
Canadian
Clean Power Coalition
Advancing Technology
for Cleaner Power
Phase IV, Final Report

Canadian Clean Power Coalition

Advancing Technology for Cleaner Power

The Canadian Clean Power Coalition (CCPC) is an association of responsible, leading Canadian and U.S. electricity producers that believes coal, along with a diverse mix of fuels like hydro, natural gas, wind, solar and nuclear, will play an important role in meeting the energy needs of the future.

Alberta Innovates Energy and Environment Solutions

Saskatchewan Ministry of Energy and Resources

The progress and achievements of CCPC are due in large part to the continued support of Alberta Innovates and Saskatchewan Energy and Resources.

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The CCPC's mandate is to research technologies with the goal of developing and advancing commercially viable solutions that lower emissions from coal-fired power plants. The CCPC aims to find ways to generate electricity from coal that effectively and economically address environmental issues – including carbon dioxide (CO_2) emissions – and move us forward to a cleaner energy future. To-date, the CCPC and its members have spent more than $50 million furthering this objective.

Key Achievements of the CCPC

- Provided early leadership to study carbon capture and storage (CCS) on coal plants
- Inspired industry to develop several CCS projects
- Established that significant advances and development will be required to reduce the cost of CCS before CCS will be widely adopted
- Accelerated understanding of cleaner coal technologies, and developed the most extensive collection of Canadian technical and economic information on the subject
- Sponsored the first Front-End Engineering and Design (FEED) study on integrated gasification combined cycle (IGCC) with carbon capture in Canada, and determined that low-ranked coals have a detrimental impact on IGCC costs
- Determined that CCS technology is expensive and requires significant cost reductions before it will be widely adopted

Executive Summary

In the past three years, the CCPC has learned about promising ways to potentially help coal plants reduce their CO_2 emissions in the future. This work may help members justify extending the life of their plants. In addition, some of the technologies considered may also lead to the development of new coal plants with partial capture should gas prices increase. The following is a short summary of the key results from studies completed in Phase IV.

Advanced Cycles

The Electric Power Research Institute (EPRI) completed a study reviewing more than a dozen advanced cycles for burning coal. Several of these cycles will be studied in more detail in the repowering project to be completed in Phase V. In addition, this study helped the CCPC make the decision to commit funds for Aerojet Rocketdyne-Oxy's PFBC demonstration project being conducted at Canmet.

In-situ Coal Gasification

This million-dollar study showed that in-situ coal gasification with partial CO_2 capture has a levelized cost of power estimated to be similar to that of a natural gas combined cycle plant operating baseloaded. There are opportunities to further optimize the plant to lower costs. This technology may be a promising way to take advantage of huge underground coal deposits in Western Canada should the price of natural gas increase.

Coal Beneficiation

Four coals were studied to determine if coal beneficiation would lead to half a dozen desired outcomes related to ash removal. It is not clear that the benefits of coal beneficiation exceed the costs. However, as Western Canadian mines age, poorer seams of coal may be employed, making coal beneficiation more atrractive.

Advanced Post Combustion Capture

EPRI reviewed 20 novel non-aqueous post combustion capture technologies. Several of these technologies look promising and may be studied in more detail in Phase V. The CCPC has been meeting with technology developers to hear more details regarding their technologies.

Fuel Cell Repowering

Molten carbonate fuel cells can be used to capture CO_2 and provide additional low emission power. Costs provided by Jacobs suggest that this technology may have a relatively low avoided cost. The cost of electricity retrofitted with molten carbonate fuel cells appears to be similar to a new natural gas combined cycle. This study will be completed in Phase V.

Biomass Co-firing

This study considered the cost of providing biomass to three plants in Canada. The avoided cost of CO_2 for biomass co-firing is generally expected to be less than that for post combustion capture. This makes it an ideal candidate for repowering coal plants if one does not wish to invest a large amount of money on CO_2 capture infrastructure. Co-firing natural gas and biomass also looks promising, particularly if volumes of biomass are insufficient to fire the plant. More work is required to better understand biomass availability and the costs to modify a coal plant to accept large volumes of biomass.

IGCC with Partial Capture

The CCPC commissioned Jacobs to complete one of the first studies that examined six novel configurations of CO_2 partial capture on IGCC plants. The results suggest that IGCC with partial capture may have a cost of power similar to a coal plant with partial CO_2 capture. All of the novel configurations considered also had power costs much lower than IGCC plants with full CO_2 capture.

The Case for Coal

Coal is vital for electricity generation in Canada and internationally because it is a low-cost fuel with large proven reserves. Coal is used in roughly 10,000 MW of power plants in Canada and these plants provide cheap baseload generation. In Canada alone, there are an estimated 80 billion tonnes of proven reserves, one of the world's largest deposits and a natural resource advantage that should provide power a thousand years into the future. The industry also provides significant employment and an overall positive economic impact.

