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Identification and prioritization of indicators influencing the assessment of potential locations for the construction of gas booster station

Ali Ashrafpour *
Department of Engineering and Construction Management ,Faculty of Engineering, Yazd Branch, Islamic Azad University, Yazd, Iran.
**Corresponding Author*

Mohamad Mirabi
Faculty member. of Engineering, Meybod Branch, Islamic Azad University, Meybod, Iran.

Alireza Mirjalili
Faculty member. of Engineering, Yazd Branch, Islamic Azad University, Yazd, Iran.

ABSTRACT

Gas booster stations are designed and established to collect and process the associated petroleum gas and inject it into oil tanks or transfer to downstream consumer facilities. Location is one of the essential issues related to gas booster stations. It should be given a special attention due to technical, environmental, safety, economic, social and cultural issues. Based on library and field studies, the indicators and criteria used in assessing the potential sites for the construction of gas booster platform, except for the requirements of the National Oil Company, have no specific scientific and experimental basis. That is why this research is to design a scientific framework based on paired comparison methods by conducting face-to-face and in-person interviews with experts of gas pressure boosting platforms. To do this, 45 indicators influencing the optimal location were identified and prioritized. The results from prioritizing showed that safety, technical and environmental dimensions and at a more detailed level, indicators of compliance with process requirements, possibility of continuing the production process, distance from active wells, distance from fuel pit, distance from burner, and difference in direction or path of prevailing winds are the most important location indicators.
Keywords: gas booster station, hierarchical method, paired comparison

Introduction

Maintaining the production capacity and increasing the recovery factor of petroleum reservoirs by considering conservation criteria is a serious concern of the National Company for Southern Oilfields. According to the laboratory researches conducted on the methods appropriate to increase the recovery of oil reserves in carbonate reservoirs of southwestern Iran, gas injection is the most suitable method (Filizadeh, 2013).

Since there are highly toxic sulfur compounds in these gases, the use of anti-corrosion materials and compliance with all technical and safety standards are essential to maintain the health of employees and the continuous and efficient use of the facilities (Karbasian, 2013).

Studies suggest that injection of gas into these reservoirs has increased the extractable petroleum. The southern oil-rich areas currently have gas collection and boosting stations with gas injection, storage tank and production and injection gas wells (Blashabadi, 2013).

Deciding on the location and site of the construction or development of an industrial unit plays a key role in the strategic orientation of a plant and impacts profitability of the unit in the long run. Gas pressure boosting platform also comply with this rule and conducting the relevant location studies will have environmental and safety effects in the construction area in addition to the economic impact on the performance of the industrial unit (Karden 2016).

It should be considered that in choosing the optimal site for a gas pressure boosting platform, the value of several criteria, instead of single criterion, with different scales and goals need to be optimized. The criteria are not comparable and even they contradict each other in some issues. It means increasing one criterion reduces the other criterion, so for decisions with multiple criteria, we usually look for the option that provides the most advantage for all criteria, which complicates decision-making. There is no doubt that by using traditional, experimental and non-systematic methods, the likelihood of making an optimal decision will seriously decrease (Yang, 2007).

At the moment, due to the lack of a clear systematic process to select the site of gas pressure boosting platforms, making decision on this issue is seriously challenged and it is necessary to propose a scientific model with multi-criteria decision models. Therefore, a scientific framework is used to identify and prioritize the indicators of the construction site. Then, an appropriate model is used to evaluate the options based on the indicators. For this purpose, the comparison method is applied to prioritize the indicators (Aiello, 2006).

Omrani and Makriani (2014) identified the indicators influencing the optimal locating of solar power plants and then used 5 questionnaires to weigh the indicators. The questionnaires were based on a fuzzy hierarchical approach designed as paired comparisons. Finally, they used a robust optimization approach considering the uncertainty for input and output data in the data envelopment analysis model. According to the indicators and location of solar power plants, Birjand city was the most efficient site for the establishment of power plants.

