

## **Opportunities And Constraints On Carbon Dioxide Sequestration And Enhanced Coalbed Methane Recovery In Coal In British Columbia**

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### **ABSTRACT**

Most people accept that climate change resulting from human activity is a reality. The details as to causes and progress are much in dispute, but again most people accept that the increase in concentration of carbon dioxide (CO<sub>2</sub>) in the atmosphere is one of the causes. The amount of carbon dioxide released when any fossil fuel is burned is dependent on the ratio of carbon to hydrogen in the fuel. This ratio is a maximum for coal and a minimum for natural gas (mainly methane, CH<sub>4</sub>) with oil having an intermediate ratio. The amount of CO<sub>2</sub> produced per unit of heat (10<sup>6</sup> BTU) for the various fossil fuels (Table 1) is a maximum for coal, but it is not zero for natural gas. The true impact of using the various fossil fuels requires an analysis of the efficiency of turning them into more useful forms of energy; often electricity or in the case of oil often momentum.

Natural gas and conventional oil reserves will be substantially depleted in the next 50 years leaving coal as the most readily available fossil fuel. Technology that uses the energy from coal or coalbed methane, while minimizing or eliminating the release of CO<sub>2</sub> to the environment, will become critically important. This means sequestering CO<sub>2</sub> as a gas, liquid, as a solid, or in the adsorbed state on coal.

In recent years there has been a lot of discussion on the possibility of sequestering CO<sub>2</sub> in coal seams or using CO<sub>2</sub> to aid in the recovery of coalbed methane (CH<sub>4</sub>). The basis of both these ideas is the fact that CO<sub>2</sub> is more strongly adsorbed onto coal surfaces than CH<sub>4</sub>. Once adsorbed, if temperature and pressure conditions do not change, then the CO<sub>2</sub> is permanently sequestered. There are of course two concerns, firstly pressure and temperature conditions must not change and secondly and more importantly there are limited pressure and temperature ranges in which CO<sub>2</sub> is a gas. At higher temperatures and pressures CO<sub>2</sub> becomes a super critical fluid and under these conditions it is not clear whether it is adsorbed by coal, occupies the pore spaces acting like a fluid with very low viscosity or infuses into the coal matrix. Under these

conditions it is probably not realistic to talk of sequestering the CO<sub>2</sub> because it might be mobile.

British Columbia ranks fourth in total greenhouse gas emissions of the provinces in Canada but ranks eighth in terms of tonnes of CO<sub>2</sub> per person per year. The province does not generate electricity by burning coal so that the more obvious point sources of anthropogenic CO<sub>2</sub> emissions do not exist. In fact the largest sources of CO<sub>2</sub> emissions are commercial and private transportation. The easiest way for the province to reduce CO<sub>2</sub> emissions may be to improve the efficiency of fuel consumption in diesel and gasoline engines. Smaller point sources may be located close to coal deposits and it may be possible to sequester some of the CO<sub>2</sub> that they generate in seams. Ideal candidates maybe cement plants and natural gas processing plants because they produce relatively pure CO<sub>2</sub> streams.

Samples for CO<sub>2</sub> isotherms were collected from a number of coalfields in British Columbia. The results indicate, as do analyses from other sources, that CO<sub>2</sub> is strongly adsorbed onto coal and that the adsorption capacity changes with rank. However the adsorption behaviour of CO<sub>2</sub> as rank and coal petrography change is different from that of CH<sub>4</sub>. The mole ratio of CO<sub>2</sub>/CH<sub>4</sub> adsorption varies from over 10 for low rank coals to under 2 for medium and high rank coals. CO<sub>2</sub> adsorption is moderately high for low rank coals, decreases for medium rank coals and then increases substantially for high rank coals.

The interaction of adsorption and selectivity of CO<sub>2</sub> and CH<sub>4</sub> means that for maximum CO<sub>2</sub> sequestration with minimum production of CH<sub>4</sub> one should use lignite. It is important to note that sequestration of CO<sub>2</sub> without collection of the released CH<sub>4</sub> may result in a net increase in the emission of green house gases over time. For maximum sequestration of CO<sub>2</sub> with maximum production of CH<sub>4</sub> during enhanced CBM recovery one should use a high rank coal.

Sequestration and enhanced CBM recovery only apply to a depth window defined by the range of pressure and temperature conditions over which CO<sub>2</sub> is a gas. The CO<sub>2</sub> phase diagram is well established but it is important to project a depth tract in to it based on actual temperature and pressure gradients existing in a coal basin. This will indicate the maximum depth for sequestration, which varies based on combinations of geothermal and pressure gradients, and is generally in the range of 500 to 900 metres.

There are a number of practical constraints on CO<sub>2</sub> sequestration. Often a pure stream of CO<sub>2</sub> is not available and the adsorption behaviour of a mixture of CO<sub>2</sub> and N<sub>2</sub> is not clearly understood. The mixture may influence the shape of the pure CO<sub>2</sub> phase diagram. Injection of CO<sub>2</sub> causes coal to swell in part because of adsorption and in part because CO<sub>2</sub> is dissolved in the coal structure. This may decrease permeability and prevent further injection.

The best application of CO<sub>2</sub> sequestration may be in conjunction with CBM extraction and use where coal permeability is increased and the coal depleted in CH<sub>4</sub>. In this case the coal volume is adequate to sequester the CO<sub>2</sub> produced by burning the CH<sub>4</sub>. There is also resurgence interest in insitu gasification of coals and the cooled partially burnt seam may provide an ideal location to sequester CO<sub>2</sub>.