Air quality issues associated with coal must be addressed. Technology will provide long-term solutions to emissions issues. The CCPC is committed to finding those solutions. Organizations such as the CCPC play a role in leading the way to cleaner power generation through partnerships between government and industry.

Canada has an estimated eight billion tonnes of proven coal reserves. This resources is primarily accessed through mining, using massive, specialized equipment.

The CCPC's membership includes responsible, leading Canadian and U.S. electricity producers.

CCPC Members

The CCPC's membership includes responsible, leading Canadian and U.S. electricity producers. The CCPC is always interested in expanding membership and collaborating with other entities to further our objectives.

CCPC's members represent the majority of Canada's coal-fired power generation capacity. The coalition was formed out of concern about greenhouse gas emissions, and to collectively evaluate strategies for emission reductions.

Phase IV CCPC Members

- Alberta Innovates – Energy and Environment Solutions
- Capital Power Corporation
- Nova Scotia Power
- SaskPower
- Sherritt International Corporation
- TransAlta Corporation

Associate Member

- The Electric Power Research Institute (EPRI)

Support and Additional Funding

- CanmetENERGY
- Saskatchewan Ministry of Energy & Resources

Former Members

- ATCO Power
- Luscar Limited
- Ontario Power Generation
- IEA Greenhouse Gas Programme
- IEA Clean Coal Centre
- Basin Electric

Collaborative Members

- Coal Association of Canada
- ICO_2N
- Lignite Energy Council

Phase I

At-A-Glance

Timeframe: 2001 to 2004

Goal: To evaluate existing or developing technologies

Budget: $4.8 million

Key Findings: Substantial detail regarding existing and emerging technologies

A Phased Approach

The CCPC was created in 2000 to ensure that environmental public policy decisions recognize Canada's vast coal resources as an important Canadian asset. Today, the CCPC is advancing the technologies needed to build cleaner, more efficient, more economical coal-fired power plants. Phase I, which involved study of emerging technologies to reduce emissions from coal plants, commenced in 2001. The CCPC is currently completing its fourth phase of study and Phase V is scheduled to commence in fall 2014.

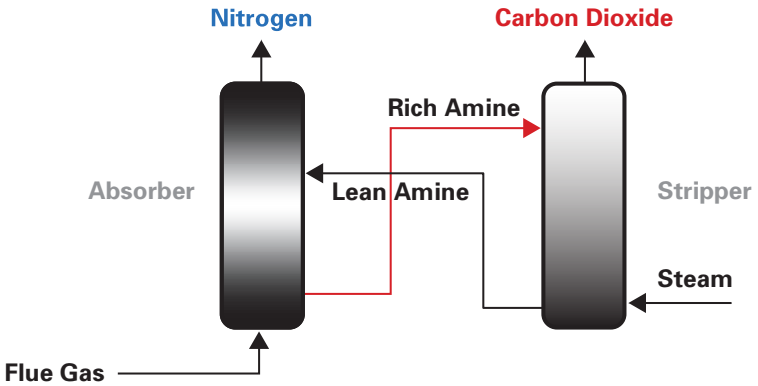
Overview

The first study work undertaken by the CCPC commenced in September 2001. The goal was to develop projects that demonstrated technology at a commercial utility scale that would allow all emissions, including CO_2, to be controlled to meet all foreseeable new regulatory requirements. The technology had to be viable for retrofitting existing plants, or for use in new coal-fired power plants. Emissions had to be reduced to a point that would allow coal-fired plants to be seen in a new light. Overall efficiency had to be maintained or improved, and costs had to remain competitive with other generation technologies. The fundamental principle underlying the goals of the CCPC was to identify processes that would produce electricity from coal in some fashion and also provide a relatively pure stream of CO_2 that could be captured, further processed as necessary, and subsequently used or stored.

Conceptual engineering and feasibility studies, undertaken from mid-2001 to early 2004, were performed on the following:

- Technologies in development for common coal-fired plant emissions, including nitrous oxide (NOx), sulphur dioxide (SO_2), particulates and mercury.
- The opportunities to capture CO_2 emissions from industrial sources and transport them to underground storage.
- Gasification: reacting raw material, such as coal, at high temperatures with a controlled amount of oxygen and steam. CO_2 can be removed from the resulting syngas fuel.
- Oxyfuel: based on the principle that if coal burns in an environment where nitrogen is absent or minimized, the resulting CO_2 will be more concentrated and therefore easier to capture.
- Amine scrubbing: a process where CO_2, in a flue gas, is absorbed and captured.
- The opportunities to store CO_2 in Canada.