Jiuping (2015) used multi-objective methods and GIS to locate the coal-fired power plant. Identification and selection of coal-fired power plant (CPP) plays an important role in the safe operation of a project and the sustainable development of an area. Jiuping proposed a GIS modeling method for identifying and selecting a CPP site. Using geographic information system (GIS) and spatial analysis, many factors such as roads, existing power grids, fuel and land have been identified. In this research, the interactive fuzzy modeling and programming method based on Genetics Algorithm II (NSGA-II) was used instead of forming a multi-criteria framework.

Yunna (2015) investigated locating a waste-to-energy conversion plant based on a multi-objective decision-making framework. He addressed two major problems in current methods: the lack of description of information risk and the correlation of criteria.

Noorollahi (2016) established a Multi-Objective Decision Support System (MCDM) to select the optimal location for a GIS-based wind farm. His study is based on multi-criteria decision making methods for evaluating wind resources, taking into account economic, technical, environmental and geographical indicators. It is worth noting that economic, technical, environmental and geographical criteria are considered with equal importance. The results suggest that the wind energy potential in Markazi province (western Iran) is favorable for electricity generation and 28% of the study area has the capacity to install large wind farms.

According to what mentioned, this research is to answer the following questions:

1. What are the effective indicators for the optimal locating of the gas pressure boosting station?
2. How is the weight of indicators for constructing a gas pressure boosting station obtained?

Method

This is an applied research.

Data collection

The data was collected by field and library methods. It was gathered from the reports of the consulting engineering companies of the National Iranian Oil Company on locating gas pressure boosting stations. Face-to-face and in-person interviews with experts of gas pressure boosting stations were also used to collect data.

Data analysis

The data was analyzed by hierarchical analysis method.

Analytic Hierarchy Process (AHP)

Applying this method requires the following main steps:

A) Modeling

In this step, the problem and the decision purpose are extracted hierarchically from the decision elements that are related to each other. (Aiello, 2012).

B) Paired comparisons

A set of matrices that numerically indicate the relative importance or superiority of the indicators over each other must be created to compare different decision options, based on each index and judging the importance of the decision index by paired comparisons. To do this, the i-th options or indicators are usually compared with the j-th options or indicators. The valuation of the ratios relative to each other are shown in Table 1.

Table 1: Relative valuation of indicators

Preferred value	Comparison status of i and j	Explanation
1	Equal importance	Option or index i is as important as j; no preference.
3	slightly important	The option or index i is slightly more important than j.
5	More important	The option or index i is more important than j.
7	Strongly important	Option or index i is strongly preferred to j.
9	Extremely important	Option or index i is extremely important than j; they can’t be compared.
8,6,4,2		The middle values in the preferred values. For example, 8 indicates a value greater than 7 and lower than 9 for i.

C) Calculations of relative weights

The sum of the numbers is computed for each column of the paired comparisons matrix. Then, every element of the column is divided by the sum of the numbers in that column. Thus, a new matrix is obtained that is called the “normalized comparison matrix”.

The average of the numbers is calculated for each row of the normalized comparison matrix which represents the relative weight of the decision elements or the matrix rows (Baykasoglu, 2006).

D) Integration of relative weights

In order to rank the decision options, in this step the relative weight of every element must be multiplied by the weight of the higher elements to obtain the final weight. Doing this step for each option, the final weight value is obtained.

Consistency in judgments

•Almost all of the calculations in the hierarchical analysis process are based on the initial judgment of the decision maker, which appears in the form of a paired comparison matrix, and any errors and inconsistencies in determining and comparing the importance between options and indicators distort the final result of the calculations. The inconsistency rate (I.R), which will be described below, is a tool that identifies the inconsistency and shows the extent to which priorities from comparisons can be trusted (Ghaseminejad, 2011).

Consistency index: The consistency index is defined as follows:

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{1}$$

Where *n* represents number of options available in the problem.

Consistency ratio: The consistency ratio is obtained by dividing the consistency index by a random index.

$$CR = \frac{CI}{CR} \tag{2}$$

Consistency ratio of 0.1 or less suggests the presence of consistency in comparisons. The random index (RI[2]) is extracted from Table 2.

