Mathematical Statistician and Engineering Applications
ISSN: 2094-0343
2326-9865

To Identify Sustainability Indicators for Thailand's Upstream Oil and Gas Sector: A Combination of Expert Interviews and a Literature Review

Chatrudee Atsavakovith, Graduate School, Chulalongkorn University, Thailand, Email. chatrudee.a@student.chula.ac.th

Prof. Dr. Kamonchanok Suthiwartnarueput, Chulalongkorn University, Thailand, Email. kamonchanok.s@chula.ac.th

Assoc. Prof. Dr. Pongsa Pornchaiwiseskul, Chulalongkorn University, Thailand, Email. pongsa.p@chula.ac.th

Article Info
Page Number: 1513-1522
Publication Issue:
Vol. 71 No. 3s2 (2022)

Article History
Article Received: 28 April 2022
Revised: 15 May 2022
Accepted: 20 June 2022
Publication: 21 July 2022

Abstract:- This study proposes the literature review and method to identify sustainability indicators for upstream oil and gas sector in Thailand based on a review of relevant literature and a survey of academicians and industry experts. The oil and gas sector is one of the most significant economic drivers. However, the business is high risk, such as the uncertainty of unproven geological reserves, the high cost of production, intervention ,maintenance, the cost of waste treatment and spill. Therefore, the industry strives to be more sustainable by causing less harm to the environment and community while still generating profits, establishing a good relationship with partners and investors, and enhancing its competitive advantage for long-term financial gains. In upstream oil and gas industry, momentum and intensity to measure sustainability are maintained even during periods of low energy demand. As we move toward a more sustainable future, the oil and gas sector should be a sustainable indicator to verify overall performance and measurable.

Keywords: Sustainability Indicators, Upstream Oil and Gas sector, Expert Interviews

INTRODUCTION

Hydrocarbons are playing an increasingly important role in reducing global energy demand. Oil and natural gas, on the other hand, make up a significant portion of the overall energy consumption(BP, 2022). Fossil fuels currently account for the majority of energy consumption, but this trend is expected to change quickly. As a result of these factors, the upstream oil and gas sector is increasingly challenged in its responsibility to ensure less environmental impact on society and that appropriate technologies are used to improve their safety and production performance.

The upstream oil and gas industry's momentum and intensity of sustainability are maintained even in times of low hydrocarbon demand. It is imperative that the upstream oil and gas sector be considered a sustainable indicator of overall performance in all aspects as we move toward a more sustainable future.

The oil and gas sector has had one of the greatest impacts on Thailand's economy, society, and environment over the past three decades. This industry has strictly adhered to government regulations not only to comply with the law, but also to improve business sustainability and its social impact. Thailand's total energy consumption decreased in 2020 due to the Covid-19

pandemic. However, Thailand continues to rely on petroleum as its primary energy source, particularly natural gas, which accounts for 43 percent of the country's primary commercial energy; 69 percent of Thailand's natural gas is derived from domestic resources.(DMF, 2020)

Enterprises use a variety of indicators to ensure business sustainability and address a variety of obstacles. This study's objective was to develop sustainability indicators for the oil and gas sector in Thailand, utilizing the triple bottom-line approach at the organizational level and integrating the three dimensions; economic, social, and health, safety, security, and environment (HSSE), a regulatory requirement for petroleum companies.

The structure of the paper is as follows: The following section presents a review of academic papers and secondary data for sustainability indicator in order to select the main indicators, develop a questionnaire, and interview the experts. Using the weighted average method, we then analyzed the data and developed a questionnaire to interview to the experts in order to eliminate less significant sustainability indicators.

There are three major differences between this study and the previous research in this area. While previous studies focused on oil and gas sector KPIs for long-term sustainability, this one takes a more country-specific approach (Elhuni & Ahmad, 2017). Despite Thailand's ability to produce and supply oil and gas domestically, the country is still a net importer of energy(Leesombatpiboon & Joutz, 2010). Second, the interviews were conducted by a variety of experts connected to Thailand's upstream oil and gas industry, rather than just E&P company employees. As a final step toward securing Thailand's national energy supply, the upstream oil and gas sector's sustainability key performance indicators will be finalized.

