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ECONOMIC ASPECTS OF UGS IN DEPLETED HIGH-NITROGEN NATURAL GAS FIELDS

Summary. The Polish storing capacity needs to be considerably increased. In search for a solution of this problem, the authors analyzed economic profits of constructing UGS in partly depleted high-nitrogen natural gas fields. They presented structure of capital cost of UGS construction, depending on the type of the storage, as well as benefits of using partly depleted high-nitrogen natural gas fields for UGS. In this solution the capital costs were cut down and the economic-financial indices considerably improved. As storing services have been commercialized, therefore lower capital costs may be a very important element of competitiveness in the free market conditions. The presented calculation example, based on one of the Polish UGS made in a high-nitrogen gas field, confirms already presented advantages of this solution

EKONOMICZNE ASPEKTY PMG W WYEKSPLOATOWANYCH ZŁOŻACH WYSOKOAZOTOWGO GAZU ZIEMNEGO

Streszczenie. Pojemność podziemnego składowania na terenie Polski wymaga znacznego powiększenia. Poszukując rozwiązania tego zagadnienia autorzy przeanalizowali ekonomiczne korzyści tworzenia PMG w częściowo wyeksploataowanych złożach wysokoazotowego gazu ziemnego. Zaprezentowano strukturę kosztów utworzenia PMG w zależności od charakteru składowania oraz korzyści płynące z tej inwestycji. Ukazany w artykule przykład obliczeniowy, oparty na warunkach polskiego złoża, potwierdza trafność proponowanego rozwiązania.

1. Introduction

Underground gas storages (UGS), being a key element of the gas system, grow in significance, and increase the demand for storing capacity. Another factor stimulating this

increase in Poland is an Act of 16 February 2007 about the reserves of oil, oil products and natural gas (Official Journal No. 52/2007, item 343), according to which:

- natural gas importers are obliged to have reserves of 30-day average import,
- transient period: obligatory reserve should be equivalent of 11-day import by the end of September 2009, 15-day average import by September 2010, 20-day average import by the end of September 2012, and 30-day average natural gas import onwards,
- the storing capacity should enable returning reserves to the system in maximum 40 days (minimum daily withdrawal rate of such storages should be 22 to 25 mln m^3).

Analogous to other European countries, it is also Poland where we can expect the growth of market of commercial storing services, competitive to those offered by Polish Oil and Gas Company (PGNiG S.A.).

The competitive market imposes on the UGS operators to define and quantify key elements affecting the profitability of the storing services. This may give competitive advantage and domination over other operators. Besides costly mistakes at the stage of designing can be eliminated. A company having information about the profitability of storing, sensitivity to the change of major economic and technological factors, and the influence of risk and minimum storage prices providing assumed rate of return may well navigate on the market, undertake good competition and finally increase its income and profits.

Economic advantages of making an UGS in a partly depleted high-nitrogen natural gas field are discussed on a calculation example employing advanced financial models for assessing the economic efficiency of this type of investment.

2. Capital and operational costs of UGS

The construction of underground gas storage is very expensive. The size and structure of capital cost depends on a number of factors, e.g.:

a) type of storage,

b) geological properties,

c) working capacity of UGS.

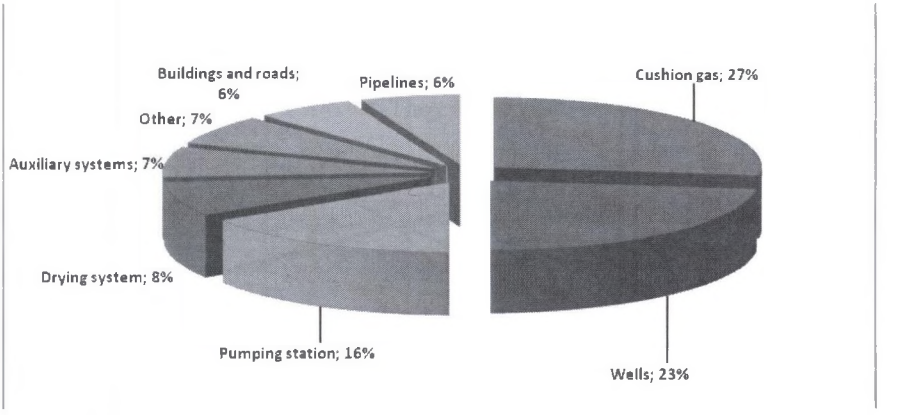

Fig. 1. An exemplary distribution of capital cost for UGS in a depleted gas field.
Source: Stopa J. Kosowski P. (2006)
Rys. 1. Przykładowy rozkład kosztów konstrukcji PMG w wyeksploataownym złożu gazu.
Wg: Stopa J. Kosowski P. (2006)

An exemplary structure of capital cost of a UGS in a depleted natural gas field is presented in Fig. 1.

