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Approaching Negative Greenhouse Gas Emissions via Bioenergy with CO_2 Capture and Storage in Saskatchewan

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Abstract

This study performed high level cost analysis of converting a Coal-Fired Power Station in Saskatchewan to Bioenergy with CO_2 Capture and Storage (BECCS). The Intergovernmental Panel on Climate Change (IPCC) reported that the world will need to take dramatic steps to avoid increasing Earth's temperatures more than 1.5 ˚C above pre-industrial levels. The IPCC report includes an assessment of the role of carbon dioxide (CO_2) removal from air technologies and negative emissions technologies (NETs) such as BECCS. BECCS removes atmospheric CO_2 through the combustion of the biomass to produce energy while simultaneously capturing the produced CO_2. Among NET technologies, BECCS is most promising as it provides a potential solution on dealing with existing coal plant infrastructure while reducing CO_2 emissions from fossil-fuel combustion.

Current federal Canadian regulations will cap CO_2 emissions from coal fired power plants to 370 tonnes/GWh by 2030. If Canadian coal plants are not retrofitted with CCS they will not meet these targets and be forced to retire prematurely, representing significant standard assets. Recently, the International CCS Knowledge Centre performed a feasibility to retrofit the Shand Power Station with CCS. Results indicated a 67% reduction in capital cost per tonne of CO_2 in comparison to the Boundary Dam 3 and a levelized cost of CO_2 capture of $45USD/tonne of CO_2. The current historically low natural gas price in North America enables fierce competition between NGCC and CCS coal fired facilities when considering the most economical means to reduce CO_2 emissions. However, if maximizing CO_2 emissions reductions is the desired outcome, a case favoring the CCS retrofit of coal and subsequent conversion to BECCS can be made.

This paper utilizes the findings of the Shand CCS Feasibility study, and the Phase IV Biomass Co-firing report from the Canadian Clean Power Coalition to explore the potential advantages which may be realized with a biomass co-firing unit equipped with a 95% CO_2 capture capacity facility. BECCS would allow Shand to take advantage of its existing infrastructure but also provide the benefits of increased fuel flexibility and reductions in SOx and CO_2 emissions. Moreover, reductions in agricultural waste and the creation of local jobs is possible as Shand is situated in the Canadian heartland of agricultural production.

Biomass available from agriculture within a 200 km radius of Shand was estimated by the Biomass Inventory Mapping and Analysis Tool (BIMAT). BIMAT, developed by Agriculture and Agri-Food Canada, allows users to view and analyze detailed information about biomass availability within Canada using digital maps and database searches. The summary of the biomass availability and co-firing rate supported within different radii from Shand is shown in Table 1. Due to Shand's proximity to the US Canada boarder additional biomass could also be available from the US.

Table 1 Biomass availability and Co-firing rate supported in Estevan area

Straw Type	Biomass Available (ODt)				Co-firing Rate Supported (%)				Biomass Cost (CAD/GJ)			
	50 km	100 km	150 km	200 km	50 km	100 km	150 km	200 km	50 km	100 km	150 km	200 km
Wheat	83,029	248,723	524,740	887,080	6%	17%	37%	62%	3.08	3.45	3.86	4.29
Flaxseed	4,974	20,075	42,548	69,195	-	2%	3%	5%	2.66	3.05	3.41	3.76
Oats	1,098	7,947	35,345	81,130	-	1%	3%	6%	-	-	-	-
Pellets (BC)	-	-	-	-	100%				9.25			