Scope of Study.

The research focuses on sustainability indicators for oil and gas fields in Thailand, both onshore and offshore, in order to identify appropriate indicators in terms of sustainability (see Figure 1).

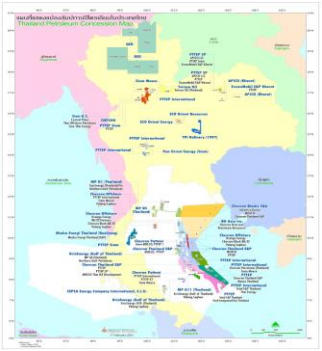

Figure 1: *Thailand Petroleum Concession Map in 2021.*

LITERATURE REVIEW

Sustainability Development Goal and Mapping the oil and gas industry.

In 2015, the United Nations (2015) laid down 17 sustainable development goals (SDGs), with 169 targets, for all countries to adopt and meet by 2030, as illustrated in Figure 2. These goals integrate the three main dimensions of sustainable development, economic, social, and environmental.

Figure 2 *The 17 sustainable development goals(UN, 2015).*

High-risk, high-return upstream oil and gas exploration and production (E&P) operations are well-known, with the latter depending on the geological characteristics of the sites and reserves as well as market demand. As a result, they're more expensive and more time-consuming than other stages.(Barata et al., 2014).

In 2017, the United Nations Development Programme (UNDP), the International Finance Corporation (IFC), and the International Petroleum Industry Environmental Conservation Association (IPIECA) developed a report called "Mapping the oil and gas industry to the SDGs: An Atlas"(UNDP, 2017) to collaborate with and ensure that the O&G industry can achieve the relevant goals.

The sustainable development of upstream oil and gas relates to environmental concerns (Gurumo & Lixin, 2011) that include oil spills, pollution from hydrocarbons, and GHG emissions. Some countries also account for environmental concerns in the technical qualification part of auctions(Mariano & La Rovere, 2007). Most environmental damage is due to a lack of safety or sustainable practices that could lead to a major accident. For instance, the largest oil spill in the Gulf of Mexico is the Deepwater Horizon spill; an oil release of approximately 4.6 million barrels 87 days before the well was capped led to severe air pollution and resultant health impacts(Beland & Oloomi, 2019). Such major events affect not only health and the environment, but also the social and financial stability and reputation of the industry. Thus, the combined effect of health, safety, and environment (HSE) is a key indicator for ensuring asset integrity in the industry in the long run.

Furthermore, HSE indicators are shown in a company's sustainability report, which is a vital way for organizations to meet business requirements and stakeholders' expectations (Orazalin & Mahmood, 2018). The standard reports of oil and gas companies have been mostly adopted from the International Oil and Gas Producers Association (IOGP), the American Petroleum Institute (API), and International Petroleum Industry Environmental Conservation Association (IPIECA), with additional indicators from the Global Reporting Initiative (GRI) (Schneider, 2013).

(Andreassen, 2017) found the major empirical findings show that the IPIECA/API/OGP oil and gas sustainability reporting guidelines are more useful in influencing production safety disclosure than the GRI global sustainability reporting guidelines. Because IPIECA specializes in offering suggestions for sustainability reporting to the oil and gas industry, their standards focus on a variety of safety issues that are pertinent to oil firms' production processes. These guidelines encourage oil corporations to incorporate problems of particular importance to the sector in their annual reports. GRI's comprehensive worldwide guidelines emphasize the importance of

mainstreaming sustainability reporting. Because they are intended to capture general business activity rather than industry-specific issues, the guideline does not provide recommendations for oil firms on specific production safety issues. Additionally, (Hourneaux Junior et al., 2017)makes use of GRI to determine the relationship between a firm's strategy and its sustainability aspects.

