Opportunities and Challenges of Harvesting Geothermal Energy from Abandoned Oil and Gas Wells

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Abstract. In recent years, the rising demand for energy, dwindling fossil fuel resources, and escalating environmental pollution and fuel supply expenses have necessitated the widespread adoption of renewable energy sources. As a result, the utilization of abandoned oil and gas wells (AOGWs) as a source of geothermal energy has become increasingly popular and crucial. This conversion eliminates considerable expenses associated with drilling geothermal wells. Nonetheless, the process of converting an AOGW into a geothermal one is a matter that demands more than technical knowledge. The feasibility of this conversion must also consider environmental concerns, potential risks, and economic factors. Therefore, a comprehensive analysis of these aspects is required to determine the viability of these projects. In this paper, according to the characteristics of AOGWs in Iran, the possibility of using them as candidates for conversion into geothermal wells is investigated from the perspective of petroleum engineering, and in the next step, the economic feasibility is evaluated. Based on the investigation, it has been found that the primary obstacles in converting AOGWs into geothermal wells in countries like Iran are the low fuel prices and the conflicting interests and responsibilities of different institutions. It is recommended to prioritize cost-effective solutions such as rig-less well completion methods and non-metallic composite tubular to make these projects economically feasible.

Keywords: Geothermal Energy · abandoned oil · gas wells (AOGWs)

1 Introduction

1.1 A Subsection Sample

Geothermal energy, which has the advantage of being independent of weather conditions, has been attracting attention for decades [1]. Geothermal energy has been used in regions with high geothermal gradients for decades. Projects such as Ocean Thermal Energy Conversion (OTEC) have shown that we can hope for economic energy production from sources with lower temperature differences [2]. Since drilling geothermal wells is costly, using AOGWs to extract geothermal energy makes sense. In recent years, China and America have successfully carried out projects utilizing geothermal energy from abandoned wells [3, 4].

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As shown in many articles, heat transfer can be calculated using various numerical and analytical methods [5–7]. On the other hand, there is sufficient expertise in the designing and manufacturing of the downhole equipment needed to convert an abandoned hydrocarbon well into a geothermal well. However, some questions still need to be answered in this area. For example, is the conversion of an abandoned hydrocarbon well into a geothermal well economically viable and attractive for oil and gas-producing countries such as Iran, where the fuel price is low? In case of a positive answer, which organization should operate these wells? Should it be national oil companies, renewable energy organizations, municipalities, or the private sector? What methods should be used to reduce project costs as much as possible to make it more economically attractive? Which abandoned wells are suitable for conversion into a geothermal well resource? These questions have been thoroughly analyzed in this article, with proposed solutions provided.

2 Challenges

2.1 Subsidized Energy Prices

Iran has traditionally had one of the world's lowest and most heavily subsidized fuel prices [8]. Although Iran has the world's second-largest reserves of natural gas and is one of the world's largest producers, severe heat loss in domestic consumption, particularly in winter, has led to gas supply problems in some areas. Many believe the low gas price has resulted in insufficient motivation to use thermal insulation materials [9–12]. In spite of Iran's potential in solar and wind energy, there have been significant delays in developing these sources [13–15]. So, a major obstacle to investing in the harvesting of geothermal energy from AOGWs is the government's lack of interest and insufficient incentives for private sectors.

2.2 Conflict of Interests Between Organizations

In Iran, the ownership of oil and gas wells is designated by law to the National Iranian Oil Company, and the development of renewable energy is the responsibility of the Renewable Energy Organization, one of the subdivisions of the Ministry of Energy [16–18]. Municipalities, the Ministry of Urban Development, and the private sector must also work together to harvest geothermal energy from AOGWs [19, 20]. Coordinating different organizations in a bureaucratic structure similar to the Iranian government [21, 22] is a significant challenge for developing these projects.

2.3 Geographical Distribution of Oil and Gas Fields

The majority of hydrocarbon fields in Iran are located in the southwest region. In several of these locations, the winter climate is bearable, resulting in less use of heating devices compared to other regions in Iran. In addition, some fields are located at a considerable distance from population centers and may even be in areas that are difficult to access. Based on the geographical distribution, it's clear that the selection of candidate wells is restricted, particularly for direct residential applications (Fig. 1).