The main elements of capital cost are cushion gas, drilling wells and such surface installations as, e.g. pumping station.

Additionally, the analysis of economic efficiency of UGS and influence of specific factors reveals that the capital cost is of key importance to the financial success of UGS investment.

The analysis of sensitivity of UGS Net Present Value (NPV), being one of the measures of profitability, to the change of selected factors, e.g.:

- price of storing,
- capital cost,
- level of fixed costs,
- level of variable costs

is presented in Fig. 2.

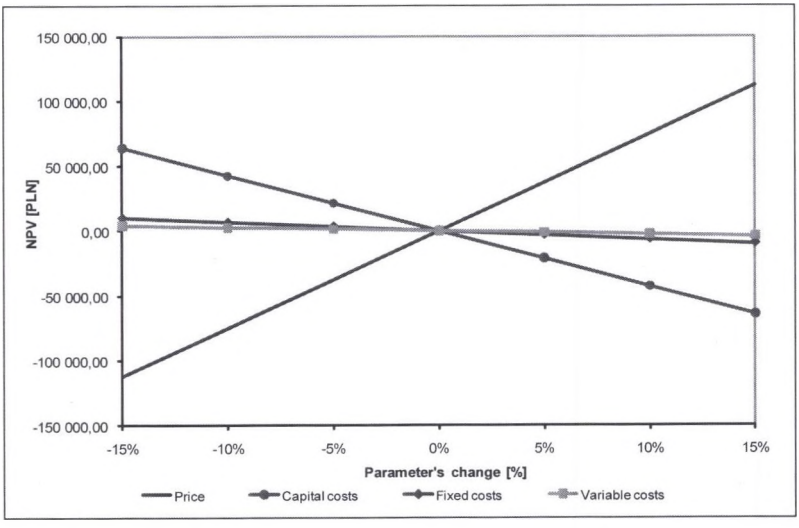

Fig. 2. The analysis of sensitivity of UGS NPV to the change of key financial factors. Source: Stopa J. Kosowski P. (2006)

Rys. 2. Analiza podatności bieżącej wartości netto PMG na zmiany głównych czynników finansowych.. Wg: Stopa J. Kosowski P. (2006)

The presented plot reveals that the change of NPV, i.e. improvement or deterioration of economic efficiency of UGS operation, is mostly influenced by two factors, i.e. storing price and capital costs. The influence of fixed and floating costs is relatively small. This is typical of investments requiring high capital costs, where the future operating costs are incomparably lower.

From the investor's point of view, the economic efficiency is of top importance, therefore measures should be undertaken to increase it to the maximum. In the conditions of market or administration control of prices, it is hard to influence the UGS financial effects by means of storing prices. A much easier solution is to considerably lower the capital costs.

As already mentioned, the cost of cushion gas is one of the biggest elements of capital cost. In this situation, UGS localized in depleted high-nitrogen natural gas fields, offering a cheaper cushion gas, are more advantageous. One should not forget that apart from natural gas, which in the course of UGS construction is pumped in, increasing the buffer capacity, there still remains native natural gas. In the case of future exploitation of the field, this gas would be exploited and sold, generating income to the owner. This fact should be accounted for when assessing the economic efficiency of an UGS in a partly depleted field.

The value of the leftover natural gas should be calculated and added to the capital costs of UGS construction. This is not a mere multiplication of the quantity of exploitable natural gas left over in the field by the current price. The present value of future cash flows generated by natural gas production should be evaluated, in line with the following formula:

$$I_{gw} = \sum_{n=0}^{J} \frac{CF_{gw_n}}{(1+r)^n} \tag{1}$$

where:

I_{gw} – additional capital costs related with exploitable gas left over in the reservoir

CF_{gwn} – capital flow generated by potential gas production in year n

J – number of years during which the field could be exploited

r – discount rate.

Two identical natural gas fields, candidates for UGS, were analyzed. They contained the same quantities of high-methane and high-nitrogen gas, respectively. Obviously the additional element of capital cost resulting from leaving part of exploitable resources in the reservoir was lower for the field containing high-nitrogen gas.

