# Fast Screening Method to Prioritize Underground Gas Storage Structures for Site Selection

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The supply-demand misbalances of natural gas require the creation of Underground Gas Storage (UGS) especially during peak period and these UGS' facilities will probably play an important role in gas market development.

Since last century, UGS sites have been used to store natural gases. However there is a key concern in managers' mind that they have limited budget and several candidate fields/structures for this purpose. Techno-economic analysis shows that the constructions of UGS for all fields/structures are not justified, although gas storage schemes are vital for Iran to meet peak energy needs. For choosing proper candidate among several alternatives, first of all, many factors have been extracted for deciding whether to store gas and, more specifically, the type of structures that should be used in a particular case in this article. In addition, a pre-screening procedure has been planned to omit disqualified UGS sites for avoiding expenses in the next steps based on killer parameters. In this step six different criteria have passed through pre-screening phase.

Also, a decision tree has been drawn based on four main parameters; technical, economical, geographical & environmental and passive defend parameters, to prioritize potential of fields for UGS execution based on expert’s opinions. This decision tree is broken down to three sub-levels for more than 60 subsidiary parameters. After drawing decision tree all the sub-parameters will be evaluated, ranked & weightened relative to each other based on Analytical Hierarchy Process (AHP) technique.

Finally, this methodology can be applied to different fields/structures to prioritize them for selecting appropriate sites of underground gas storage and the best choice to execute this technology on, can then be selected. The techniques described in this article should be used by decision makers and managers to select the proper and potential site for UGS.

Keywords: Underground Gas Storage, Screening method, prioritization, workflow

In the majority of oil/gas fields, the oil and/or gas is held in a porous rock, often sandstone, which has spaces between the grains of sand, forming an interconnecting, permeable network between the grains. The porosity and permeability enables the hydrocarbons to move through the rock mass. As oil (and/or gas) is removed from the oil/gas field, the pressure in the reservoir depletes and water invasion occurs. Saline groundwater replaces the oil in the pore spaces due largely to hydrodynamic gradients. The existence of an oil/gas field demonstrates the capability of a structure and rock sequences to trap and successfully retain (commercial) quantities of hydrocarbons over significant periods of geological time (many millions of years). Depleted oil/gas fields therefore offer the potential for reinjection and storing natural gas underground. Gas can be injected into the reservoir rock, displacing the water, to be stored, as was the oil, in the connected pore spaces. In many instances, re-injecting gas is associated with an increase in pressure within the reservoir, which can also lead to a period of increased oil recovery. Depleted oil and gas fields represent the most cost effective process and represent the preferred method of underground storage.

Gas storage in depleted oil and gas fields is the most widespread and generally the least expensive method of storing natural gas in large quantities. Worldwide, depleted reservoirs currently providing around 70% of gas storage volume . The first gas storage experiment was made in a gas field in Canada in 1915. The first gas storage facility in a depleted reservoir was built in 1916, using a gas field near Buffalo, New York (USA) and is still operational. By 1930, there were nine storage facilities in six different American states and prior to 1950, virtually all natural gas storage facilities were in depleted reservoirs.

## 1. Problem Definition

We know developing UGS facilities can be useful in most depleted structures especially in peak periods but we are worry about budget and economy. The situation becomes worse when there are several fields' documents on the desk. Limited budget and lack of enough expert personnel cause companies not to recommend applying this technology for all fields. How do they select among these fields? We know that there is no well-established screening method in the world. We present novel screening criteria under Multi Criteria Decision Making (MCDM) with Analytical Hierarchy Process (AHP) engine in which the most important criteria affecting prioritization of potential fields to implement UGS and their weights. The novelty of this work is proposing the way to acquire fields' expert opinions for applying Under Ground gas Storage, how to ask questions from fields' expert and how criteria affect selection of one structure in comparison with one another.

In our belief there are two methods to do Selection phase; one is Multi Criteria Decision Making (MCDM) and another is modeling and simulation of technical and economic evaluation for all fields. It is well known that performing later method is costly and time consuming. As a result MCDM, specifically AHP was taken into account. This method is fast and very much less costly but less accurate with respect to modeling and simulation method. However; it helps investigating other aspects of the structures such as geographical and environmental issues rather than only technical factors.

