M., 2021. The European Union oil dependency: A threat to economic growth and diplomatic freedom. *International Journal of Energy Sector Management*, 15(5), pp.987-1006. <https://doi.org/10.1108/IJESM-10-2020-0010>.
- Altundeđer, N., 2015. *A Dream Coming True? Turkey Becoming an Energy Hub*. International Academic Conference Proceedings, 2015 Prague, Czech Republic. The West East Institute (WEI), pp.72-81. [pdf] Available at: <<https://www.westeastinstitute.com/wp-content/uploads/2015/06/Nurettin-Altundeđer.pdf>> Accessed [Accessed 22 April 2023].
- Bella, G. D., Flanagan, M., Foda, K., Maslova, S., Pienkowski, A., Stuermer, M. and Toscani, F., 2022. *Natural Gas in Europe: The Potential Impact of Disruptions to Supply*. Working Paper No. 2022/145. International Monetary Fund (IMF), pp.WP/22/145 of 48. [online] Available at: <<https://www.imf.org/en/Publications/WP/Issues/2022/07/18/Natural-Gas-in-Europe-The-Potential-Impact-of-Disruptions-to-Supply-520934>> [Accessed 12 March 2023].
- Bjørnmoose, J., Roca, F., Turgot, T. and Hansen, D.S., 2009. *An Assessment of the Gas and Oil Pipelines in Europe*. [pdf] European Parliament. Available at: <<https://www.europarl.europa.eu/cmsdata/173435/20091014ATT62488EN.pdf>> [Accessed 12 March 2023].
- Coşkun, B.B. and Carlson, R., 2010. New Energy Geopolitics: Why does Turkey Matter? *Insight Turkey*, 12(3), pp.205-220.
- Creswell, J.W. and Clark, V.L.P., 2017. *Designing and Conducting Mixed Methods Research*. Los Angeles: SAGE Publications.
- Doulah, A. and Shafee, M., 2016. Study of the Legal Regime of Oil and Gas Transit in Energy Charter Treaty and Law of Iran. *Journal of Politics and Law*, 9(5), pp.194-208.
- Ersen, E. and Celikpala, M., 2019. Turkey and the Changing Energy Geopolitics of Eurasia. *Energy Policy*, 128, pp.584-592. <https://doi.org/10.1016/j.enpol.2019.01.036>.
- Essaadi, I., Grabot, B. and Féliès, P., 2019. Location of global logistic hubs within Africa based on a fuzzy multi-criteria approach. *Computers & Industrial Engineering*, 132, pp.1-22.
- Etikan, I., 2016. Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), p.1. <https://doi.org/10.11648/j.ajtas.20160501.11>.
- European Commission, 2022. *Autumn 2022 Economic Forecast: The EU Economy at a Turning Point* [online]. European Commission. Available at: <https://economy-finance.ec.europa.eu/economic-forecast-and-surveys/economic-forecasts/autumn-2022-economic-forecast-eu-economy-turning-point_en#gdp-map-2023> [Accessed 1 December 2022].
- European Council, 2022. *Impact of Russia's Invasion of Ukraine on the Markets: EU Response* [online] European Council. Available at: <<https://www.consilium.europa.eu/en/policies/eu-response-ukraine-invasion/impact-of-russia-s-invasion-of-ukraine-on-the-markets-eu-response/>> [Accessed 22 November 2022].
- Hammad, M.A., Elgazzar, S. and Sternad, M., 2021. A Conceptual Framework to Establish and Operate a Global Logistics Energy Hub. *Sustainability*, 13(19), no. art.10976. <https://doi.org/10.3390/su131910976>.

