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Anna Gustina Zainal
MA (Economics),
Communication Department,
University of Lampung
Lampung, 35141, Indonesia (Correspond author)
anna.gustina@fisip.unila.ac.id
ORCID ID:
https://orcid.org/0000-0003-2619-4897

Habibullah Djimad
MA (Economics),
Management Department,
University of Lampung
Lampung, 35141, Indonesia
habibullah.djimad@fe.unila.ac.id
ORCID ID:
https://orcid.org/0000-0003-2355-1342

Rudy
MA (Economics),
Faculty of Law,
University of Lampung
Lampung, 35141, Indonesia
rudy.rudy@fh.Unla.ac.id
ORCID ID:
https://orcid.org/0000-0001-8041-3224

Wulan Suciska
MA (Economics),
Communication Department,
University of Lampung
Lampung, 35141, Indonesia
wulan.suciska@fisip.unila.ac.id
ORCID ID: https://orcid.org/0000-0001-6711-7682

Gita Paramita Djausal
MA (Economics),
Business administration,
University of Lampung
Lampung, 35141, Indonesia
gita.paramita@fisip.unila.ac.id
ORCID ID: https://orcid.org/0000-0003-1215-7366

Economic analysis and investment in fuel industry considering risk management by analytical hierarchy process

Abstract. Natural Gas production and distribution network plans are one of the most common ways to increase energy consumption efficiency. Due to the uncertainty of the economic parameters, the economic justification of this system is very difficult. In this research, the economic risk of investing in urban gas distribution systems has been done with the analytical hierarchy process (AHP). With the development and condensation of urban gas supply networks, accidents caused by gas leaks and other external factors have also increased. Therefore, in recent years, the issue of safety and risk analysis of urban gas networks has received special attention from responsible companies and other urban and safety experts. Gas distribution lines often pass in the vicinity of crowded areas and buildings, so any accident for these lines will lead to a lot of human and financial losses. In the present study, in order to improve the gas supply situation and reduce the risk of failure in Indonesia, urban gas pipelines have been studied to reduce the costs. In this paper, multi-criteria decision making method analysis is used to identify and evaluate the hazards of urban gas pipelines and the risk of occurrence of each hazard is calculated. There was a meaningful relationship based on economic-financial theories between economic factors and investment risk in the gas industry, which emphasizes the greater and more significant effect of exchange rate, failures and inflation rate variables in comparison with other research variables in the matter of controlling investment risk in the gas industry. The effects of changes in energy prices and the economic environment

in explaining the behavior of investment risk in this industry have placed the next level of importance. The results showed that with the increase in energy prices, the economics of gas production and distribution risk management plans have improved and the regular trend of energy price increases can guarantee the profitability of fuel consumption optimization plans.
Keywords: Economic Analysis; Fuel Economy; Risks; Gas Pipelines; Multi-Criteria Decision Making; Analytical Hierarchy Process
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1. Introduction

Today, the use of gas as one of the most important sources of energy supply, has a special place in the daily lives of people around the world, so that in many macro-country planning in various economic, political, military and even culture is considered as one of the important factors of social life (Abrahamsen et al., 2020; Alves de Araújo et al., 2022; Bozorgkhou & Hakimipour, 2014). The increasing acceleration of industry and technology and the increasing dependence of people on industrial products, as well as the tendency of governments to use cheap fuels in industry and domestic consumption all indicate the undeniable role of the gas industry in human societies and its optimal use in economies, while accelerating the growth and prosperity of society, can be considered as one of the important indicators of achieving comprehensive development.

The economic importance of using gas as a cheap fuel, without environmental side effects, easy transportation, having abundant thermal energy that can be used in many factories, power plants, huge industrial and production centers is not hidden from anyone, and this is a wide and comprehensive application (Lashgari et al., 2022). It has caused gas to play a very important role in human life today. The gas industry starts from the exploration stage and continues until gas consumption. This process can be divided into the following stages:

1) Production;
2) Refinement;
3) Transfer;
4) Gas supply (gas distribution system);
5) Exploitation and consumption.

The gas enters the CGS main city gas station through the transmission pipeline with a maximum pressure of 700-1000 psi and a minimum pressure of 300-350 psi (Nursalim, 2021), and after reducing the pressure to 250 psi, the gas enters the pressure reduction stations through the main lines of the supply network or the belt loop.