Post-Combustion Capture



Implementation plans, preliminary designs and cost estimates were developed for those technologies, recognizing the diverse geographical variability of coal in Canada.

The CCPC's Phase I budget was $4.8 million, $2.1 million of which was provided by participants. The remainder was provided by Canadian governments.

Phase I Results

Developing Emission Reduction Technologies

Research showed that technologies were either available or under development to control NOx, SO_2, particulates and mercury emissions from coal-fired power plants to levels approaching that of natural gas power generation.

Gasification

Gasification was shown to be a potentially low cost CO_2 capture technology; however, gasification requires significant development to improve availability. Gasification is a mature technology in the chemical and petrochemical industries, but is not mature for power plant applications using sub-bituminous and lignite coals as a feed stock.

Oxyfuel

Oxyfuel technology is not yet mature and many issues need to be resolved prior to full scale deployment. Any application of the technology to an existing power plant would be expensive and could involve significant operational problems. At the time of the study oxyfuel appeared to be a less cost effective way to produce power and capture CO_2.

Amine Scrubbing

The study suggested that amine scrubbing technology provides the greatest opportunity for a demonstration project in that it is a mature technology in its own right, and has fewer issues to satisfy before one could develop a high degree of confidence of success. It also has the advantage of potentially being able to be applied as a retrofit to an existing facility. It can be scaled to process between zero and 100 per cent of a flue gas stream. The study showed that it may offer lower costs of electricity and CO_2 capture and the lowest risks compared to the technologies considered. In addition, it provides the opportunity to design and construct a plant in which the amine process could be de-coupled from the power generation plant, and provide the greatest operational flexibility should significant problems be encountered with the process.

CO_2 Storage

The Western Canada Sedimentary Basin provides storage capacity for a vast amount of CO_2 in British Columbia, Alberta and Saskatchewan. Storage opportunities and capacities for the Ontario and Maritime regions are less understood. Transportation and storage of CO_2 is also a challenge to a demonstration project. The reports suggest that enhanced oil recovery and geological storage are the best options, and that these choices are available principally in Western Canada.

Phase II

At-A-Glance

Timeframe: 2004 to 2007

Goal: To complete in-depth studies of top viable CCS technologies

Budget: $2.6 million

Key Findings: Amine scrubbing and oxyfuel processes showed improvement but capture costs were prohibitive; improvements in gasification positively impacted the cost of capture compared to Phase I

Overview

Phase I of the CCPC efforts identified promising CCS technologies and benchmarked the performance capabilities of each. Phase II was undertaken to gather more information through the detailed study of the most viable technologies. The goal was to study commercial or near-commercial technologies to better understand their design and costs.

Phase II was initiated in 2004 and was completed in 2007. Two major areas of work were undertaken:

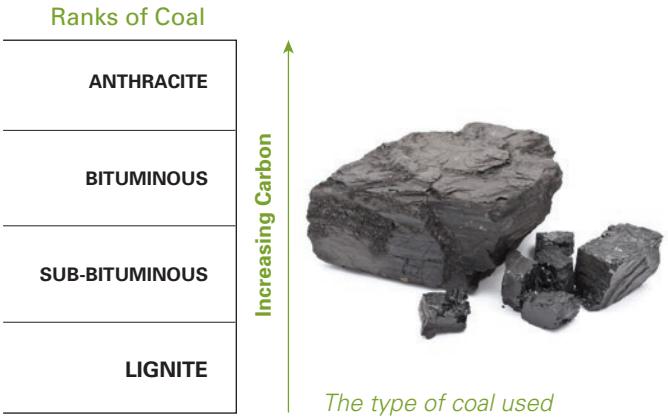
Supercritical Pulverized Coal (SCPC) Plants with CO_2 Capture

- An assessment of both amine scrubbing and oxyfuel combustion processes.

Gasification Technology Optimization

- Stage 1 – Assessed IGCC technologies that were suitable for low-rank coals.
- Stage 2 – Assessed feedstock blending as well as optimized electrical power and hydrogen production to improve the value of gasification. The gasification technologies selected were next generation technologies not commercially available.

The budget for Phase II was $2.6 million, $1.4 million of which was provided by participants. The remainder was provided by various Canadian governments.



The type of coal used affects the performance of any technology.