Economic aspects may refer to the financial and profitability-earning capacity of the organization and the reflex to business performance as an important factor contributing to its survival (Sharma, 2013). The economic part can be expressed in terms of the investment between oil and gas production volume; if one another is not efficient, then the share is decreased (Gong, 2018). In addition, the upstream and gas industry currently use big data analytics to address the challenge of increasing profit. Big data analytics also helps improve performance and helps in the sustainable development of the overall oil and gas business (Desai et al., 2021). There have been many instances of machine learning techniques and artificial intelligence (AI) being employed in the upstream business (Sircar et al., 2021).

To ensure long-term viability, it is essential to consider all of these factors. For assessing and evaluating a company's overall performance, key performance indicators (KPIs) are widely accepted. Studies have proposed a set of sustainability KPIs focused on potential environmental contamination from on-surface oil spills from offshore oil and gas installations(Crivellari et al., 2021), while others have identified key indicators for reputation loss in oil and gas pipeline failure (Chen et al., 2019). In the petroleum industry, one study identified six key HSE performance indicators (Yan et al., 2017). KPIs for evaluating sustainable production in the petroleum sector using the analytical hierarchy process (AHP) were proposed and found that the most important indicators for evaluating sustainable production in oil and gas based on sustainability in economic, environmental, and social factors are net profit, flaring gas (and preventing corruption), and reducing emissions (Elhuni & Ahmad, 2017).

(Longlong & Yifei, 2012) shows the current situation for oil and gas in China, explains and lists the constraints on the sustainable development of China's oil and gas upstream industry still concerns, such as low-grade oil reserves and improvements in advanced technologies, although China is the fifth largest oil and gas producer in the world.

For Thailand, examples of industry security indicators during 1986-2009 can be the reserve to production ratio (R/P ratio) and CO_2 emissions, based on energy supply and environmental parameters, respectively (Martchamadol & Kumar, 2012). Indicators for sustainability upstream O&G.

(Sadeghi Mojarad et al., 2018) shows the general set of challenges of sustainable development in the oil and gas industry, which are flaring and venting, decommissioning of oil and gas installations, oil storage tanks disposal, managing drill cuttings produced water disposal/treatment, managing drilling muds and fluids, estimating and validating, greenhouse gas emissions, subsidence, spills, safety and enhanced profitability.

Moreover, some research explains that oil and gas businesses should incorporate sustainability issues in their integrated reports, with a focus on social factors, according to the findings. Training, health and safety, human rights compliance, and community development in the places where they operate were among them (Nortje et al., 2014).

Indicators to achieve sustainability target are not limited to the oil and gas company but also related to supplier companies of oil and gas industry(Barata et al., 2014).

However, sustainability indicators for upstream O&G sector in Thailand are not widely found in the literature.

A total of twenty-one literature sources related to sustainability KPI in upstream oil and gas. Moreover, three data sources from expert advice, company best practice and IPIECA, which were reviewed by experts in 2019, are included.

The distribution of articles reviewed is illustrated in Figure 3. These are compared between the number of articles, indicators and similar ones.