This difference can be expressed in the following way:

$$R = M_w - M_z \tag{2}$$

where:

R – lowering of capital costs

M_w – value of high-methane gas in the reservoir

M_z – value of high-nitrogen gas in the reservoir

Value of exploitable gas leftovers can be calculated from the formula:

$$M_w = DCF_w = \sum_{n=0}^{J} \frac{CF_{w_n}}{(1+r)^n} \tag{3}$$

$$M_z = DCF_z = \sum_{n=0}^{j} \frac{CF_{z_n}}{(1+r)^n} \tag{4}$$

where:

DCF – value of discounted capital flow (w – high-methane has, z – high-nitrogen gas)

The difference in the capital cost has the form:

$$R = \sum_{n=0}^{j} \frac{CF_{w_n}}{(1+r)^n} - \sum_{n=0}^{j} \frac{CF_{z_n}}{(1+r)^n} \tag{5}$$

$$R = \sum_{n=0}^{j} \frac{CF_{w_n} - CF_{z_n}}{(1+r)^n} \tag{6}$$

If the capital flows in the year n are defined as:

$$CF_n = P_n - K_n = W_n * C - K_n \tag{7}$$

where:

P_n – cash inflows in year n,

K_n –cash outflows in year n,

W_n – production in year n,

C – natural gas price.

And then let's assume that capital outflows and production are equal in both cases:

$$R = (C_w - C_z) \sum_{n=0}^{j} \frac{W_n}{(1+r)^n} \tag{8}$$

where:

C_w – price of high-methane gas,

C_z – price of high-nitrogen gas.

3. Influence of high-nitrogen gas use on the UGS economic efficiency

To illustrate the influence of the field-type on the economic efficiency of UGS in it, a hypothetical UGS (working capacity 500 mln Nm^3 and cushion gas volume 600 mln Nm^3) was analyzed. The cushion capacity was assumed to consist of 250 mln Nm^3 native gas, out of which 100 mln Nm^3 was exploitable. The remaining 350 mln Nm^3 was the injected high-methane gas.

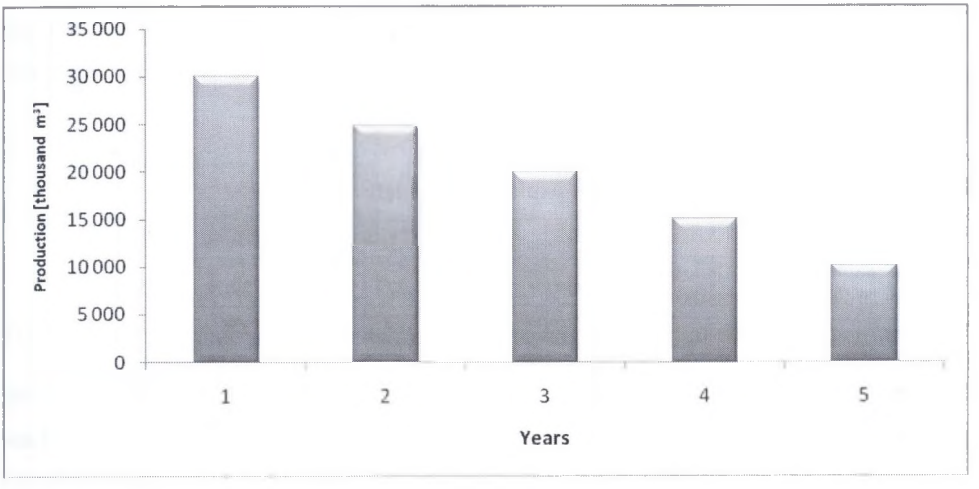

Fig. 3. Natural gas production from the analyzed field (no UGS was made in it)
Rys. 3. Produkcja gazu z analizowanego złoża (bez PMG)

Without any UGS in the field, the gas production could be continued for the next 5 years, at the assumed constant drop of yield (Fig. 3).

The remaining financial assumptions for UGS construction are presented in Table 1.

The authors used their own financial models for analyzing the economic efficiency of the investment, accounting for the real level of costs and other financial parameters. A 30-year time horizon was assumed. The change of NPV was analyzed in view of high-nitrogen gas prices, and assuming the storing price of 250 PLN/thousand m^3. A minimum price of storing, guaranteeing internal rate of return (IRR) of 10% was also determined.

Table 1

Financial and operational parameters of UGS

Capital costs without buffer gas	350 mln PLN
Value of gas injected to the buffer	332.5 mln PLN
Fixed costs	9 mln PLN/year
Variable costs	15 PLN/ thousand m^3
Discount rate	0.1
Price of high-methane gas	950 /thousand m^3

The value of exploitable gas leftovers changed depending on the gas/high-methane gas price ratio (100% for high-methane gas), which is presented in Table 2. The type of gas was expressed by the natural-gas/high-methane-gas price ratio.

Table 2

Value of exploitable gas leftovers

Gas price /high-methane gas price	100%	80%	70%	60%	50%	40%
Value of exploitable gas leftovers calculated with DCF method (mln PLN)	67.50	52.41	44.87	37.32	29.78	22.24

The results of analysis of influence of gas-type on NPV and the price of storing guaranteeing IRR of 10% are presented in Figs. 4 and 5. The natural-gas price/high-methane gas price ratio equal to 100% corresponds to the case when high methane gas field is used for an UGS.