Phase II Results

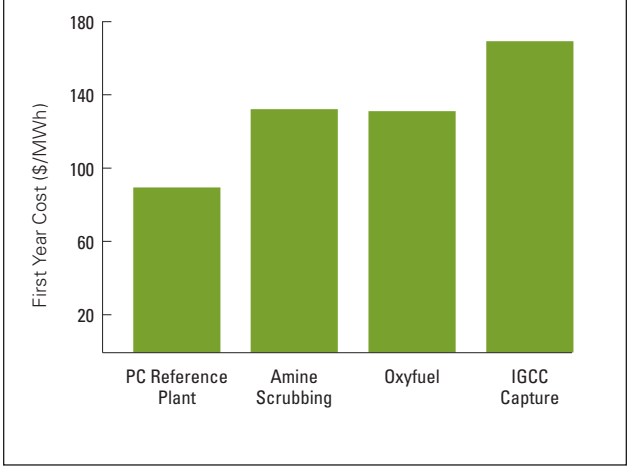
There are no commercial-scale amine scrubbing, oxyfuel or IGCC plants with CCS operating on coal; as a result, CCS technologies are fairly immature.

The technologies studied in Phase II were at different stages of development, making accurate comparisons challenging. Nevertheless, it was determined that the costs of all technologies studied are high. Additionally, the type of coal used and site specifics impact the technology choice for any given project. Therefore, detailed site-specific studies must be completed to make a final technology selection.

For these reasons, further development of a wide variety of technologies was recommended.

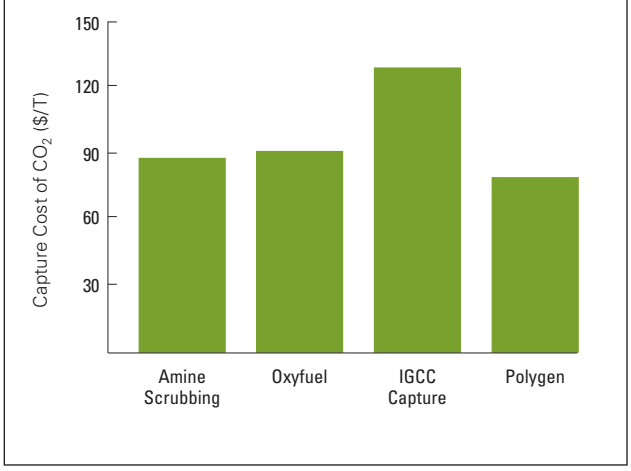
Phase II studies showed that further development of a wide variety of technologies is needed.

CCPC Phase II
Cost of Power Comparisons



This study showed that adding CO_2 capture would increase the costs of power by more than 50 per cent.

CCPC Phase II
Capture Cost



The cost of capture is expected to exceed $80 per ton.

SCPC with CO_2 Capture

Further optimization of the amine scrubbing and oxyfuel processes showed significant improvement over the results from Phase I; however, capture costs were high. Mandated greenhouse gas (GHG) compliance costs would need to be greater than $80 per tonne before CCS would be implemented.

Gasification

Gasification performance is dependent on coal quality, with lignite presenting the greatest challenge. Since this study, improvements in gasification processes for low-rank coals have reduced the cost of CO_2 capture.

IGCC costs were higher than the other technologies studied – this was unexpected given results from other recent studies. Since IGCC cases were for next generation technologies, the cost estimates may not be comparable to other cases studied. Additionally, the economics of gasification were improved by selling hydrogen rather than just power.

Phase III At-A-Glance

Timeframe: 2008 to July 2011

Goal: To study new advances and technologies

Budget: $6.7 million plus $11 million for Capital Power IGCC FEED study

Key Findings: Shared Fall 2011

Overview

Phase III involved the detailed study of new CCS advances and other ways to reduce the CO_2 emissions from coal plants. Five final reports containing results from phase III can be found on the CCPC website.

IGCC FEED

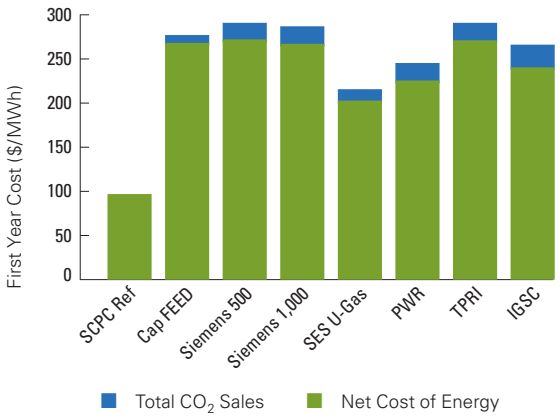
The CCPC, in partnership with Alberta Innovates (formerly AERI), Natural Resources Canada and Capital Power Corporation provided $33 million to conduct a FEED study to determine the feasibility of developing an IGCC facility with CCS at Capital Power's Genesee facility. The study detailed the design, technology, engineering and economic requirements to build a commercial-scale facility at the site. The study showed the cost to produce power from this configuration, at this location, was $9,500 per kilowatt or $266 per megawatt hour.