Table 2: Random index

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	58.0	9.0	12.1	24.1	32.1	41.1	45.1	51.1

Locating indicators of gas pressure boosting station

First, the criteria of the Ministry of Oil are noticed for locating oil and gas sites. Then, the important issues of location, extracted from the preliminary research reports of the National Iranian Oil Company, were reviewed. Finally, by summarizing the opinions of the research team, the indicators affecting the optimal location of the gas pressure boosting station were introduced as economic, technical, safety, environmental, cultural and social perspectives.

Findings

Forming a research team

As the first step, a research team consisting of experts in the construction of gas pressure boosting stations was formed. Therefore, 7 managers and engineers of the Southern Oilfields Company were selected who had sufficient technical, economic, safety, environmental, cultural and social expertise and experience in the construction of gas pressure boosting station. Their views was used at different stages of the research.

Table 3- Details of the research team

Row	Organizational position	Specialty (degree of education)	Experience (year)
1	Head of Engineering and Design	Chemical-Polymer Engineering, Master of Management	20
2	Master of Engineering and Design	PhD in Electrical Engineering - Power	16
3	Head of Civil Executive Group	Civil Engineering	25
4	Head of Project Planning and Control	Industrial Engineering - Systems Planning and Analysis	15
5	Project Manager	Master of Drilling and Well Engineering	23
6	IMS Management Representative	Master of Civil-Structural Engineering	15
7	Master of Surveying office	Civil Engineering-Surveying	20

Factors affecting the location of the gas pressure boosting station in the report of consulting engineers

In this section, by reviewing various studies and reports conducted by consulting engineering companies of the National Iranian Oil Company on locating gas pressure boosting station, the most influencing criteria are introduced as follows:

Environmental conditions

Atmospheric conditions: temperature and periods of inversion of temperature, humidity, pressure (altitude), precipitation (rain, snow), sunshine, wind speed, prevailing direction of the storm, lightning rate, atmospheric groups, dust, corrosive gases and noise pollution.

Geological conditions: Preliminary soil studies and determination of soil engineering characteristics, seismological studies and seismic engineering, information about the elevations of the location and vibrations caused by other sources.

Hydrological conditions: Surface and groundwater studies

Environmental conditions: studies of biogeography and studies of soil vital structure

Infrastructure facilities and public facilities

Checking infrastructure and public facilities available during the implementation and operation, including:

Surface water sources, groundwater and drinking water piping network.

Wastewater treatment and disposal facilities

Power supply sources.

Access routes and types of road transport, railways, airlines and waterways to and from the site.

Available resources

Checking the accessibility of the required resources during implementation and operation, including:

Sources of building materials.

Professional, skilled, semi-skilled and simple manpower resources.

Public facilities.

Consistency of construction area with other accessions

The construction area must be compatible with existing or buildable accessions of the site including:

Independent town for living

Welfare amenities

Communication facilities

Proportional workshop facilities

Proportional supply and protection facilities

Oil and gas facilities

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

Other criteria

The ground should be as flat as possible so that excavation and leveling operations are possible at the time of execution.

The selected site should not be located in the pipeline route or at least changes should be made in the pipeline route.

The area should be safe from soil and rocks fall.

There is enough space to install mechanical and electrical equipment as well as the construction of required buildings.

Sufficient space should be available for the future development of the station.

Due to the drop in gas pressure, it is advisable to locate the site as close as possible to the operating unit.

Proximity to existing equipment including the exploitation unit - the power transmission line and other facilities in order to minimize the costs

Locating indicators

As seen in Table 4, the research indicators are classified into two levels. Level 1 includes the main economic, technical, safety, environmental and socio-cultural indicators, the detailed level includes each of the main indicators with several sub-indicators. The hierarchical framework is essentially used when high numbers of indicators is a common issue.