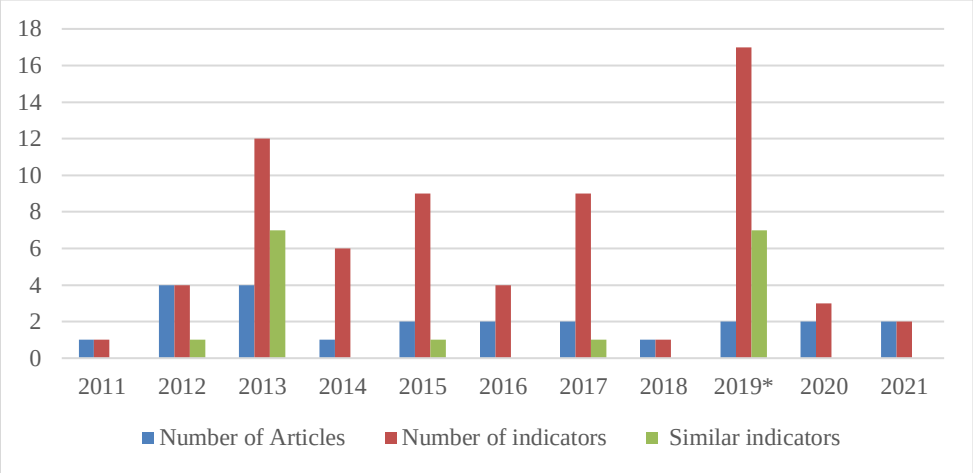

Figure 3 *Distribution of article reviewd.*

Note: Includes best practice and expert advice.*

RESEARCH METHODOLOGY

Two experts from each respondent group (oil and gas companies, government, contractors, academicians, and non-governmental organizations) were interviewed to review all sustainability indicators. Then, experts were asked to pre-rank the score of each sustainability key indicator to screen out the least significant indicators by using weighted indicator ranking. The pre-rank score shows that the higher the number, the lower the importance. The score for rating the experts was adapted from Chen (Chen et al., 2019) and Ramzali, Lavasani, and Ghodousi (Ramzali et al., 2015). Lastly, the remaining important indicators will be finalized.

Expert selection.

Five groups of participants can be categorized as practitioner, government, contractor, academia and non-government organization.

Practitioner participants are representatives from upstream oil and gas sector. Include both national and international Oil and gas company who hold petroleum concessionaires in Thailand. The selected experts have expertise in Thailand's oil and gas fields. For instance, surface operation, subsurface operation, business analysis, and overall project planning.

Government participants are representatives from governmental agency managing the Thailand’s upstream petroleum industries. The selected experts have expertise in Thailand and international petroleum policy.

Contractor participants are representatives from products and services providers for upstream petroleum industries. The selected experts have expertise in technology, products, and

services for the upstream oil and gas industry in Thailand. In addition, they are all management level involved in contract bidding strategy and seeking business opportunities.

Academia participants are representatives from faculty which related to upstream petroleum industries. The selected experts have experience conducting research on Thailand's upstream oil and gas. In addition, they are experienced as project advisor for oil and gas company in Thailand.

Non-Government Organization are representatives from global network of independent organizations which involved with environment and social in Thailand. The selected experts have experience in Thailand on issues such as air pollution, climate change and social impacts.

RESEARCH RESULTS

After conducting interviews with ten experts, it was determined that they all agreed that big data, digital transformation, robotics, and artificial intelligence contribute to existing indicators. For instance, using big data, digital transformation, robotics, and artificial intelligence, can reduce time and costs while increasing profit and even boost contingency resources.

Moreover, the experts suggested categorizing indicators into three existing main categories under the sustainability aspect. economic, social, and environmental. However, combining health, safety, and security with the environment into HSSE in term of the upstream oil and gas industry.

Subcategories under economics are composed of net income, unit cost per barrel, daily sales volume, return on investment, return on assets, maintaining reserve to production ratio, and cost optimization program.

Workforce training and development, value to society, psychosocial and gender equality and diversity, partners and stakeholders, anti-corruption, and governance and management are all subcategories of social under the social category.

Subcategories in HSSE also include the Lost Time Injury Frequency Rate (LTIF), the Total Recordable Incident Rate (TRIR), the Loss of Primary Containment (LOPC), the Fatal Accident Rate (FAR), oil spills or hydrocarbon spills, GHG, CO2 emissions or sustainable emission reductions, hazardous waste and waste reduction, and baseline studies for onshore-offshore areas.

To select sustainability key performance indicators, this study using the weight of experts. The expert weight calculated from their professional position, years of experience, education level, and age. Subsequently, the multiplied pre-rank score with the expert weight yielded the weighted indicator ranking (Chen et al., 2019). Finally, five of each sub categories with the lowest weighted indicator ranking value were maintained.

There is an average score of 4.2 for profession, 3. 1, 4 and 3.4 for education, experience and age. The average score is 14.7, and the average expert weight is 0.1.

Ten experts provide their pre-rank scores for economic, social, and environmental dimensions to neglect the less important sub-dimensions. The greater the significance, the lower the rank. Return on investment and return on investment were removed from the economic categories based on the weighted indicator ranking.

Two sub categories psychosocial and gender equalities and diversity were deleted from under the social categories.

Three sub categories under the environment dimension, composed of the fatal accident rate or FAR, oil spills or hydrocarbon spills, and hazardous waste and waste reduction, were deleted.

