

2013 Resource Options Report Update

Appendix 10

**Coal-Fired Generation
with Carbon Capture and Sequestration**

September 15, 2009

Kathy Lee
Energy Planning
BC Hydro
333 Dunsmuir St.
Vancouver BC
V3B SR3

Dear Kathy,

Re: Coal with Carbon Capture & Sequestration for Long Term Transmission Inquiry (Section 5)

As requested Powertech labs is pleased to provide the following information:

(1) Coal and CO₂ Sequestration locations in BC

➤ Coal site locations

A map of coal resources in BC prepared by Geological survey of Canada is attached.

➤ Sequestration site location(s)

Geological sequestration of CO₂ emission from coal-fired power plants may be suited for regions such as *northeastern BC*. The potential storage sites at northeastern BC have been historically utilized for acid-gas injection and need to be confirmed for CO₂ storage. In addition to the potential storage reservoirs in northeastern BC, there are several other sedimentary basins such as Quesnel Trough, Nechako and Bowser Basin in BC that could also be potential locations for CO₂ storage.

Currently Spectra Energy is conducting a CO₂ storage feasibility project at Fort Nelson, BC with the support of the Government of Canada and a grant from the Government of British Columbia. This feasibility investigation is in preliminary stage. Hence, it is recommended that BC Hydro closely monitor the progress of this project and produce a map of potential sequestration locations based on the conclusions.

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Given the current knowledge of coal location, potential sequestration sites and associated infrastructure need for CCS, the Northeast BC has the highest, Northwestern BC maybe and Vancouver Island not likely possible condition for sequestration project.

(2) Potential of coal-fired power generation with IGCC -CCS in BC

➤ Potential IGCC power plant

Integrated Gasification Combined Cycle (IGCC) power plants are believed to be the type of power plants that may be used for coal-fired generation and to replace aging power plants in the future. There are three major manufacturers GEE gasifier, CoP E-Gas gasifier and Shell gasifier. Gasifiers produced by these manufactures have been utilized in demonstration power plants with various plant sizes. Following are some examples of IGCC demonstration power plants and their sizes; Kentucky Pionner Energy (580 MW), Tampa Electric Company (250 MW), Pinion Pine IGCC project (107 MW), ISAB Energy IGCC plant, Italy (512 MW), Elcoges IGCC power plant, Spain (335 MW).

➤ Fuel consumption of IGCC power plant

Type of coal and its quality would have a large effect on IGCC power plant efficiency and fuel consumption. Tampa Electric IGCC demonstration project in average utilized approximately 2,265 tonne/day of bituminous coal to generate approximately 250 MW electricity. Net heat rate of this IGCC power plant was between 8000-9000 Btu/kWh.

➤ Competing use of coal and trend in BC

According to BC Ministry of Energy, Mines and Petroleum Resources, most of the coal produced in BC is exported to Asia, Europe and South America. The future use of coal for coal fired-generation in BC will depend on the economy, price of electricity and the export to Asia. There is no better or more recent information available to identify and predict competing use of coal and to establish a trend.

➤ Estimating competing coal use in BC

To our knowledge, currently there is no rule of thumb or industry norm to estimate the fraction of coal that produced in BC that may be used for coal-fired generation in BC in the future.

(3) Update of clean coal technology status**➤ Clean coal CCS technology**

There is no major technology advancement since the LTAP Appendix F2 memo dated March 05, 2008. The US office of Fossil Energy has received \$3.4 billion fund from the US Recovery Act. This initiative will focus on research, development and deployment of technologies to use coal more cleanly and efficiently.

➤ Status update of planned demo projects listed in LTAP Appendix F2 memo

The following provides the current status of demonstration projects listed in LTAP Appendix F2 memo.

- Rio Tinto/BP Alternative Energy Partnership - This project is now being proposed to be built near Taft, Kern County next to Elk Hills Oilfield which was originally planned to be built in Carson in Los Angeles County. Following an 18 month long regulatory approval, the company hopes to begin construction in 2010. This project will be receiving US \$ 308 million funding from DOE.
- Energy Northwest - Energy Northwest announced on September 2008 that it no longer plans to build IGCC power plant at the port of Kalama in Washington because of concerns over implementation of CCS in that state.
- Future Gen - On June 2009 DOE announced that it plans to commit more than 1 billion dollars toward this project. An analysis of where the CO₂ emissions can be sequestered and an update cost estimate is planned to be completed by early 2010. Once these steps are completed a decision on whether to continue with the project will be made.
- Xcel Energy - Xcel energy has decided to put construction of IGCC plant on hold. According to Xcel the plant remains possible but 2016 may be a more realistic date.
- NRG Energy Huntley IGCC project - On July 2008 the New York Power Authority (NYPA) decided against funding the near zero emission coal power plant due to rising cost.
- Sask Power - The current proposal under consideration would see 1000 tons of CO₂ captured daily and transported via pipeline to Montana for underground storage from a coal-fired power plant owned by Saskpower. The Montana government is seeking funding from the stimulus packaged to pay for the project.