- Hammad, M.A., Elgazzar, S., Obrecht, M. and Sternad, M., 2022. Compatibility about the concept of energy hub: a strict and visual review. *International Journal of Energy Sector Management*, 16(1), pp.1-20. <https://doi.org/10.1108/IJESM-06-2020-0022>.
- Ibrayeva, A., Sannikov, D.V., Kadyrov, M.A., Zapevalov, V.N., Hasanov, E.L. and Zuev, V.N., 2018. Importance of the Caspian countries for the European union energy security. *International Journal of Energy Economics and Policy*, 8(3), pp.150-159.
- Iseri, E., 2015. Addressing Pipeline Security Regime of the Prospective Regional Energy Hub Turkey. *Security Journal*, 28(1), pp.1-15. <https://doi.org/10.1057/sj.2012.38>.
- Kakachia, K.K., 2011. Challenges to the South Caucasus regional security aftermath of Russian-Georgian conflict: Hegemonic stability or new partnership? *Journal of Eurasian Studies*, 2(1), pp.15-20. doi:10.1016/j.euras.2010.10.005.
- Lynx, 2019. *Egypt an Emerging Gas Hub*. LYNX Industry Notes. LYNX Strategic Business Advisors.
- Maharjan, R. and Hanaoka, S., 2019. Fuzzy multi-attribute group decision making to identify the order of establishing temporary logistics hubs during disaster response. *Journal of Humanitarian Logistics and Supply Chain Management*, 9(1), pp.2-21. doi:10.1108/jhlscm-02-2018-0013.
- Maharjan, R. and Hanaoka, S., 2020. A credibility-based multi-objective temporary logistics hub location-allocation model for relief supply and distribution under uncertainty. *Socio-Economic Planning Sciences*, 70, no. art.100727. <https://doi.org/10.1016/j.seps.2019.07.003>.
- Misiągiewicz, J., 2012. Turkey as an Energy Hub in the Mediterranean Region. *Spectrum: Journal of Global Studies*, 4(1), pp.107-126.
- Mustafayev, N., 2016. The Southern Gas Corridor: legal and regulatory developments in major gas transit pipeline projects. *The Journal of World Energy Law & Business*, 9(5), pp.370-387. <https://doi.org/10.1093/jwelb/jvw022>.
- Pourghasemi, A. and Akhbari, M., 2018. The Role of Fossil Fuel (Oil and Gas) in the World Geopolitics of Energy (Case Study of Iran 2000-2015). *Journal of Ecophysiology and Occupational Health*, 18(1 & 2), pp.18-23. <https://doi.org/10.18311/jeoh/2018/21369>.
- Rokicki, T. and Perkowska, A., 2021. Diversity and Changes in the Energy Balance in EU Countries. *Energies*, 14(4), no. art.1098. <https://doi.org/10.3390/en14041098>.
- Shahparvari, S., Nasirian, A., Mohammadi, A., Noori, S. and Chhetri, P., 2020. A GIS-LP integrated approach for the logistics hub location problem. *Computers & Industrial Engineering*, 146, no. art.106488. <https://doi.org/10.1016/j.cie.2020.106488>.
- Stratakis, A.M. and Pelagidis, T., 2018. The South-East Energy Corridor Connecting Greece and Cyprus. How Feasible, How Viable? *Eastern Mediterranean Geopolitical Review. Mediterranean Quarterly*, 3(1), pp.16-33.
- The World Bank, 2022. *Russian Invasion of Ukraine Impedes Post-Pandemic Economic Recovery in Emerging Europe and Central Asia* [online] The World Bank Group. Available at: <<https://www.worldbank.org/en/news/press-release/2022/10/04/russian-invasion-of-ukraine-impedes-post-pandemic-economic-recovery-in-emerging-europe-and-central-asia>> [Accessed 1 December 2022].
- Vieira, C.L.D.S., Catapan, A. and Luna, M.M.M., 2016. *An Updated Perspective on the Concept of Logistics Hubs*. [pdf] Available at: <<https://www.pomsmeetings.org/>>

ConfProceedings/065/Full%20Papers/Final%20Full%20Papers/065-0083.pdf>
[Accessed 1 December 2022].

- Yilmaz-Bozkus, R., 2019. Analysis of Turkey's role as a possible energy hub. *GeoJournal*, 84(5), pp.1353-1364. <https://doi.org/10.1007/s10708-018-9928-6>.
- Zgurovsky, M., Kravchenko, M., Boiarynova, K., Ilyash, O., Kopishynska, K. and Pyshnograiev, I., 2022. Analysis of the impact of Russia's military invasion of Ukraine on the energy independence of European countries. *System Research and Information Technologies*, (2), pp.7-31. <https://doi.org/10.20535/SRIT.2308-8893.2022.2.01>.
- Zhang, X., Lu, J. and Peng, Y., 2021. Hybrid MCDM Model for Location of Logistics Hub: A Case in China Under the Belt and Road Initiative. *IEEE Access*, 9, pp.41227-41245. <https://doi.org/10.1109/ACCESS.2021.3065100>.