## 2. Methodology

### Multi Criteria Decision Making

Multi Criteria Decision Making (MCDM) is a general term for a set of decision making tools. It is divided into two categories as Multiple Objective Decision Making (MODM) and Multiple Attribute Decision Making (MADM); both of which have several methods. The

Analytic Hierarchy Process (AHP) is under MADM which is a structured technique for dealing with complex decisions.

AHP has two sets of matrices; first set of matrices is created from comparison of criteria and sub criteria in terms of decision goal and second set of matrices is created from comparison of alternatives based on each criteria and sub-criteria in the last level of decision tree. The final result (prioritization) of AHP is from summation of multiplication of weight of each criterion to weight of each alternative with respect to that criterion. The comparisons are performed based on **Fejl! Henvisningskilde ikke fundet.** constructed by Thomas L. Saaty. Range of pair comparison is between 1/9 and 9.

**Table 1: Degree of importance in pair comparison**

| Quality of Importance | Quantity of Importance |
|---|---|
| Extremely preferred | 9 |
| Very strongly preferred | 7 |
| Strongly preferred | 5 |
| Moderately preferred | 3 |
| Equally preferred | 1 |
| In between | 2, 4, 6, 8 |

The following procedure for the AHP process can be as follow:

- Definition of the objective;
- Development of the hierarchy from the top (the objective from a general viewpoint) through the intermediate levels (judgment criteria) to the lowest level (the list of alternatives);
- Implementation of the pair-wise comparison among the criteria and alternatives
- Consistency evaluation

- Derivation of the global ranking among the alternatives

**Extracting Killer Parameters**

For storage of gas in different structures such as depleted oil/gas fields, aquifers and salt caverns, a pre-screening procedure should be planned for avoiding more expenses in other steps. Some criteria are very crucial and meeting even one of them can stop the UGS structure selection procedure. Knowing and applying these important criteria decrease the time of decision making to select an appropriate structure for Underground Gas Storage. These killer parameters can be described in figure 1. The output s of this step will be used for later steps for evaluation and selection appropriate structure.