➤ Status of carbon capture technology and CO₂ sequestration

Status of capture technology has not changed since the LTAP Appendix F2 memo. The time line suggested in LTAP APPENDIX F2 memo is similar to the road map produced by EPRI April 2009 (see Figure 1).

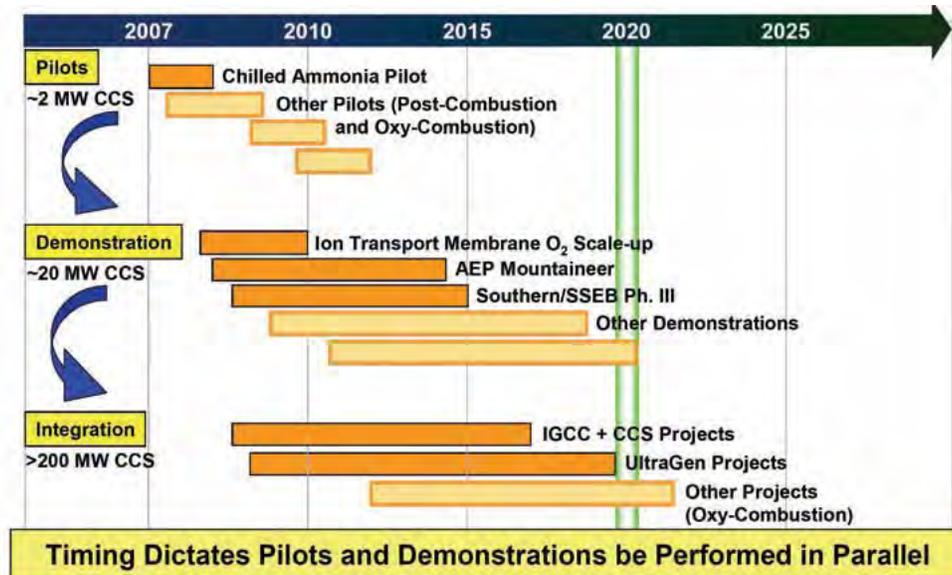


Figure 1: EPRI Roadmap for Goals for Advanced Coal Technologies with CCS (Source: Carbon Capture Journal March/April 2009)

➤ Status of related legislation/regulation

- US department of interior in consultation with the Department Of Energy (DOE), the environmental protection agency (EPA) and US Geological survey has prepared "Framework for geological carbon sequestration on public land" in compliance with section 74 of the energy independence and security act of 2007
- Alberta government introduced Bill 14 "carbon capture and storage funding act" in February 2009

➤ Coal-fired generation with CCS in BC

As per advanced coal power generation pathway by EPRI, DOE regional partnership CO₂ sequestration program is anticipated to be completed by 2017 and new coal-fired generation with carbon capture and sequestration (CCS) is expected to be commercially available by 2022. EPRI expects 3 to 5 large volume CO₂ storage demos by 2022.

According to the definition of "proven technology" or "commercial" operation used in BC Hydro's electricity acquisition processes, a generation technology need to be readily available in commercial markets and in commercial use (not demonstration use only), as evidenced by at least 3 generation plants generating energy for a period of not less than 3 years, to a standard of reliability generally required by good utility practice.

Hence, the earliest any proponent can propose a commercial coal-fired power generation plant with CCS in BC may be 2022. Further, it may take another 3 to 5 years to construct a power plant and develop infrastructure needed for CCS in BC.

Therefore, 2025 may be the earliest deployment of coal-fired generation with CCS in BC based on current technology development path way and BC Hydro "proven technology" definition.

(4) Cost of Coal-fired generation with CCS

- 20 year levelized cost of electricity, including the cost of capture, transport, storage and monitoring, for a IGCC power plant is expected to be about \$106 US per MWh and for a Supercritical pulverized coal combustion (PCC) is expected to be about \$117 US/MWh at a discount rate of 10% and fuel cost of \$1.8 per MMBtu of coal (National Energy Technology Laboratory¹). All these costs are stated in 2007 US dollars.

Following are the list of assumptions for the levelized cost provided:

Income tax rate = 38%
Repayment of dept = 15 years
Depreciation = 20 years
Plant life = 30 years
Duration of construction = 3 years

CO₂ is transported 80 kilometers (50 miles) via pipe line to a geological sequestration field for injection into a 1200 m depth slain formation.