Jo & Ahn (2002) studied the ranges caused by the damage of high pressure gas lines, and in this study, a distance of 20 meters for low pressure lines and a distance of 300 meters for high pressure lines was determined as a distance with high risk potential. In this method, the location map of the lines and population density information were used for risk analysis and acceptable results were obtained (Muhlbauer, 2004). In research by Jo et al. (2004), the authors assessed the risk on a 40-kilometer high-pressure pipeline using the qualitative method of indexing and the use of GIS capabilities. Abdelaziz et al. (2006) in their results stated that the use of GIS increased the accuracy of the risk estimation process. Ma et al. (2013) used an indexing method to estimate the risk of gas transmission lines, the output of which was a relative risk score. In the mentioned method, the potential of line breakage was done in the form of a number of weighted factors by experts.

Alkhalidi et al. (2020), by conducting a study on the failure of pipelines and risk estimation, the corrosion index of the lines over time carefully examined and confirmed the reduction of the thickness of the steel lines and the increase in the risk caused by it. Marhavilas et al. (2019), by conducting a quantitative analysis regarding the risk of urban gas networks, investigated the distance of the risk leading to death and the influencing parameters. The distinctive feature of their work is the use of GIS analytical capabilities in estimating the risk levels of parameters. Najafi & Nasiri (2013), in order to quantify the risk assessment of gas supply networks, with the help of graph theory, formed the network divided into parts and for the important points located in each part, a number was extracted as the risk value, and then with the help of interpolation functions in ArcGIS software, prepared a risk zoning map in the whole city. In this research, the economic model for the gas supply system is examined in order to control and manage risk in urban gas pipelines in order to improve the level of safety in them. Also, it is the best option based on various criteria for safety in urban gas pipelines to reduce the maintenance costs of the fuel supply system.

2. Method

Risk management is a dynamic process and indicates the identification, evaluation and economic control of all types of risks. In order to establish a written system of risk management in the organization, it is first necessary to determine the scope and extent of the risk and to study it in order to collect relevant information. The better the quality of information, the more consistent the results of risk management will be with reality. At this stage, which is known as risk analysis, all obvious and hidden risks are identified and the value of each risk is determined qualitatively. Then, analysis of probabilities and modeling of the consequences of accidents is done in order to determine the severity of risks, which is known as quantitative risk analysis.

The sum of qualitative and quantitative risk analysis steps is called risk assessment (Brito & Almeida, 2009). The stages of the risk management process are data collection, risk identification, qualitative assessment of risk, quantitative risk assessment (Probability analysis, analysis of the severity of occurrence), and risk assessment. Finally, if the amount of risk under consideration is acceptable, the operation will be over. By reduction of the risk, the cost analyses can be reduced and financial status can be stable.

The structure of the risk acceptance criteria is organized in three parts as shown in Figure 1. This form is known as risk carrot. The upper part shows the unacceptable risk area and the lower part shows the risk area that can be ignored. The area between upper part and the lower part is the place where the amount of personal, occupational and social risk should be reduced as much as possible (Ishenin et al., 2021).

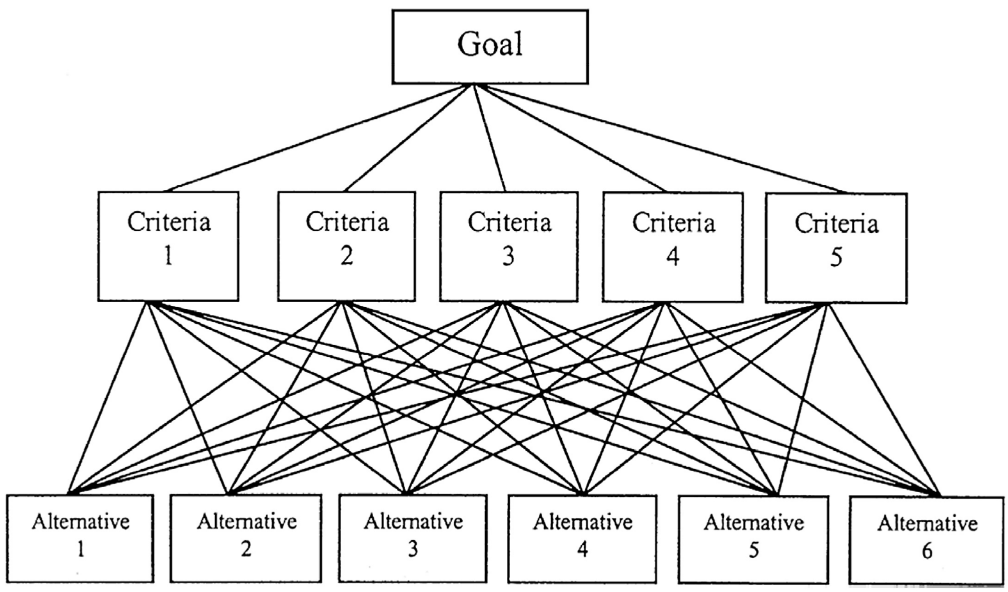

Figure 1:
The general structure of the analytical hierarchy process
Source: Ma et al. (2013)