Table 4: locating indicators

Sub-criteria	Criteria	Criterion type
difference in direction or path of prevailing winds	Output	Safety
Distance from explosive sources		
Distance from the burner		
Distance from the fuel pit		
Distance from active wells		
Distance from the fault		
The degree of soil liquefaction and corrosion		
The amount of soil and rock fall		
Landslide rate		
The cost of land acquisition	Input	economic
Leveling and excavation costs		
Cost of inlet pipelines		
Cost of outlet pipelines		
Cost of road construction and access roads		
Cost of buildings construction		
Cost of relocating existing pipelines		
Cost of relocating existing communication routes and roads		
Cost of construction of burners		
Access to specialized human resources and simple workers		
Possibility of treatment and disposal of various wastewater		
Access to power supply sources		
Access to groundwater (subsurface water) and drinking water piping network		
Access to building materials resources		
Access to transportation system (road, rail, sea and airport)		
Access to public facilities (health-care centers, telecommunications, welfare, residential town, etc.)		
Station construction time		
Compliance with station technical standards (excluding process and equipment)	Output	Technical
Compliance with process requirements		
Compliance with equipment standard (functional conditions such as altitude)		
Possibility of continuing the production process		
Possibility of station development		
Performing various tasks under different operating conditions		
Fit with optimal layout		

Air pollution (toxic greenhouse gases)	Input	Environmental
Water pollution		
Noise pollution		
Pollution caused by radiation and waves		
Distance from the protected area		
Vegetation rate		
Animal life		
Possibility to create green space		
Impact on historical monuments	Output	Cultural and social
Employment and increasing the income of the local people		
Possibility of creating and developing public and welfare facilities in the region		
Fading of local and indigenous culture		
The rate of elite migration to the region		

Table 4 also shows that using the data envelopment analysis, the main indicators of the research are divided into two categories of output and input. This classification is based on the fact that the desired direction in the input index is when the index is minimized and in the output index it is when the index is maximized. For example, desirability means reduction of economic indicators, which mainly include construction costs as well as the increase of environmental indicators, which mainly include the reduction of pollutants.

Prioritization of indicators

Comparisons by the research team was the instrument for weighing the indicators of this research. The matrix of paired comparisons of indicators at level 2 is described in Table 5 for the main locating criteria.

Table 5: Paired comparisons of the main criteria

Paired comparison matrix for the main locating criteria	Safety	Economic	Technical	Environmental	Cultural and social	Total weight
Safety	1.00	3.00	1.00	2.00	4.00	0.32
Economic	0.33	1.00	0.33	0.50	2.00	0.12
Technical	1.00	3.00	1.00	2.00	4.00	0.32
environmental	0.50	2.00	0.50	1.00	2.00	0.17
cultural and social	0.25	0.50	0.25	0.50	1.00	0.07

Conclusion

Gas booster stations are designed and established to collect and process the associated petroleum gas and inject it into oil tanks or transfer it to downstream consumer facilities. Location is one of the most important issues related to the gas booster platform. It should be given a special attention due to technical, environmental, safety, economic, social and cultural issues (Karray, 2000; Meixner, O., 2009).

Based on library and field studies, in the National Iranian Oil Company, locating station for gas booster is done by consulting engineering companies. Their reports seriously lack a standard and scientific framework to assess the optimal site for the gas booster station. On the other hand, the indicators and criteria for evaluating the options for the construction of such stations are different in each report (compared to other reports) and except for the requirements of the National Oil Company, other indicators and criteria suffer from a clear scientific and experimental basis. Therefore, we used a scientific framework to identify and prioritize indicators of construction site. Then, an appropriate model was used to evaluate the options based on the problem indicators.

In order to identify and introduce the indicators that impact on optimal locating of the gas pressure boosting station, we first reviewed the criteria of the Ministry of Oil for locating oil and gas sites. Then, we extracted the major locating issues from the reports of consulting engineers of the National Iranian Oil Company. Finally, by summarizing the opinions of the research team, we identified and selected 45 indicators influencing the optimal location including 17 economic indicators, 7 technical indicators, 9 safety indicators, 7 environmental indicators and 5 cultural and social indicators.

In the next step, the paired comparison method was used to calculate the indicators weight. Accordingly, they were evaluated separately by the research team at levels 1 and 2. The results showed that safety, technical and environmental dimensions are the main indicators, respectively. Moreover, the indicators of compliance with process requirements, the possibility of continuing the production process, distance from active wells, distance from the fuel pit and distance from the burner and difference in direction or path of prevailing path winds were selected as the major sub-criteria that impact locating the station.

According to the results, a standard and scientific research framework that identify and prioritize indicators can be used to solve the research problem around one of the operational areas of the southern oilfields. This is consistent with and confirms the reports provided by consulting engineers.

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