Advanced Gasification Studies

Feasibility studies of 10 optimized schemes to capture CO_2 from state-of-the-art sub-bituminous coal IGCC and polygen plants have been completed. The design, costs, risks and other benefits of these technologies was considered. The gasification technologies studied include:

- Three 500 megawatt (MW) Siemens gasifiers (base case)
- Two 1,000 MW Siemens gasifiers
- The SES U-Gas gasifier
- The Pratt & Whitney Rocketdyne gasifier
- China's TPRI GreenGen technology
- Jacobs Integrated Gasification Steam Cycle (IGSC)

Cost of Energy for IGCC Cases with Capture

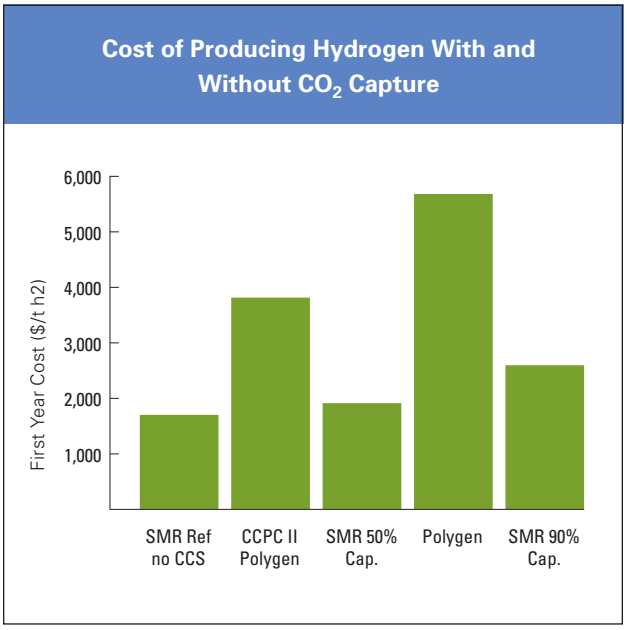


This study showed the first year cost of energy for various IGCC cases with capture are significantly greater than a supercritical pulverized coal (SCPC) without capture.

Case Studies

- Retrofit and greenfield cases
- Polygeneration cases to produce power and hydrogen for comparison to hydrogen production from a steam methane reformer with and without CO_2 capture

Carbon capture is seen as a means to reduce the emissions produced through coal combustion.



The cost of hydrogen production from polygen with CCS is not competitive with steam methane reformers with CCS.

CCS Research

The CCPC has participated in a gasification research program carried out by CanmetENERGY. In turn, Canmet has provided bench-scale and pilot-scale experimental data and modeling results for entrained flow slagging gasification of Canadian coals.

The research included the gasification characteristics of various fuels, and a bench-scale oxyfuel circulating fluidized bed combustion study employing calcium oxide to capture CO_2. A new high-pressure dry feed system, warm and hot gas clean up and coal beneficiation were studied to improve gasifier efficiency. Simulations were conducted to look for breakthroughs in process efficiency and environmental performance. Models of gasifier components have been created to support scale-up to commercial implementation, and to find process improvements.

Coal Cleaning Technology

Coal cleaning is seen as a means to reduce the emissions produced through coal combustion. A comparative study has been completed to test raw as-received coal and beneficiated coal using gasification test facilities at CanmetENERGY as part of their gasification research program. Beneficiated coal samples from several Alberta and Saskatchewan coal beds were produced at Sherritt's Clean Coal Technology Centre.

The CCPC was established to research commercially viable technologies that will lower coal-fired power plant emissions.

EPRI Post-combustion CO_2 Capture Retrofit Studies

The CCPC is participating in an Electric Power Research Institute project that is studying retrofitting five power plants, including one in Nova Scotia, with advanced amine CO_2 capture technology. The study determined the thermal and economic impact of retrofitting and the technological barriers and limitations associated with each site. This project was completed in the summer of 2011.

Biomass Use Evaluation

The CCPC participated in a Nova Scotia Power research project to evaluate the potential for co-firing biomass with coal in power plant boilers to achieve cost effective CO_2 reductions. Both laboratory combustion tests and engineering studies of typical utility boiler systems have been completed.

IGCC Roadmap

The CCPC undertook a study conducted by EPRI CoalFleet Program staff, consisting of an engineering and qualitative economic evaluation of technological advances in processes involved in gasification including:

- coal preparation and feeding – beneficiation, drying and feeding improvements
- oxygen production – ion transport membranes
- syngas processing and CO_2 capture – warm gas clean up, hydrogen (H_2) membranes, various novel CO_2 capture processes, and CO_2 purification
- the effect of increases in turbine firing temperatures – developments on gas and steam turbines

The base case for this study will be a 500 MW Siemens gasifier fired on Alberta sub-bituminous coal. An evaluation of the impact of individual and combined technologies advances on the base case were considered. An assessment of the development status of these technologies was produced.