3. Results

Risk management and assessment is one of the most important activities for gas pipeline networks, especially in cities. In this section, an economic analysis was performed to estimate the risk in gas pipelines as urban fuel consumption and its results were presented. Natural gas passes through different gas supply networks to reach consumers. Natural gas reaches the gate of the city through the main lines that make up the transmission network, then it is transferred to the consumers that include domestic, industrial and special consumers using the distribution network. Therefore, maintaining the safety of gas pipelines is of particular importance. Figure 2 shows the breakdown of the gas network in the last 5 years (2018-2022) separately.

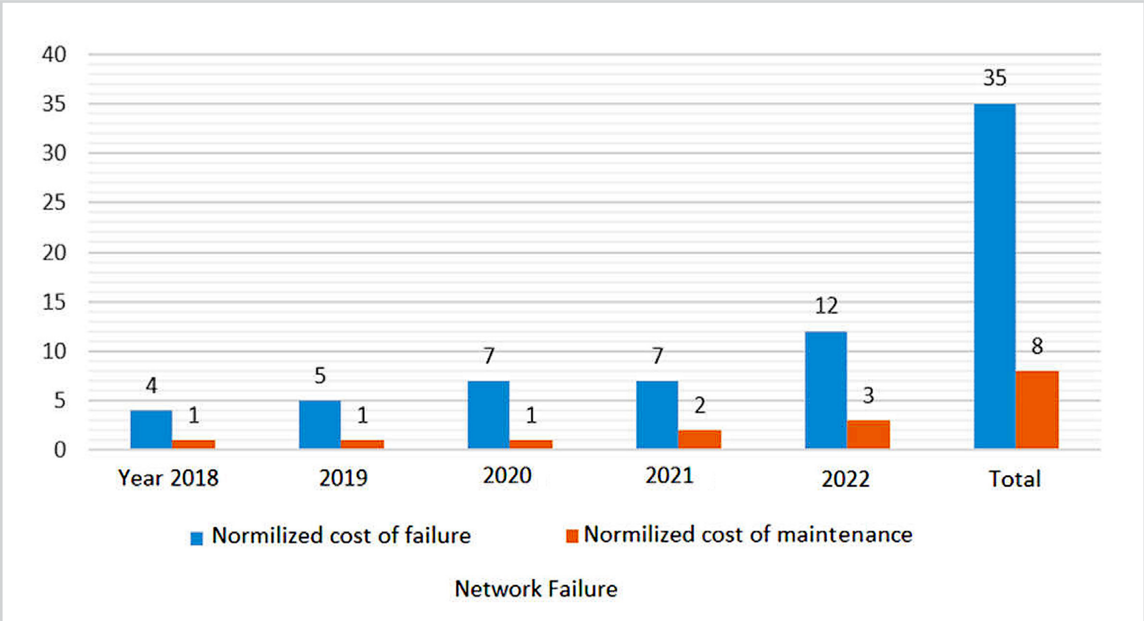

Figure 2:
Comparing of cost of network failure vs maintenance in risk analysis in Indonesia, USD
Source: Authors' own finding based on Indonesian Economic and Financial Statistics (SEKI)

3.1. Analytical Hierarchy Process

At this stage, the main problem is defined and the purpose of decision making is drawn as a hierarchy of factors and elements that make up the decision. The process of hierarchical analysis requires breaking the decision problem with several indicators into a hierarchy of levels. For this purpose, a decision tree is used, which consists of three levels. The first level includes the overall goal of decision making. In the second level, there are general criteria, based on which decisions are made, and in the third level, the decision options for improving the gas network are given. At this stage, using the advice and opinions of 20 experts (taken in 2021 and 2022), comparisons were made between the decision-making criteria and according to the nine quantitative results, the priority of the criteria is specified and presented in Table 1.