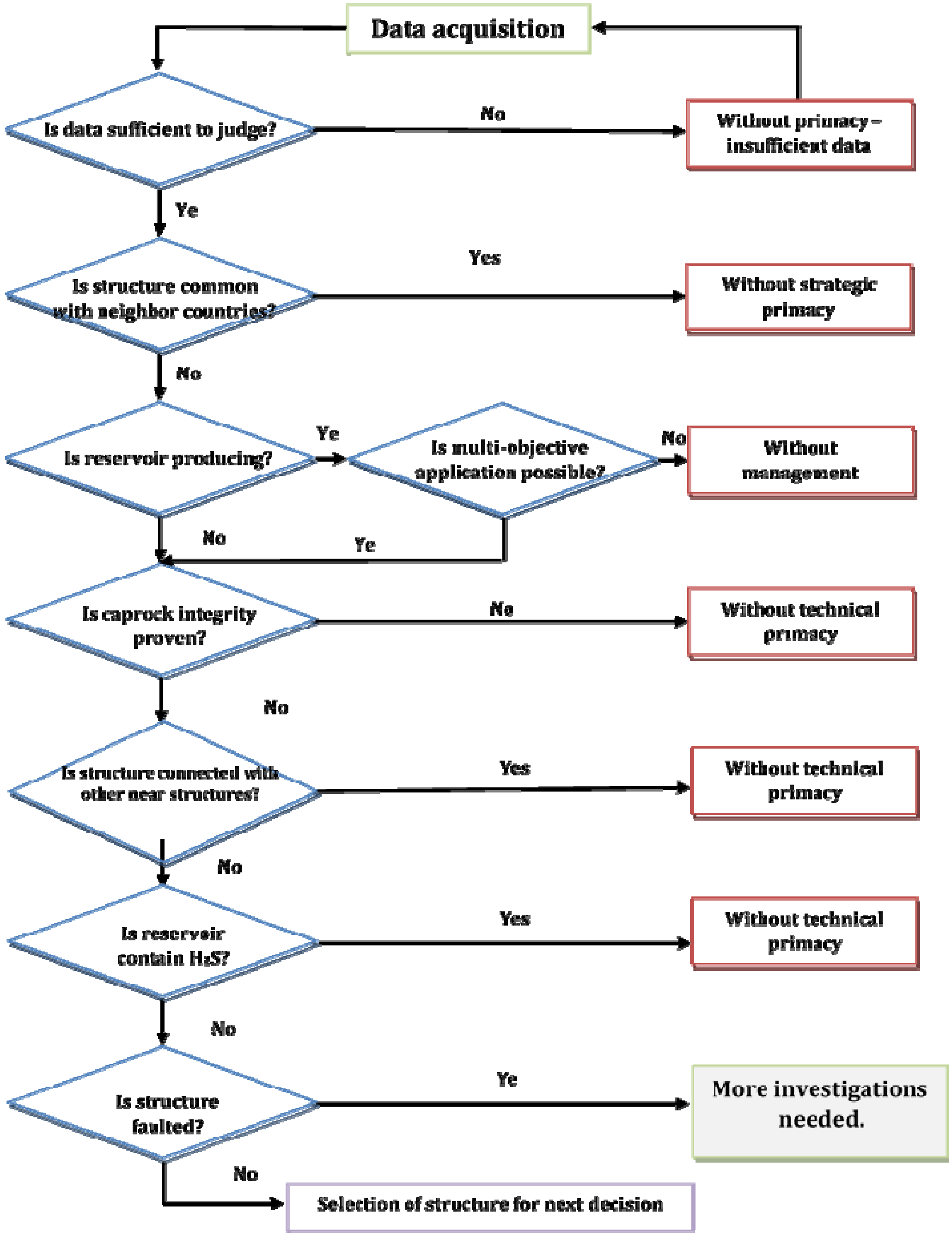


Fig1: Killer Parameters

## Decision Tree

In this step, all related parameters than can affect the procedure of UGS Site Section, are extracted and weighted related each other. All these parameters are used to design and develop a decision tree. This tree has been started with objective definition as the main header. This process has continued with main branches definitions. After that, the subdivision of each branches have been developed. In this study the main purpose is to find an appropriate structure for underground gas storage. By putting this subject on the top of the decision tree, the main branches including technical, economical, geographical and passive defends have been exctracted.by continuing the procedure other sub_branches have been defined. This decision tree can be shown in figure 2.