Biomass Co-firing

KEMA Consulting has completed a study of various technologies that can be used to complete modest and significant co-firing of biomass fuels in a coal boiler. The study reviewed the characteristics of various biomass feedstocks and also describes capital costs and configurations for six co-firing and feedstock configurations. It recommended configurations for further study.

Coal Beneficiation

Sherritt completed a study on the costs, benefits, risks and status of several dozen coal beneficiation technologies. EPRI also looked at the economic benefits of reducing specified amounts of ash and moisture for several coals.

The budget for Phase III was $6.7 million, $2.0 million of which was provided by participants. It included $2.5 million of work in kind with CanmetENERGY and the remainder was provided by various Canadian governments. Phase III also included the provision of $11 million to Capital Power's $33 million IGCC FEED study. The $11 million was provided by Alberta Innovates (formerly AERI).

Phase IV At-A-Glance

Timeframe: 2011 to 2014

Goal: To study new partial CO_2 capture options to meet new Canadian coal regulations

Budget: $6.3 million

Key Findings: To be shared in the Fall of 2014

Overview

The CCPC was established to research commercially viable technologies that will lower coal-fired power plant emissions. Phases I through III of the CCPC's studies have advanced the understanding of available and emerging technologies, their limitations and benefits.

Phase IV had two cleaner coal study themes:

- Near-term technologies: retrofit and greenfield technologies that will be commercially available within 10 years
- New transformative technologies: designs that might be available for the new greenfield coal fleet in 2020

Near-term Technologies

It is anticipated that the technologies the CCPC classified as near-term will have a low impact on power costs and be broadly applicable across the coal fleet. This study increased our confidence that these technologies will perform as expected and increased our knowledge of technologies that have not yet been extensively studied.

Near-term technologies included:

Coal Beneficiation

During this project, four coals were beneficiated using float sink processes. The data collected was used to understand how commercially available coal beneficiation technologies would likely perform on these coals and what the technical and economic benefits might be.

For more details, see Appendix A.

Biomass Co-firing

FP Innovations focused on identifying the costs and volumes of various kinds of biomass at three plant locations in Canada. The cost of biomass with or without natural gas co-firing is likely significantly lower than post-combustion capture options and might be a viable way to extend the life of coal plants, particularly for periods of five to 10 years. The prices for most forms of biomass are likely too high to consider co-firing in the short term given prevailing carbon taxes.

For more details, see Appendix B.

In-situ Coal Gasification

Alberta Innovates – Energy and Environment Solutions, Sherritt and the CCPC funded a $1 million study evaluating several underground gasification technologies for the production of syngas. The study assessed the cost of producing this syngas and using it to produce power, Fischer-Tropsch (FT) liquids and fuel for boilers. The power configuration employed carbon capture to meet the GHG emissions requirements.

For more details, see Appendix C.

Phase IV had two cleaner coal study themes: Near-term technologies and new transformative technologies.

New Transformative Technologies

New coal fleet technologies were defined as those that are designed to more economically reduce CO_2 emissions. They were in early stages of design, had lower capture costs and had broad application potential. They were also designed to meet GHG regulatory requirements.

New transformative technologies included:

Advanced Cycles

EPRI looked at the comparative advantages and disadvantages of a dozen advanced cycles for combusting coal with lower emissions. Many of these cycles may be attractive options for building new coal plants and for retrofitting existing coal plants.

For more details, see Appendix D.

Advanced Post-combustion Capture

EPRI evaluated 20 promising non-aqueous post-combustion capture technologies. These technologies were chosen because they may hold the promise for significantly reducing the cost of carbon capture in the future.

For more details, see Appendix E.

IGCC Partial Capture

Jacobs completed this first-of-its kind study to evaluate several IGCC configurations employing partial capture of CO_2. The cost of power and the capture cost of CO_2 from IGCC with partial CO_2 capture was found to be significantly lower than IGCC with full CO_2 capture and comparable to the cost of a super-critical coal plant with partial CO_2 capture.

For more details, see Appendix F.

CanmetENERGY – Task Share

CanmetENERGY completed the following tasks:

1) Determined gasification characteristics of Canadian coals and petroleum coke.
2) Developed and tested gasifier component designs and materials.
3) Investigated methods for improving gasification power plant efficiency firing high ash coals.
4) Determined the efficiency and environmental performance of calcium and chemical looping systems for hydrogen, steam and power production.
5) Created computational fluid dynamics models of gasifier injectors, reactors and quench systems for technology scale-up and for process improvement.
6) Developed and tested regenerable solid CO_2 sorbents.