The finalized sub categories under economic, social, and HSSE is illustrated in Figure 4.

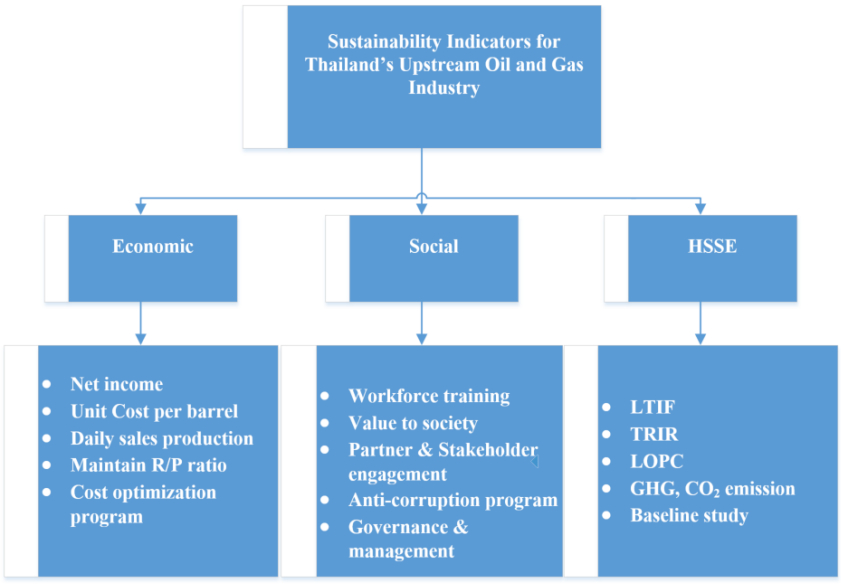

Figure 4 *Finalized sub categories under main categories.*

DISCUSSION AND CONCLUSION

Known as John Elkington's Triple Bottom Line, this method has been used in business for over two decades and considers economic, social, and environmental factors. For supply chains to be sustainable, people working in the upstream oil and gas industry need to ensure their own health and safety, as well as that of their coworkers and the community around them. One of the most pressing issues is this. The oil and gas industry's security and protecting the environment are also important. In the upstream oil and gas industry, health, safety, and security can't be separated from environmental considerations. Economic, social, and environmental well-being all fall under the umbrella of health, safety, and security.

Observations from the study.

Net profit is a similar indicator in the economic dimension. However, the observations from this study found some key indicator differences from the previous study. This study found that maintaining reserve to production ratio is the second-ranking economic dimension for Thailand's upstream oil and gas sector. It can be clearly seen that the proven petroleum reserves in Thailand have declined over the past decade. Therefore, the maintained reserve to production ratio shall be specific for Thailand's upstream oil and gas industry.

However, the dimensions of Thailand's upstream oil and gas sectors differ from those of the United Nations and the previous study. This study highlights the unique aspects of the Thai case. Indicators of anti-corruption and workforce development share similar social dimensions. Similar to the lost time injury frequency rate (LTIF) in this study, which is specified in health, safety, security, and the environment, the injury frequency rate of previous studies is specified in

the social context. For value to society, partner and stakeholder engagement, governance and management systems are specified in this study. Furthermore, in this study, Loss of Primary Containment (LOPC), greenhouse gases, and CO_2 emissions are stated in health, safety, security, and the environment, whereas in the previous study, greenhouse gases and oil spills are specified in environmental dimensions. Although the onshore-offshore baseline study is ranked last in this study and was not shown in the previous study, it serves as the environmental baseline for tracking improvement.

The challenge of the oil and gas business is not only balancing their financial, environment, and social considerations, but also need to focus more on technologies to ensure social and environmental performance improves in parallel with business growth.

Recommendations for further study.

Further studies recommend studying more on methods to prioritize the importance of sustainability indicators such as the analytical hierarchy process (AHP) method. The AHP method is validated by using a consistency ratio that makes results more reliable**.** In addition, the number of experts in each group should be increased to reevaluate the result. Finally, these might be the initial guidelines for Thailand's upstream oil and gas sector.

