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Economic value of underground natural gas storage for the Brazilian power sector☆

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ABSTRACT

This paper aims at assessing the main obstacles to the development of underground natural gas storage (UGS) in Brazil and at identifying the conditions required for the feasibility of UGS projects in the country. The paper estimates the economic value of UGS facilities for the power sector in Brazil, considering the specificities of the Brazilian power and gas sectors. It is shown that the Brazilian gas demand does not have a seasonal characteristic; instead, the demand is volatile of a random nature associated with the demand from thermal power plants, which are complementary to hydropower generation. This paper has proved that there is an important economic value associated with the storage of gas in periods of low power prices and its consumption in period of high power prices. Finally, this paper argues that it is essential to seek mechanisms to include the economic value of UGS for the power sector into the UGS regulation and market design, as well as to explore the possibility of making gas storage a resource for the power sector operation.

1. Introduction

Like in many other countries, the Brazilian natural gas industry has been developed under the leadership of a large state-owned company, Petrobras, which was the main driver for the development of the natural gas industry in Brazil. Petrobras still has a dominant position in all the segments of the natural gas value chain in Brazil.

Due to the deep financial crisis faced by Petrobras, in 2016 the company decided to refocus its activities and investments on its core business and announced, among other measures, that it would reduce its participation in the natural gas chain through the sale of assets.

Seeing the withdrawal of Petrobras from the gas sector as an opportunity, the government launched the “Gás para Crescer” ("Gas to Grow") initiative, aiming at restructuring the natural gas industry through a series of institutional and regulatory changes. The main objectives of this initiative include: creating a market environment open to competition, with a larger number and more diversity of players, greater dynamism, more transparent access to information, and respect for contracts, in order to build an environment favorable to the attraction of investments, especially from private companies.

As a result of this governmental initiative, several regulatory changes are expected, such as natural gas spot price; Hubs; pricing of transport pipelines in the entry and exit model; and others, to support the UGS introduction, in Brazilian market.

Natural gas currently accounts for 12% of the Brazilian energy mix (average 2016).[1] However, it is important to note that this market share varies substantially depending on the dispatch of gas-fired power plants. When gas-fired power plants are fully dispatched, their gas demand accounts for about half of the total gas demand in the country. However, gas-fired power plants are not generally fully dispatched, and their gas consumption is highly variable. Since thermal generation in Brazil has a complementary role in relation to hydropower and wind power, the dispatch of thermal power plants (of which a large part is gas-fired) is subject to the uncertainty of weather conditions.

The great volatility of gas demand from the power sector needs to be matched with substantial gas supply flexibility. Until now, Petrobras has been able to provide this flexibility through its portfolio of gas production, through the volume stored in pipelines (line packing), through the take-of-pay conditions of its import contract with Bolivia; and since 2009, through spot LNG imports. So far, there is no

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[1] BEN (National Energy Balance), 2017.

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underground gas storage (UGS) in Brazil.

At the international level, UGS has been used as an important tool to add flexibility to gas supply. However, in Brazil this flexibility option has not yet been adopted, and the projects under consideration are facing important economic and regulatory obstacles. In view of this scenario, it is relevant to understand why there are no UGS facilities in Brazil so far.

This paper aims at assessing the main obstacles to the development of UGS in Brazil and at identifying the conditions required for the feasibility of UGS projects in the country. In particular, it attempts to estimate the economic value of UGS facilities for the power sector in Brazil, given the specificities of the Brazilian power and gas sectors.

The rest of the paper is organized as follows: Section 2 presents a brief literature review regarding the economic evaluation of UGS projects; Section 3 shows the specificities of the Power and Natural Gas Sector in Brazil and the UGS; Section 4 details the methodology adopted to assess the economic value provided by UGS to the Brazilian power sector; Section 5 shows the estimation of this economic value; and Section 6 presents the conclusions and recommendations.

2. Literature review

The literature on the economics of underground gas storage is quite extensive. UGS is a flexibility tool to achieve a balance between supply and demand, mainly when there are substantial seasonal variations (winter-summer), as well as short-term fluctuations of gas demand. In developed markets, it is also used for speculation through price arbitration. Thus, it is possible to identify three main objectives for investing in UGS: speculation, precaution and to manage seasonal load variations (Baranes et al., 2013).

In most countries, especially those with a temperate climate, the demand for natural gas from thermal power plants is complementary to the demand from other market segments. The demand for natural gas in the residential and commercial sectors increases during winter due to heating needs, and then decreases sharply in the summer months. In countries where there is a liberalized gas market, the gas demand reduction during the summer months translates into a drop in the price of gas. Thus, an opportunity arises to increase the consumption of gas for thermal generation (Hirschhausen, 2006).