For more details, see Appendix G.

Phase V

Next Steps

Timeframe: 2014 to 2016

Goal: To identify ways to extend the life of existing coal plants and to build new coal plants while meeting emission limits

Budget: $8.5 million

Fuel Cell Repowering

Jacobs has been commissioned to work with Fuel Cell Energy, Inc. to study the feasibility of using molten carbonate fuel cells to capture CO_2 from an existing coal plant in Nova Scotia while producing power. Initial results indicate that this approach may have a low cost of CO_2 capture and a low incremental cost of power. This work may be used to help justify funding a pilot plant.

Coal Repowering

EPRI will evaluate several ways to repower existing coal plants. These options may require removing large portions of the plant and installing more advanced cycles. Fuel switching to natural gas and biomass may be evaluated.

Making an Additional Commodity

This study will review up to a dozen options for using coal in a greenfield plant to produce both power and some other commodity. Coal could be used as a feedstock directly. Heat, steam and/or electricity could be used to support the production of another commodity such as pyrolysis products, FT liquids, fertilizers, fuels and chemicals. The objective is to find ways to continue to use coal with less reliance on power as an end product.

Greenfield Studies

In Phase IV, EPRI reviewed a few novel cycles that may hold promise for future development. This study builds on previous work by the CCPC. Small high efficiency biomass co-fired plants, closed Brayton cycles, etc. have been proposed. The objective is to select a few ideas for techno-economic evaluation.

Novel Carbon Capture Option

In Phase IV, the CCPC commissioned EPRI to review 20 novel post-combustion carbon capture options. If some of these options, or other options, look promising, the CCPC may study them in more detail. The objective is to find options that could be used to extend the life of coal plants.

Demonstrating Coal Beneficiation

If promising technologies are likely to yield economic benefits, the CCPC may fund the testing of several coals in coal beneficiation test facilities.

Demonstrating Biomass Co-firing

The CCPC may help fund efforts to test fire biomass in an existing Canadian coal plant.

The feasibility of using molten carbonate fuel cells to capture CO_2 from an existing coal plant in Nova Scotia while producing power is being studied.

Lower Temperature Heat Recovery

CanmetENERGY has been developing condensing heat exchangers that could be used to condense water and a significant amount of air emissions out of flue gas while providing heat that could be used for other purposes, such as in an organic Rankine cycle. The objective for the CCPC will be to determine whether this technology can reduce mercury and sulfur emissions while providing water and possibly useful heat.

NOx and SOx Due Diligence

This study will review the various new and novel ideas to reduce NOx and SOx by having a credible third party perform due diligence on them. The objective is to identify promising new lower costs options to reduce NOx and SOx so companies can study them in the context of their current plant emissions.

Aerojet Rocketdyne-Oxy PFBC Demo

The CCPC plans to contribute $300,000 to Aerojet Rocketdyne's demonstration of their Oxy Pressurized Fluidized Bed Combustion (PFBC) technology at CanmetENERGY in Ottawa. Aerojet plans to test two coals provided by the CCPC. The CCPC will have access to the final results for this project.

Canmet Task-Share Work

CanmetENERGY will develop pressurized chemical looping combustion for production of H_2, steam and power using a naturally occurring oxygen carrier, ilmenite, in a small pilot. CanmetENERGY will work towards developing gasification systems for hydrogen, power, synthetic natural gas (SNG), clean liquid fuels and chemicals production at ultra-high efficiency. The oxy-PFBC program will result in the construction and operating of a 0.25 to 1.0 MWth pressurized pilot-scale facility with oxygen firing using petcoke and coals to produce steam and power.

Antelope Valley Station

Boundary Dam Power Station

Project Pioneer's generating station, Keephills 3

The CCPC's Impact – Member Projects

The CCPC's member companies use the research conducted by the organization to advance their own environmental performance. Read on for examples of the CCPC's research at work.

Antelope Valley

- Basin Electric worked with HTC Purenergy and Doosan Babcock to complete a $6.2 million FEED study on post-combustion capture at the 450 MW Antelope Valley Station. Had the project proceeded it would have captured approximately one million tons of CO_2 per year from a portion of the plant's exhaust stream and sent it to oil fields in Saskatchewan to be used in existing enhanced oil recovery operations.