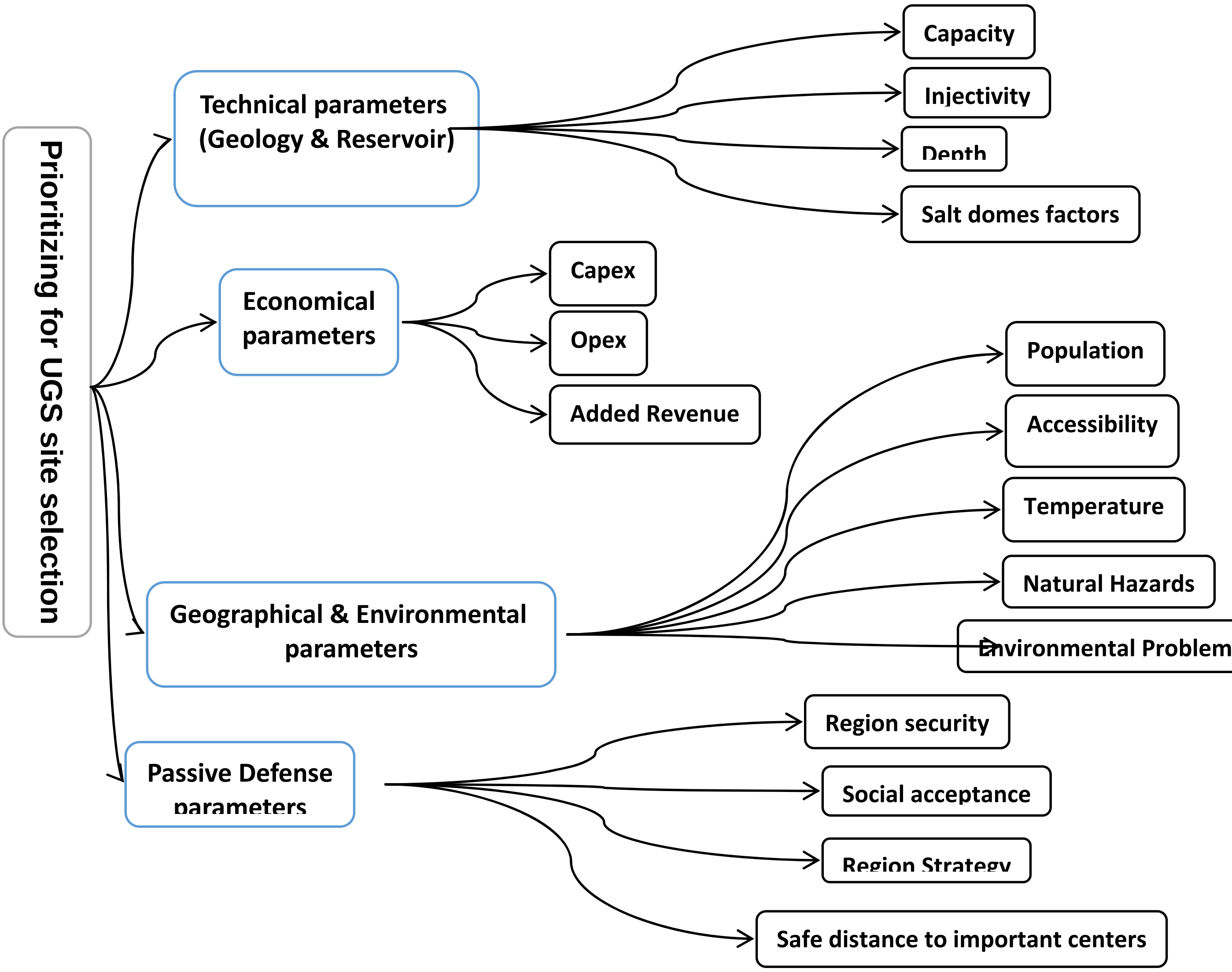


Figure 2: decision tree

## Conclusion

In this paper we applied a novel screening technique under Analytical Hierarchy Process (AHP). It is helpful to alleviate economic concern of using UGS over several fields by prioritizing the fields. The results of weighteining of all parameters can summarize in table 2.

**Table 2. The weight of UGS prioritization parameters based on MCDM**

| Goal | Criteria | Weight | Sub-Criteria | Weight (Porous media) | Weight (Aquifer Structure) |
|---|---|---|---|---|---|
| **Underground Gas Storage Structure Prioritization** | Technical Factor | 0.428 | Capacity | 0.524 | 0.113 |
| | | | Infectivity | 0.328 | - |
| | | | Depth | 0.148 | 0.617 |
| | | | Salt Cavern properties | - | 0.270 |
| | Environmental and Geographical Factor | 0.167 | population | 0.322 | 0.322 |
| | | | availability | 0.303 | 0.303 |
| | | | region temperature | 0.219 | 0.219 |
| | | | Natural events | 0.057 | 0.057 |
| | | | Environmental problem | 0.099 | 0.099 |
| | Economical Factor | 0.322 | Capex | 0.254 | 0.254 |
| | | | Opex | 0.112 | 0.112 |
| | | | Revenue | 0.635 | 0.635 |
| | Passive Defense Factor | 0.083 | Region safety | 0.403 | 0.403 |
| | | | Social acceptance | 0.046 | 0.046 |
| | | | Strategic plan | 0.403 | 0.403 |
| | | | Distance from plants | 0.149 | 0.149 |
| **Summation** | | **1** | | | |

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