Table 1:
Relative priority of general criteria

General criteria	Possibility	Reduction of the outcome	Reduction in the probability of occurrence	Cost of implementation
Possibility	1	2	4	6
Reduction of the outcome	1/2	1	2	3
Reduction in the probability of occurrence	1/4	1/2	1	2
The cost of implementation	1/6	1/3	1/2	1

Source: Authors' own finding

According to Table 1, it is clear that the diameter of the matrix is 1 in all cases, and this shows that the importance ratio of a factor compared to itself is equal to one, and the importance of the factors to each other has the property of reversibility, so that the importance ratio is possible Feasibility to the degree of reduction of the consequence is the inverse of the ratio of the degree of reduction of the consequence to the feasibility, and it is clear that the feasibility is twice more important than the degree of reduction of the consequence, because an option must first of all have the ability to be feasible to be implemented in order to be able to reduce the amount of consequences.

As the case study in the natural gas distribution network for Bandar Lampung city for calculation of the sum of the values of each columns of the general criteria, as presented in Table 2 (normalized one) we add the values of each column together.

Table 2:
Total values of each column of general criteria

General Criteria	Possibility	Reduction of the outcome	Reduction in the probability of occurrence	The cost of implementation
Possibility	1	2	4	6
Reduction of the outcome	1/2	1	2	3
Reduction in the probability of occurrence	1/4	1/2	1	2
The cost of implementation	1/6	1/3	1/2	1
Total	12/23	6/23	15/2	12

Source: Authors' own finding

For the rate of reduction of the outcome as an example: 2 + 1 + 1 / 2 + 1 / 3 = 6 / 23. Calculation of the normalization of the elements of the column, the rate of reduction of the probability of occurrence: First row: 4 ÷ 15 / 2 = 0.533; Second row: 2 ÷ 15 / 2 = 0.266; Third row: 1 ÷ 15 / 2 = 0.133; Fourth row: 1.2 ÷ 15 / 2 = 0.066.

Mean calculation of the elements of each line of general criteria: In this section, according to Table 3, we calculate average of elements in each row.

Calculation of the average lines of the criterion of the amount of cost for implementation: 0.083 + 0.066 + 0.086 + 0.086 = 0.080.

The sum of the importance coefficients of the general criteria is equal to 1, which indicates its relative importance (0.52 + 0.26 + 0.14 + 0.08 = 1).

Table 3:
Calculation of the average of each row of general criteria

General Criteria	Possibility	Reduction of the outcome	Reduction in the probability of occurrence	The cost of implementation	Mean
Possibility	0.521	0.521	0.533	0.500	0.520
Reduction of the outcome	0.260	0.260	0.266	0.250	0.260
Reduction in the probability of occurrence	0.130	0.130	0.133	0.166	0.140
The cost of implementation	0.086	0.086	0.066	0.083	0.080

Source: Authors' own finding

The developing countries, especially Southeast Asia, have not only benefited from the technology and technical knowledge of the developed countries, but also the management techniques of the developed countries for their economic and industrial progress. There is no doubt that suitable industrial accounting systems are able to identify the bottlenecks and problems of production systems (Kim & Kim, 2018). Among these, we can mention the cost price invoices in which the items that make up the cost price of goods such as direct materials; direct labor and overhead costs are the main components of this bill. In this invoice, the items of production overhead costs can be examined separately and through them, appropriate solutions can be taken to reduce the cost price. The most important items that make up the cost of goods in organizations are the costs of indirect materials; depreciation; Maintenance; electricity, fuel, etc. As the results showed, maintenance and repair costs take a major share, and the analysis of the results related to this cost item can help us to improve the level of productivity in this industry.

3.2. Cost and Investment Analysis

In this part the economic analysis of the investment in gas industry is done based on the final price strategy. The mean price of natural gas is 0.093 U.S. Dollar per kWh for households and 0.081 U.S. Dollar per kWh for businesses (Hermawan & Purwanto, 2020). In this situation, it is assumed that the price of energy will not remain constant in the coming years and we will see the trend of increasing prices according to the previous years. Therefore, the obtained probability distributions are used to estimate energy prices in the coming years.

As can be seen in Figure 2, the investment return period is between 25 and 32 months, which is a relatively acceptable investment for the implementation of the simultaneous production plan. Figure 3 shows that despite the increase in the initial investment cost, due to the increase in energy prices, the profitability of the plan is still high and with a probability of 96% between 30-55%.