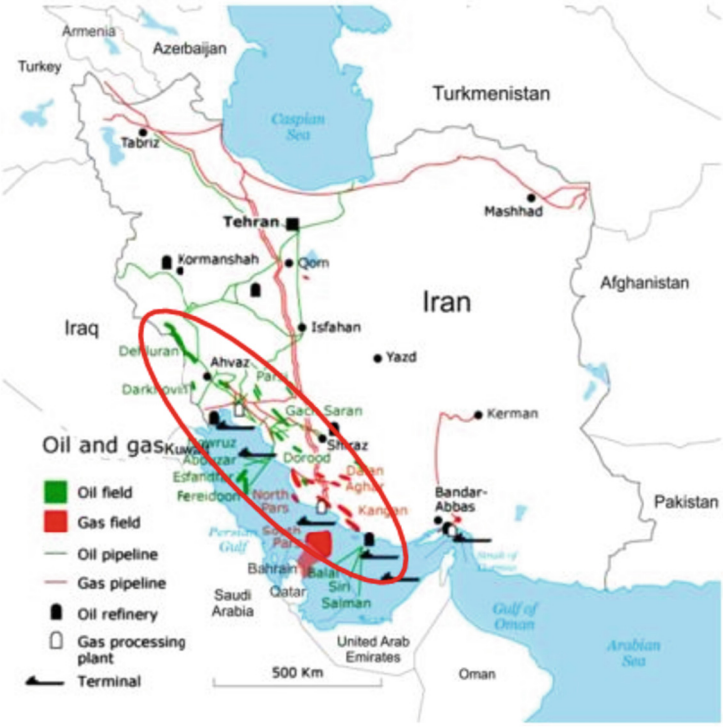

Fig. 1. Iran oil & gas fields [23]

3 Opportunities and Recommended Procedures

AOGWs are primarily found in older fields. These fields are well known regarding geology, rock and reservoir fluid properties, temperature gradient, and other characteristics. The first step is to investigate the well's history, including the well's drilling, completion, and production history, as well as the reasons for abandonment. Abandoned wells, especially older wells, usually do not have digital records, and their records are kept in paper form.

The next step is to check the X-mass tree and the wellhead. Experience with workover wells shows that the X-mass tree and wellhead valves have problems such as leakage and jamming. Valves need to be serviced and repaired to further check the integrity of the well. The next step is to check the integrity of the well. Annulus pressure test failure indicates packer sealing element failure, possible casing collapse, completion string washed out, etc.

It is possible to circulate through the sliding side door in wells completed by the packer by plugging the NO-GO landing nipple and converting these wells to Borehole heat exchanger (BHEX), Without the need to run a new completion string, this can be achieved with the Slickline unit. If the abandoned well does not have a completion string (Exploration wells) or the existing completion string cannot be used, a drilling rig, snubbing unit, or even coiled tubing [24, 25] can run the new completion string.

Logically, rig-less completion methods are preferable to reduce the cost and time of operations. In addition, utilizing non-metallic composite tubing can be a cost-effective solution for completing these wells [26].

Some older wells were completed with short string and without packer (as shown in Fig. 2). These wells can be utilized as a component of a ground source cooling system because the temperature in shallow depth layers is lower than the ambient temperature during summer. If circulation results in fluid loss, setting a plug is necessary.

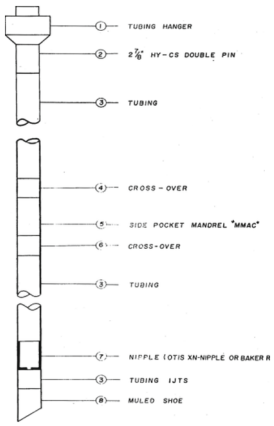

Fig. 2. Schematic of old wells completed without packer

Finally, it is recommended to input candidate well locations with demographic information, urbanization levels, and other relevant data in a GIS model for the ultimate decision-making process.

4 Conclusion

Converting AOGWs to geothermal resources in oil and gas producer countries like Iran faces technical and non-technical challenges such as economic attractiveness and bureaucratic regulations. Focusing on cheaper solutions such as rig-less well-completion methods and non-metallic composite tubulars is recommended to make these projects more economically attractive. AOGWs are an asset that can help us move towards zero-emissions cities.

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