REFERENCES

1. Andreassen, N. (2017). Sustainability Reporting Guidelines—Safety Issues for Oil Companies. *European Journal of Sustainable Development*, *6*(1). https://doi.org/10.14207/ejsd.2017.v6n1p377
2. Barata, J., Quelhas, O., Costa, H., Gutierrez, R., Lameira, V., & Meirino, M. (2014). Multi-Criteria Indicator for Sustainability Rating in Suppliers of the Oil and Gas Industries in Brazil. *Sustainability*, *6*. https://doi.org/10.3390/su6031107
3. Beland, L.-P., & Oloomi, S. (2019). Environmental disaster, pollution and infant health: Evidence from the Deepwater Horizon oil spill. *Journal of Environmental Economics and Management*, *98*, 102265. https://doi.org/https://doi.org/10.1016/j.jeem.2019.102265
4. BP. (2022). *bp Energy Outlook: 2022 edition*. BP p.l.c. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2022.pdf
5. Deepak Mathur, N. K. V. . (2022). Analysis & Prediction of Road Accident Data for NH-19/44. International Journal on Recent Technologies in Mechanical and Electrical Engineering, 9(2), 13–33. https://doi.org/10.17762/ijrmee.v9i2.366
6. Chen, X., Wu, Z., Chen, W., Kang, R., He, X., & Miao, Y. (2019). Selection of key indicators for reputation loss in oil and gas pipeline failure event. *Engineering Failure Analysis*, *99*, 69-84. https://doi.org/https://doi.org/10.1016/j.engfailanal.2019.01.071
7. Crivellari, A., Bonvicini, S., Tugnoli, A., & Cozzani, V. (2021). Key performance indicators for environmental contamination caused by offshore oil spills. *Process Safety and Environmental Protection*, *153*, 60-74. https://doi.org/https://doi.org/10.1016/j.psep.2021.06.048
8. Desai, J. N., Pandian, S., & Vij, R. K. (2021). Big data analytics in upstream oil and gas industries for sustainable exploration and development: A review. *Environmental Technology & Innovation*, *21*. https://doi.org/https://doi.org/10.1016/j.eti.2020.101186
9. DMF. (2020). *DMF ANNUAL REPORT 2020*. THAILAND