In the US market, for example, the dispatch of gas-fired power plants increases during the summer, largely due to the price signal. This means, ultimately, that the US power sector adjusts itself to the seasonality of the natural gas market and its price signals. This price mechanism allows for a convergence between the gas and power industries, thus improving the allocation of resources (in infrastructure investments) and decreasing the marginal cost related to expansion and operation. These aspects make sectoral demand for natural gas quite seasonal in the United States, as can be seen in Fig. 1.

Thus, investments in UGS in the USA are made possible by the difference in price between the purchase of natural gas during the summer (lower price) and its sale in the winter (higher price). They may even mitigate the price risk buying a position in the futures market (Hirschhausen, 2006). That is, predictability makes all the difference in the UGS business in the USA, as well as in other markets.

In Brazil, on the other hand, seasonality is not significant, because the demand of the residential and commercial segments is low and stable throughout the year. The only segment with significant demand variations is the power generation sector. However, the behavior of the power sector demand is not seasonal, since it is the result of the interaction of several variables (tropical rain patterns[2] and variation in demand for power), which translates into an erratic behavior with little predictability.

The literature on the economics of natural gas storage highlights some key characteristics of UGS projects. UGS projects are characterized by a high initial investment (CAPEX) and low fixed operating costs (OPEX) which are concentrated in the actual moments of gas injection and withdrawal.[3] In general, these characteristics give a significant market power to UGS companies, which implies the need to regulate this activity in order to guarantee non-discriminatory access and fair tariffs.

The economic evaluation of a UGS facility is usually based on a study of the seasonality of gas demand and on its prices. Thus, the economic evaluation of a UGS facility commonly considers an independent player (a deverticalized storage operator) that buys gas at low prices, stores it and sells it when the price is higher (Ejarque, 2011). That is, revenues are defined by the spread between the purchase price and sale price over time. Such revenues should be sufficient to pay for the CAPEX and OPEX, and to generate an expected return on capital. For this reason, the discounted cash flow method and the Net Present Value (NPV) and Internal Rate of Return (IRR) indicators are widely adopted for the economic assessment of UGS facilities (Escobar et al., 2011; Anyadiegwu et al., 2012; Atoyebi, 2010).

According to Escobar et al. (2011), the economic evaluation of a UGS facility through the discounted cash flow method can be made using two options. The first one, called “implicit” or “seasonal”, is based on the price difference between the natural gas purchase price during the summer (lower price) and sale price during the winter (higher price). The second one, called “extrinsic”, considers that a certain proportion of the UGS capacity can be used more than once, with several cycles throughout the year (applied to UGS in salt caves), thus increasing the value of installation.[4]

In line with the adoption of the discounted cash flow method, for the economic assessment of UGS facilities, we find it relevant to include a sensitivity analysis and stochastic optimization, through a combination of the Monte-Carlo method with a metaheuristic method (Escobar et al., 2011; Budny et al., 2013). Finally, we can also consider the price of power, in addition to the price of natural gas, and model future power and natural gas price curves. The use of Brownian motion is applied to simulate futures prices, allowing to integrate uncertainties arising from futures market (Budny et al., 2013).

In addition to seasonal differences in gas prices, many other factors may contribute to the feasibility of a UGS project. Firstly, the functionality of a UGS facility may be associated with the management of a gas field by a specific producer. In other words, if the facility investor is actually a gas-producing player, the economic assumptions for evaluating the project can go further than the spread between buying and selling due to the seasonality (Karovic and Danilovic, 2010).

Another application of UGS that can contribute to its economic feasibility is its use to increase a country's energy security. In this case, investments can be strategic for national energy policy, and specific mechanisms can be created to contribute to the economic feasibility of projects (financing or purchasing capacity by the government or by the power sector). As we will see later, this is an option to be considered to make UGS feasible in Brazil.

[2] It is important to note that rain patterns in the Tropics are much more variable than in other regions of the world. This makes the hydropower generation much more unpredictable in the tropical regions.

[3] Cavaliere et al. (2013) argues that UGS should not be considered a natural monopoly. Although storage costs are affected by economies of scale, any UGS facility may provide storage services in competition with other UGSs, since the minimum efficient scale is generally below the amount of total demand for natural gas storage by potential UGS customers. Also, it is worth noting that according to this paper, today in Europe there are only two effectively competitive UGS markets: the United Kingdom and the Netherlands.

[4] This alternative is usually more difficult to be economically evaluated. Therefore, it is harder to convince players about the extrinsic value of the of a UGS project.