The conversion of Shand to BECCS with 95% CO_2 capture capacity produces a negative CO_2 emission intensity as shown in Fig. 1 which increases with increased levels of cofiring. With complete conversion of Shand to BECCS, its emission intensity is estimated at negative 1,384 tonnesCO_2/GWh which equates to a 3% reduction in Saskatchewan's annual emissions. The costs of electricity and CO_2 avoided are illustrated in Fig. 2. Main factors influencing the cost of electricity are biomass purchasing and transportation costs. BECCS with BC pellets cases have significantly higher costs compared to other cases. For co-firing cases, higher levels of co-firing lead to slightly increased cost of electricity due to the requirement for transportation of biomass from greater distances. The cost of CO_2 avoided from BECCS varies from 79.20 to 60.47 CAD$/tonne with co-firing and 71.44 to 90.06 CAD$/tonne with full conversion. The cost of CO_2 avoided might be lower when the rate of co-firing straw is higher than 60%, however, it will require further study of additional biomass supplies such as forestry, energy crops, and marginal farming operations. For comparison purposes the cost of CO_2 avoided from a commercial scale Direct Air Capture (DAC) facility (published by Carbon Engineering) is evaluated. The levelized cost of CO_2 capture with DAC varies from 94 US$/tonne up to 232 US$/tonne based on financial assumptions and energy costs. By comparison, the costs of CO_2 avoided from BECCS and DAC, including the cost of conversion for the existing thermal power plant to BECCS, is potentially the best approach for realizing global CO_2 emissions reduction target. However, an effective regulation on policy, carbon pricing, and negative emission credits will be required to incentivize the implementation of BECCS in the power industries' business plans.

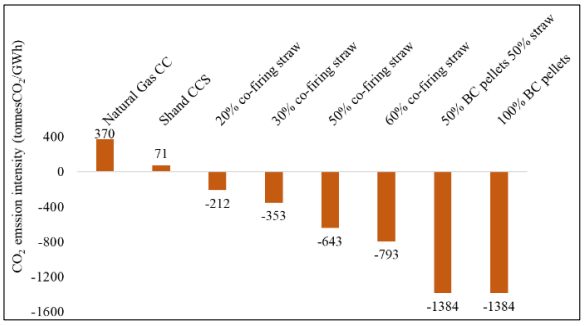

Fig. 1 CO_2 Emission Intensity

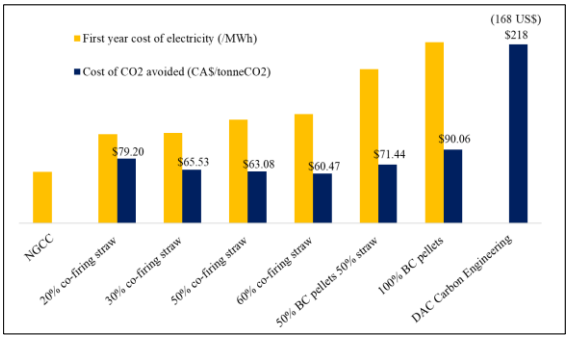

Fig. 2 Cost of Electricity and CO_2 Avoided

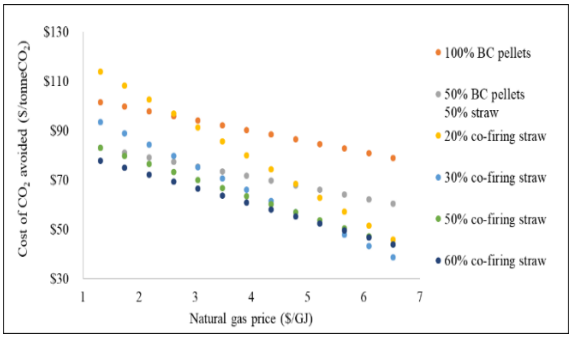

Fig. 3 Effect of Natural Gas Pricing on Cost of CO_2 Avoided

The effect of the price of natural gas on the cost of CO_2 avoided is also evaluated in this study as shown in Fig 3. The low price of natural gas in Canada makes it difficult for the cost of power generated from BECCS to compete with NGCC and can result in a high cost of CO_2 avoided. However, in regions where the natural gas price is high, the cost of CO_2 avoided will be reduced. This can be one of the driving forces for power utilities to consider BECCS as an option.

Keywords: BECCS; CO_2 capture; Shand Power Station; biomass; co-firing

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