In Figure 4, the current value of the capital after a period of four years and including the bank loan with an interest rate of 20%, with a probability of 95% is between 5.2 and 5.7 times the value of the investment, which is an attractive investment in the world economic conditions.

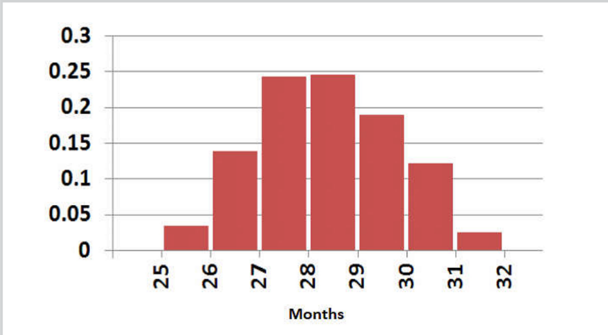

Figure 2:
Histogram of probability distribution of capital return period
Source: Authors' own finding

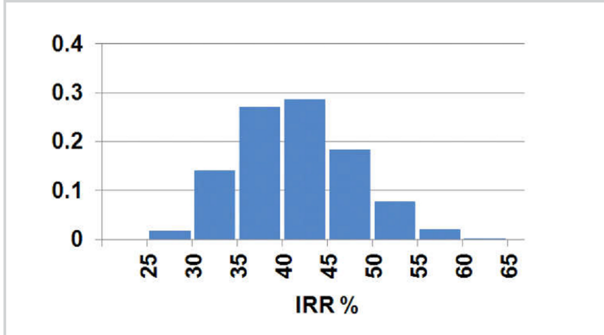

Figure 3:
Percentage of Probability distribution (PPD, or IRR) for a period of four years
Source: Authors' own finding

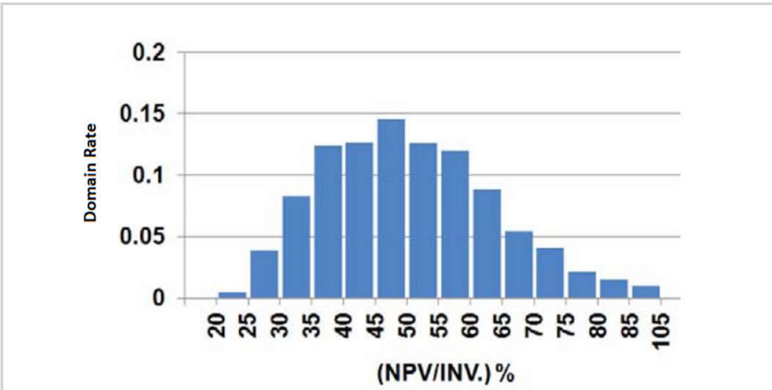

Figure 4:
NPV probability distribution chart relative to the investment
Source: Authors' own finding

4. Conclusion

The increasing urbanization, especially in big cities, has caused the growth of gas consumption demand and consequently the development and densification of gas supply lines. With the development and densification of the gas supply network, the cost and accidents caused by gas leakage and other external factors have also increased. For this reason, in recent years, the issue of safety and risk analysis of gas networks has received the special attention of trustee companies and other urban and safety experts. If pipelines or related equipment have an accident, it will result in consequences such as fire, explosion, and release of toxic gases, which is a threat to the safety of people, industries, infrastructure, and the environment. In this article, by presenting the economic model and investment management in the maintenance and repair sector of the fuel supply system, the effective factors in reducing the cost have been prioritized and presented. It is obvious that prevention is better than cure, so in order to reduce the accidents and damages caused by it, it is necessary to provide a scientific framework for assessing and analyzing the risk caused by gas pipelines that can quantify and display the risk of gas supply networks.

References

1. Abrahamsen, E. B., Milazzo, M. F., Selvik, J. T., Asche, F., & Abrahamsen, H. B. (2020). Prioritising investments in safety measures in the chemical industry by using the Analytic Hierarchy Process. Reliability Engineering & System Safety, 198, 106811. https://doi.org/10.1016/j.ress.2020.106811
2. Alkhalidi, A., Tahat, S., Smadi, M., Migdady, B., & Kaylani, H. (2020). Risk assessment using the analytic hierarchy process while planning and prior to constructing wind projects in Jordan. Wind Engineering, 44(3), 282-293. https://doi.org/10.1177/0309524X19849862
3. Alves de Araújo, F., Mendes dos Reis, J. G., Terra da Silva, M., & Aktas, E. (2022). A Fuzzy AHP Model to Evaluate Logistics Service Expectations and Delivery Methods in Last-Mile Delivery in Brazil. Sustainability, 14(10), 5753. https://doi.org/10.3390/su14105753