Boundary Dam

- The Boundary Dam Integrated CCS Project came online in 2014 as one of the world's first and largest CCS projects on a coal-fired plant. Unit 3 of Boundary Dam power station was scheduled to reach the end of its useful life soon, but a rebuild and retrofit with carbon capture technology will extend its lifespan by decades. Once fully operational, SaskPower's capture facilities will be able to capture up to one million tonnes per annum of CO_2 that will be sold for enhanced oil recovery projects or stored deep underground at the organization's Carbon Storage and Research Centre.

  Construction began in 2011. Commissioning of all parts involved is currently taking place. This project represents more than 4.5 million man-hours of work, approximately half of the man-hours that went into the construction of the CN Tower in 1975.

  In 2013, SaskPower officially retired Unit 1 to meet federal carbon dioxide regulations. The new rules called for coal-fired units that have been operating for 50 years or more to either meet new emissions standards by July 1, 2015 or shut down. Unit 2 will follow suit in 2014. Retrofitting these units in time to meet the new regulations was not deemed economically feasible.

Project Pioneer

- TransAlta and various partners undertook a world-scale CCS demonstration project designed to capture one million tonnes of CO_2 per year at its Keephills 3 generating station west of Edmonton. A full front-end engineering study was carried out assessing the technical and economic feasibility of several capture technologies. The company's interest in CCS was founded in part on the CCPC's Phase II studies. Unfortunately, the project was cancelled in 2012 due in part to regulatory uncertainties and market demand for CO_2 for enhanced oil recovery (EOR) injection.

Mock-up of an IGCC facility at Capital Power's Genesee plant

IGCC FEED

- Capital Power Corporation, along with the federal and Alberta governments, funded a FEED project to determine the feasibility and cost of developing a commercial-scale coal-fuelled gasification power plant with CCS.

Nova Scotia Power

- Nova Scotia Power is studying the use of biomass from sustainable resources for co-firing in both CFB and pulverized coal plants. CCS Nova Scotia, whose members include Nova Scotia Power, is preparing plans to build a CCS pilot plant with the outlook of a commercial scale project by 2020.

Sherritt International

- Sherritt has studied underground coal gasification and also recently completed a coal cleaning laboratory in Fort Saskatchewan. The project, partially funded by Alberta Innovates, tested various techniques to determine the optimal coal cleaning technology. Both beneficiated and non-beneficiated coals have been assessed by CanmetENERGY to determine impacts on plant performance. Sherritt also developed the Dodds-Roundhill IGCC project.

The CCPC's Impact – Collaboration

The CCPC, through its membership and ongoing research, fosters a collaborative and cooperative approach to advancing technology across Canadian industry. Along with sharing of research, CCPC represents its members on various other organizations. This ensures a comprehensive two-way flow of information, thereby allowing more efficient and effective advancements within individual organizations. Government and other funding ensures this work continues.

Vendor Access to Industry

Broad access to industry can be challenging. Through the CCPC, technology vendors are able to present technologies and projects to the CCPC technical committee, fostering learning and allowing for industry support of new initiatives.

Research Collaboration

The body of research that needs to be undertaken is vast. The CCPC serves as a central point through which studies from other organizations can be shared with industry and with each other. The CCPC also works with various groups to obtain funding, execute projects, share information, or to collaborate, such as:

- ICO_2N
- Carbon Management Canada
- CO_2 Capture Project
- Lignite Energy Council
- Electric Power Research Institute (EPRI)
- Global CCS Institute
- CanmetENERGY
- Canadian Wood Pellet Association
- Climate Change and Emissions Management Corporation (CCEMC)
- Environment Canada
- Alberta Innovates – Energy and Environment Solutions
- International Energy Agency
- National Energy Technology Laboratory
- North Dakota Industrial Commission
- Alberta Energy

Sharing Our Findings

Educating the public about cleaner coal is an important part of the CCPC's mandate. The CCPC is committed to sharing its research findings with its members and the public. Valued as a trusted information source for carbon capture costs and other information, the CCPC frequently receives queries from teachers, government, industry and members of the public.

The CCPC also undertakes structured dissemination of its study findings to interested stakeholders. Formal external communication activities have included the provision of the CCPC's website, fact sheets, industry reports, delivery of presentations and media releases. As a coalition, members also learn from each other and share studies and ideas.

The CCPC has become a thought leader on CCS and other emission reduction technologies, and receives numerous questions and inquiries. Additionally, the CCPC's leadership presents current findings at conferences and to government. In the early days, the CCPC played a policy development role, providing industry expertise as needed. Today, the CCPC has evolved to become a great source of information in Canada about CO_2 reduction technologies and economics.

The CCPC has evolved to become the best source of information about Canadian carbon capture technology and economics.

CANADIAN CLEAN POWER COALITION

For more information

The Canadian Clean Power Coalition (CCPC) welcomes comments on this report, as well as questions about our ongoing research projects. Queries can be sent to:

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