10. Elhuni, R. M., & Ahmad, M. M. (2017). Key Performance Indicators for Sustainable Production Evaluation in Oil and Gas Sector. *Procedia Manufacturing*, *11*, 718-724. https://doi.org/https://doi.org/10.1016/j.promfg.2017.07.172
11. J. . Hermina, N. S. . Karpagam, P. . Deepika, D. S. . Jeslet, and D. Komarasamy, "A Novel Approach to Detect Social Distancing Among People in College Campus", Int J Intell Syst Appl Eng, vol. 10, no. 2, pp. 153–158, May 2022.
12. Chauhan, T., and S. Sonawane. "The Contemplation of Explainable Artificial Intelligence Techniques: Model Interpretation Using Explainable AI". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 4, Apr. 2022, pp. 65-71, doi:10.17762/ijritcc.v10i4.5538.
13. Gong, B. (2018). Different behaviors in natural gas production between national and private oil companies: Economics-driven or environment-driven? *Energy Policy*, *114*, 145-152. https://doi.org/https://doi.org/10.1016/j.enpol.2017.12.004
14. Gurumo, T., & Lixin, H. (2011). Petroleum and Sustainable Development: The Role of International Conventions. International Conference on Petroleum and Sustainable Development IPCBEE,
15. Hourneaux Junior, F., Galleli, B., Gallardo-Vázquez, D., & Sánchez-Hernández, M. I. (2017). Strategic aspects in sustainability reporting in oil & gas industry: The comparative case-study of Brazilian Petrobras and Spanish Repsol. *Ecological Indicators*, *72*, 203-214. https://doi.org/10.1016/j.ecolind.2016.08.007
16. Leesombatpiboon, P., & Joutz, F. L. (2010). Sectoral demand for petroleum in Thailand. *Energy Economics*, *32*, S15-S25. https://doi.org/https://doi.org/10.1016/j.eneco.2010.07.006
17. Longlong, C., & Yifei, L. (2012). Research on Main Constraints in Sustainable Development of China Oil-Gas Upstream Industry. *Energy Procedia*, *14*, 325-330. https://doi.org/10.1016/j.egypro.2011.12.937
18. Mariano, J., & La Rovere, E. (2007). Oil and gas exploration and production activities in Brazil: The consideration of environmental issues in the bidding rounds promoted by the National Petroleum Agency. *Energy Policy*, *35*(5), 2899-2911. https://doi.org/https://doi.org/10.1016/j.enpol.2006.10.005
19. Martchamadol, J., & Kumar, S. (2012). Thailand's energy security indicators. *Renewable and Sustainable Energy Reviews*, *16*(8), 6103-6122. https://doi.org/https://doi.org/10.1016/j.rser.2012.06.021
20. Nortje, C., Middelberg, S., Oberholzer, M., & Buys, P. (2014). Developing a sustainable balanced scorecard for the oil and gas sector. *Environmental Economics*, *5*, 31-39.
21. Varun, B. N. ., S. . Vasavi, and S. . Basu. "Python Implementation of Intelligent System for Quality Control of Argo Floats Using Alpha Convex Hull". International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 5, May 2022, pp. 60-64, doi:10.17762/ijritcc.v10i5.5554.
22. Orazalin, N., & Mahmood, M. (2018). Economic, environmental, and social performance indicators of sustainability reporting: Evidence from the Russian oil and gas industry. *Energy Policy*, *121*, 70-79. https://doi.org/https://doi.org/10.1016/j.enpol.2018.06.015
23. Ramzali, N., Lavasani, M. R. M., & Ghodousi, J. (2015). Safety barriers analysis of offshore drilling system by employing Fuzzy Event Tree Analysis. *Safety Science*, *78*, 49-59. https://doi.org/https://doi.org/10.1016/j.ssci.2015.04.004

24. Sadeghi Mojarad, A., Atashbari, V., & Tantau, A. (2018). *Challenges for Sustainable Development Strategies in Oil and Gas Industries*.
25. Schneider, J., Ghettas, S., Merdaci, N., Brown, M., Martyniuk, J. (2013). Towards Sustainability in the Oil and Gas Sector: Benchmarking of Environmental, Health, and Safety Efforts. *Journal of Environmental Sustainability*, *3*(3). https://scholarworks.rit.edu/jes/vol3/iss3/6
26. Sharma, S. (2013). Profitability Analysis: An Empirical Study of BSE Oil and Gas Index Companies. *International Journal of Innovative Research and Development*, *3*(2).
27. Sircar, A., Yadav, K., Rayavarapu, K., Bist, N., & Oza, H. (2021). Application of machine learning and artificial intelligence in oil and gas industry. *Petroleum Research*, *6*(4), 379-391. https://doi.org/https://doi.org/10.1016/j.ptlrs.2021.05.009
28. Agarwal, D. A. . (2022). Advancing Privacy and Security of Internet of Things to Find Integrated Solutions. International Journal on Future Revolution in Computer Science &Amp; Communication Engineering, 8(2), 05–08. https://doi.org/10.17762/ijfrcsce.v8i2.2067
29. UN. (2015). *Sustainable Development Goals*. https://www1.undp.org/content/oslo-governance-centre/en/home/sustainable-development-goals.html
30. UNDP. (2017). *Mapping the oil and gas industry to the SDGs: An Atlas*. https://www.undp.org/publications/mapping-oil-and-gas-industry-sdgs-atlas
31. N. A. Farooqui, A. K. Mishra, and R. Mehra, "IOT based Automated Greenhouse Using Machine Learning Approach", Int J Intell Syst Appl Eng, vol. 10, no. 2, pp. 226–231, May 2022.
32. Yan, L., Zhang, L., Liang, W., Li, W., & Du, M. (2017). Key factors identification and dynamic fuzzy assessment of health, safety and environment performance in petroleum enterprises. *Safety Science*, *94*, 77-84. https://doi.org/https://doi.org/10.1016/j.ssci.2016.12.022