4. Amirat, A., & Mohamed-Chateauneuf, A., & Chaoui, K. (2006). Reliability assessment of underground pipeline under the combined effect of active corrosion and residual stress. International Journal of Pressure Vessels and Piping, 83(2), 107-117. https://doi.org/10.1016/j.ijpvp.2005.11.004
5. Bozorgkhou, H., & Hakimipour, H. (2014). Studying the Impact of Brand Equity, Brand Experience, Brand Satisfaction and Brand Trust on Brand Loyalty (Case: ECCO Customers). Modiriat-e-farda, 36(36), 1-12. http://modiriyatfarda.ir/en/Article/24484 (in Persian)
6. Brito, A. J., & de Almeida, A. T. (2009). Multi-attribute risk assessment for risk ranking of natural gas pipelines. Reliability Engineering & System Safety, 94(2), 187-198. https://doi.org/10.1016/j.ress.2008.02.014
7. Hermawan, E., & Purwanto, W. W. (2020). Gas Price Policy Analysis for Fertilizer Industries in Indonesia Based on Netback from Final Product. Jurnal Sosial Humaniora (JSH), 13(2), 190-202. https://doi.org/10.12962/j24433527.v13i2.7704
8. Ishenin, D., Govorkov, S., Teslenko, I., Klykov, M., Kabanov, O., Lyalin, E., Mukhamedova, Z., & Shaposhnikov, A. (2021). An Algorithm for Computer-Aided Design of a Technological Process with Preset Manufacturability Parameters, Procedia Environmental Science. Engineering and Management, 8(4), 733-738. https://www.procedia-esem.eu/pdf/issues/2021/no4/2_Ishenin_21.pdf
9. Jo Y., Park, K.-S., & Ahn, B. J. (2004). Risk Assessment For A High-pressure Natural Gas Pipeline In An Urban Area. In N. Marchettini, C. A. Brebbia, E. Tiezzi & L. C. Wadhwa (Editors), The Sustainable City III, (pp. 541-547). https://www.witpress.com/Secure/elibrary/papers/SC04/SC04053FU.pdf
10. Jo, Y. D., & Ahn, B. J. (2002). Analysis of hazard areas associated with high-pressure natural-gas pipelines. Journal of Loss Prevention in the Process Industries, 15, 179-188. https://doi.org/10.1016/S0950-4230(02)00007-4
11. Kim, J., & Kim, J. (2018). Optimal portfolio for LNG importation in Korea using a two-step portfolio model and a fuzzy analytic hierarchy process. Energies, 11(11), 3049. https://doi.org/10.3390/en11113049
12. Lashgari, A., Hosseinzadeh, H., Khalilzadeh, M., Milani, B., Ahmadisharaf, A., & Rashidi, S. (2022). Transportation energy demand forecasting in Taiwan based on metaheuristic algorithms. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 44(2), 2782-2800. https://doi.org/10.1080/15567036.2022.2062072
13. Ma Lei & Yongshu Li, Lei Liang, & Manchun Li, & Cheng Liang (2013). A novel method of quantitative risk assessment based on grid difference of pipeline sections. Safety Science, 59, 219-226. https://doi.org/10.1016/j.ssci.2013.04.012
14. Marhavilas, P. K., Filippidis, M., Koulinas, G. K., & Koulouriotis, D. E. (2019). The integration of HAZOP study with risk-matrix and the AHP for identifying critical control-points and prioritizing risks in industry - A case study. Journal of Loss Prevention in the Process Industries, 62, 103981. https://doi.org/10.1016/j.jlp.2019.103981
15. Muhlbauer, W. (2004). Pipeline Risk Management Manual. Gulf Professional Publishing.
16. Najafi, M. L., & Nasiri, M. (2013). Identification and prioritizing the effective factors on addiction by use of Fuzzy analytical hierarchy process (F-AHP). Life Science Journal, 10(9s), 89-99. http://www.lifesciencesite.com/lsj/life1009s/027_20151life1009s_209_215.pdf
17. Nursalim A. (2021). Investigating the Complex Relationship between Environmental and Financial Performances. Procedia Environmental Science, Engineering and Management, 8(4), 863-870. http://procedia-esem.eu/pdf/issues/2021/no4/16_Nursalim_21.pdf

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