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ESTIMATION OF MAXIMUM COST OF CO_2 IN EOR PROJECTS

Рассматривается проблема оценки максимально приемлемого уровня затрат на CO_2 в проектах по повышению нефтеотдачи. Эта проблема связана с ограничениями Киотского протокола и ограничением выброса парниковых газов. Способы оценки таких затрат показаны на примере одного из месторождений Польши.

In this article author presents the problem of estimating the maximum, acceptable cost of CO_2 for EOR projects. This problem is connected with the Kyoto Protocol regulations and limits of greenhouse gases emission. The way of estimating such cost was shown on the example of one of Polish reservoirs.

Introduction

The worldwide statistics show that only 25-30 % of crude oil in a reservoir can be recover by primary methods. The large amount of oil remains inaccessible in a reservoir and cannot be recover by conventional methods. These oil reserves are the potential target for enhanced oil recovery (EOR).

Injection of gases, especially carbon dioxide has been one of the most popular among the various EOR methods in the recent years. It was caused among other things by the Kyoto Protocol regulations. According to them in the European Union countries limits of CO_2 emission will be introduced. The limits will be followed by emission rights trading.

The fossil-fired power plants and industrial plants, which emit huge amounts of greenhouse gases, may build installations for CO_2 separation and storage. Separated CO_2 can be sold for later use in EOR projects.

In this way the plants emitting greenhause gases will not exceed the limits and even will have the opportunity to sold the unused emission rights. If the price of emission rights is high enough it will also be profitable to storage CO_2 in depleted oil and gas reservoir without any EOR projects.

Fig.1 shows the cost of separation of CO_2 in three fossil-fired power generation technologies: Pulverized coal fired (PC), Natural gas fired combined cycle (NGCC) and Integrated gasification combined cycle (IGCC).

One of the most important profitability factors for EOR projects is the cost of injected substances. The lower cost, the higher profitability. This paper presents the way to estimate the maximum acceptable cost of CO_2 for EOR project.

Estimating of maximum price of CO_2

In this paper one of the Polish oil fields on Polish Lowland is analysed. The analysis was based on three scenarios of oil price – 35, 40 i 45 US dollars per barrel.

In order to determine the impact of gas injection on oil filed the CO_2 Prophet application designed by Texaco for US Department of Energy was used. This application models processes of waterflooding and gas injection into oil and gas fields.

It must be emphasised that the economic evaluation analysis only these costs and revenues, which come from EOR project and additional production. Costs and revenues, which

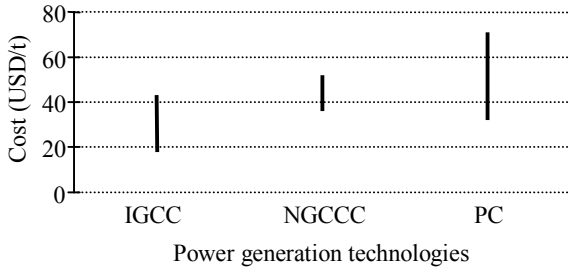


Figure 1. Cost of CO_2 separation.
Source: Herzog, H. *The Economics of CO_2 Capture*, MIT Energy Laboratory, 1999

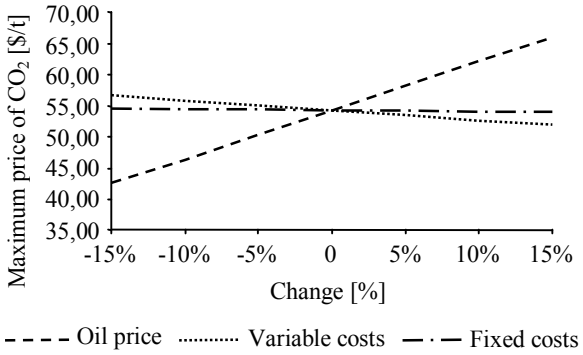


Fig.2. Sensitivity analysis of maximum cost of CO_2

would be the results of traditional production without EOR project are not included.

The maximum cost of CO_2 was estimated using discounted cash flow method. For each scenario of oil price was found such cost of CO_2 that NPV is equal to zero. The calculations was made according to the formula below:

$$NPV = \sum_{i=1}^{n} \frac{CF_i}{(1+d)^i} = 0$$

CF_i – Cash flow during year i, d – discount rate, n – number of years.

For each cost of CO_2 higher than calculated the NPV would be negative and EOR project would be unprofitable. This paper also contains a sensitivity analysis of the impact of the key factors change on the CO_2 cost.

Table 1 shows assumptions of the analysis and table 2 presents results of the calculations

Table 1. Assumptions of analysis

Investments [$]	5 483 871	Depreciation rate	7 %
Variable costs [$/t]	65	Royalty [$/t]	8,06
Fixed costs [$/year]	483 871	Duration of investment [years]	15
Discount rate	10 %	Income tax rate	0,19 %

Table 2. Maximum price of CO_2

Oil price $/bbl	35	40	45
Maximum price of CO_2 $/t	44,50	54,32	64,14

The maximum price for each oil price scenario is respectively: 44,5, 54,32, and 64,14 $/t CO_2. The sensitivity analysis demonstrates that the largest changes of maximum price of CO_2 are caused by changes of oil price. The change of fixed or variable costs has no significant impact on acceptable price of CO_2. When one compare the results to the costs presented on figure 2 he can notice that there is a possibility to use a carbon dioxide separated from flue gases and achieve profits. The cost of transport however, which is the second component of overall cost of CO_2, must be considered. This paper does not analyse it.

Conclusions

The application of EOR methods may be connected with the underground storage of greenhouse gases. The main factor which decides about the profitability of such projects is the price of oil and cost of carbon dioxide. The high prices of emission rights may be the additional stimulant for industry to undertake projects of separation and underground storage of carbon dioxide.

LITERATURE

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