Since neither IGCC nor PCC power plants have yet been built at a full scale with CCS, the above costs of electricity from these power plants cannot be state with a high degree of confidence at this time (IPCC Special report, 2005). Obtaining individual current cost break down may involve extensive research and can't be fit into the current budget.

¹ National Energy Technology Laboratory, 2007. "Cost and performance Baseline for Fossil Energy Plants". Office of Fossil Energy, United States Department of Energy.

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Coal with CCS update

Powertech Labs Inc.

Long Term Transmission Inquiry (Section 5)

Please call me at 604-590-7412 if you have any questions.

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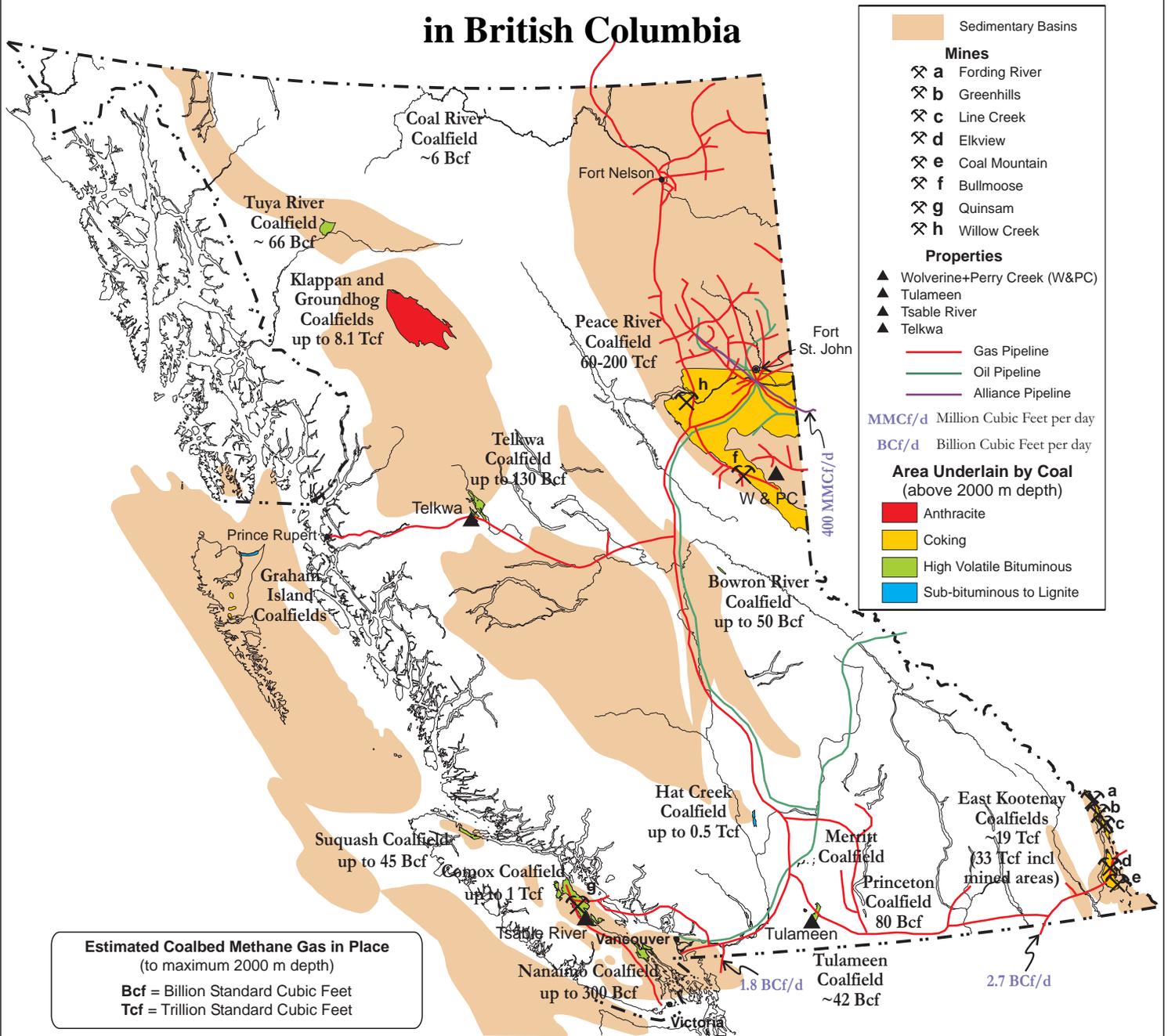
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Project: 19248-35

Coalfields and Coalbed Methane Potential in British Columbia



EPRI CCS Development Pathway