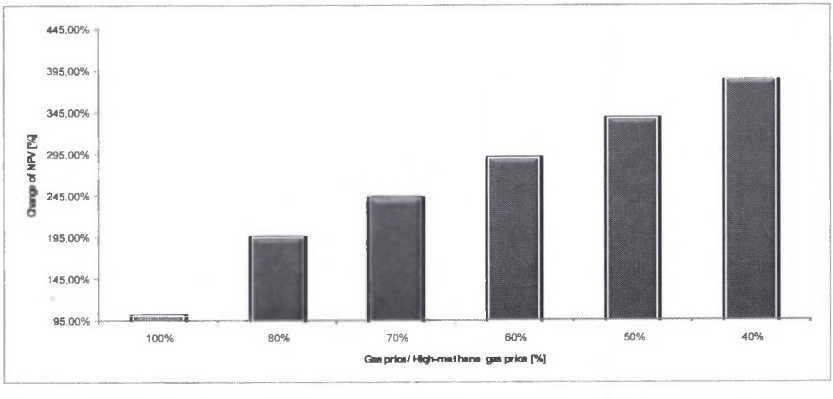

Fig. 4. Change of NPV vs. gas-type in the reservoir for a price of storing equal to ca. 250 PLN/thousand m^3

Rys. 4. Zmiana bieżącej wartości netto w zależności od rodzaju gazu, przy kosztach składowania na poziomie około 250 PLN/1000 m^3

The results of analyses show to considerable advantages of UGS in partly depleted high-nitrogen gas fields.

A slight deterioration of natural gas quality (expressed by a drop of its price to 80% of high-methane gas), accounted for in the evaluation of 100 mln m^3 exploitable gas leftovers, results in a ca. 94% increase of NPV (at a stable price) and nearly 2% lowering of the storing price, which guarantees IRR of 10%.

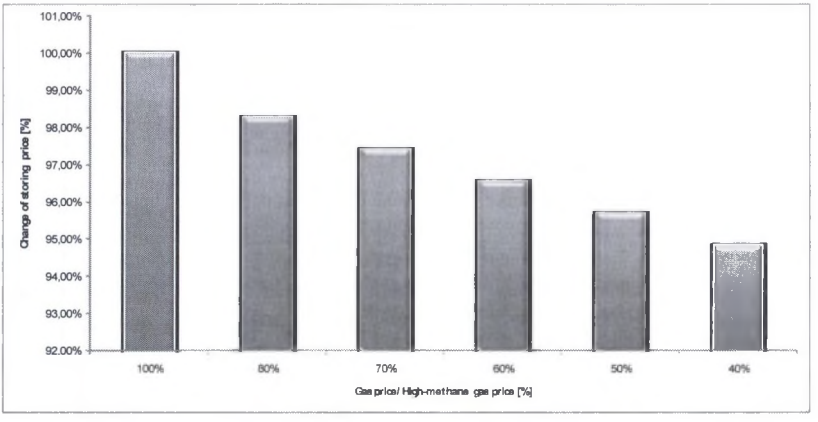

Fig. 5. Change of storing price guaranteeing average annual profitability of 10%, depending on the type of gas in reservoir

Rys. 5. Koszta składowania zapewniające opłacalność na poziomie 10% rocznie, w zależności od rodzaju gazu w złożu

If the price of gas equals to 60% of high-methane gas, which roughly corresponds to the tariff price of high-nitrogen gas Ls, NPV of an exemplary UGS increases by almost 190%, and the price guaranteeing IRR of 10% drops by 3.5%.

The above calculation example shows the potential economic advantages of UGS in partly depleted high-nitrogen gas fields. It should be born in mind, however, that every case of UGS should be analyzed individually and the obtained results may considerably vary.

4. Conclusions

The working capacity of UGS in Poland has to be increased and commercial tariffs for storing introduced.

UGS require high capital costs and definitely lower level of operation cost in the future. To maximize economic effects, the UGS operator should concentrate on optimization of capital costs related to UGS construction.

As indicated in this paper, the economic situation of the UGS operator in the competitive market conditions can be significantly improved if the UGS is localized in a partly depleted high-nitrogen gas field.

There also exists a technical risk related with using this type of fields, e.g. threat that the quality of the received gas may deteriorate. However, the experience related with operation of such facilities, e.g.: the largest Polish UGS in Wierzchowice localized in a partly depleted high-nitrogen gas field, does not confirm these threats.

The selection of high-nitrogen gas field results in lowered capital costs and improved economic-financial indices of UGS. In the face of commercialization of storing services, the lower capital costs may be a competitive factor in the free market conditions.

It should be also emphasized that all fields analyzed as potential UGS, should be analyzed separately as their economic efficiency may be influenced by a number of geological, technical and economic factors typical of every field.

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