EVALUATION OPTIONS FOR CARBON CAPTURE TECHNOLOGIES

Tomáš Bartošík
Doctoral Degree Programme (2), FEEC BUT
E-mail: xbarto36@stud.feec.vutbr.cz

Supervised by: Petr Mastný
E-mail: mastny@feec.vutbr.cz

ABSTRACT

Carbon capture and storage provides wide range of different technologies. It is not essential to compare them and evaluate them. Most common evaluation is known as energy penalty and express additional energy needed for carbon dioxide capture. This evaluation is rather general and suitable for power plant comparison. Evaluation by costs of electricity provides accurate values, but requires extended input data. Previous methods evaluate whole project, but classification according to capture costs concentrates on main aspect of CCS. If we focus on government subsidy it is very important to get low capture costs, however other economical values cannot be overlooked.

1. INTRODUCTION

Carbon capture and storage (CCS) is an option how to reduce carbon dioxide emission to the atmosphere. It covers carbon dioxide capture, transport and geological storage. Carbon dioxide is separated from technological process, liquefied, transported to safe geological storage and pumped into the aquifer.

Carbon dioxide capture technologies are categorized to Post-combustion, Pre-combustion and Oxyfuel combustion capture. In post-combustion is CO_2 captured from flue gas. For CO_2 separation from flue gas are used calcium, amine or ammonia absorption, membranes and adsorption. In Pre-combustion is CO_2 separated from syngas in gasification unit. Oxy-fuel combustion is similar to post-combustion, but fuel is burned in oxygen which provides convenient high concentration of CO_2 in flue gas. For these high concentrations seems to be sufficient cryogenic separation. After separation, carbon dioxide is liquefied or more precisely turned to supercritical state. For this process is used multi-stage compression. Supercritical carbon dioxide is then transported by cistern or pipeline to geological storage and pumped into the ground. Even there are many industrial applications, where CO_2 can be utilized, quantity is too high. Therefore large scale sequestration projects focusses on underground storage. Carbon dioxide can be placed into saline aquifers, left coal mines, depleted natural gas and crude oil fields. There is also possibility to increase mining efficiency of crude oil, natural gas or methane. Methods are known as Enhanced Oil Recovery (EOR), Enhanced Gas Recovery (EGR) and Enhanced Coal Bed Methane Recovery (ECBMR). [4]

2. EVALUATION OPTIONS

Reliability of carbon capture and storage is discussed in many countries over the World. Many technologies have been developed and have been proven. Number of pilot projects has been established, but economically acceptable solutions are still missing. When designing a new project it is very important to evaluate applicable technologies. It is rather questionable how to make this evaluations and which aspects should be preferred.

Carbon capture technologies can be evaluated by initial costs, specific costs, energy penalty, required energy for capture, fuel type, etc.

2.1. Energy penalty

Energy penalty expresses energy, which is needed for CO_2 capture. It can be calculated as energy output of power plant with capture minus energy output of power plant without capture. Energy penalty is often expressed in percentage values, than energy penalty is divided by energy output of power plant without capture. The same fuel input must be used in both cases for this calculation.[1]

According to [2] it is also possible to calculate it by efficiency fraction expression (1). However this expression is more simple it does not reflect required energy for maintenance, etc..

$$\Delta E^{*} = 1 - \frac{\eta_{CCS}}{\eta_{REF}} \quad (1)$$

This kind of evaluation provides very useful data. It respects efficiency decrease of particular technology, however it does not reflect amount of captured carbon dioxide or price of CO_2 capture.

	Net Effic. without CCS (%)	Net Effic. with CCS (%)	Efficiency penalty (%)
Pulverised coal	44	35,3	19,8
IGCC coal, dry feed	43,1	34,5	20,0
IGCC coal, slurry feed	38	31,5	17,1
Gas Turbine comb. cycle	55,6	44,7 – 49,6	10,8 – 19,6

Table 1: Efficiency of power plants with and without CCS [3].

2.2. Costs of electricity (COE)

Electricity costs covers fuel costs, operational and maintenance costs, capital expenditure, etc. If there are available values of electricity costs for technology with and without CCS, it is simple to obtain additional electricity costs for CCS. Carbon capture evaluation according to electricity costs seems to be sufficient and crucial for economical analysis. Despite of electricity costs high-value information, it does not covers amounts of captured CO_2. In following table are shown electricity costs for Natural gas combined cycle plant (NGCC), Pulverized coal plant (PC) and Integrated gasification combined cycle plants (IGCC).

technology	COE without (USD/MWh)	COE with capture (USD/MWh)
New NGCC plant	31 – 50	43 – 72
New PC plant	43 – 52	62 – 86
New IGCC plant	41 – 61	54 – 79

Table 2: Cost of electricity (excluding transport and storage costs) [2].

2.3. Capture costs and specific capture costs

Capture cost expresses additional expenditures required for amount of CO_2 captured. The capture costs do not include costs of CO_2 transport and storage. Additional costs include both operational costs and capital expenditure.

technology	capture costs (USD/1000 kg CO_2)
New NGCC plant	37 - 74
New PC plant	29 - 51
New IGCC plant	13 - 37
different processes(cement and steel plants, refneries)	25–115

Table 3: Cost of net CO_2 captured (excluding transport and storage costs) [2].

Capture cost does not respect power plant energy penalty neither profit, therefore additional capture costs can bring totally different economical impact for different technologies. An technology with competitive capture costs doesn't need to be economically acceptable, because of relatively high costs without CCS.

3. CONCLUSIONS

It is not obvious how carbon capture technologies should be evaluated. Several methods have been listed and described. Energy penalty is generally used and provides values suitable for comparison of characteristic power plants. Cost of electricity requires more specific data and provides accurate results of economical balance of examined project.

CCS will not become financially feasible, unless associated additional costs become covered by CCS profits and government subsidies. Nowadays CCS pilot projects are subsided by funds from government and companies involved. If CCS income become sufficient Capture costs evaluation could become the most important.

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