Canadian Carbonization Research Association

2019-2020 Annual Report
(April 1, 2019-March 31, 2020)

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The Canadian Carbonization Research Association (CCRA) was formed on September 2, 1965 – providing over 54 years of Research supporting the Canadian Coal and Carbonization Industries

CCRA
Canadian Carbonization Research Association

CHAIRMAN'S REMARKS

Since its inception in 1965, the Canadian Carbonization Research Association (CCRA) has provided an excellent framework for technical/technological cooperation between government and industry, which has been very successful for both parties. The CCRA is a unique organization in being Canada's only technical support for the Canadian metallurgical coal and coking industries. This organization continues to be of real value to its member companies and to the financial health of the associated industries. The value of its research is becoming more recognized and appreciated on a global basis.

The role of the CCRA is to strive to meet its members' needs. Its technical research program continues to evolve constantly as the demands of the coal, cokemaking and ironmaking industry change with the issues facing Canada. With new members arise more ideas leading to potential solutions for technical challenges facing the coal and steel industries. It is important to continue sharing our research findings with fellow researchers and industry. The CCRA has again published its work in several international journals and presented papers at both domestic and international conferences.

With the pilot Energy Recovery Coke Oven construction near completion and the new pulverized coal test rig up and running, the R&D capability of CCRA and CanmetENERGY has increased tremendously. There is a new wave of research the CCRA is undertaking with the development of bio-based carbon to mitigate GHG emissions in our industries. We look forward to these new technical challenges.

"The CCRA is a unique organization in being Canada's only technical support for the Canadian metallurgical coal and coking industries."

The CCRA continues to be supported by key members representing the coal sector, the cokemaking sector and the integrated ironmaking sector. We remain in touch with past member companies and invite them to rejoin the Association as they continue to grow their respective companies.

Globally, the Canadian Carbonization Research Association is autonomous in its ability to continue to expand and meet its members' requirements. This remarkable co-operative relationship between the coal industry, steel industry and government is truly unique, and the CCRA R&D technical program will strive to address and reflect its members needs for years to come.

Ted Todoschuk

Ted Todoschuk,
Chairman, Board of Directors

TECHNICAL COMMITTEE REPORT

TECHNICAL COMMITTEE MEETINGS

The CCRA Technical Committee held four meetings during Fiscal Year 2019-2020:

Meeting No.	Location	Date
247	Ottawa, ON	June 11-12, 2019
248	Vancouver, BC	September 17-19, 2019
249	Ottawa, ON	December 3-4, 2019
250	Vancouver, BC	March 10-12, 2020

The 2019-20 Research Program consisted of four main research areas:

1. Fundamentals of coal science
2. Fundamentals of cokemaking and coke quality
3. Energy and CO_2 reduction in cokemaking and ironmaking
4. Database, standards and procedures

In total, 10 projects were part of the active Research Program.

Major accomplishments/highlights:

1. During FY 2019-20, the CCRA authored ten papers for presentation at AISTech 2019 in Pittsburgh, USA (6) and International Conference on Science and Technology of Metec-4th ESTAD Conference in Düsseldorf, Germany (4).

   CCRA produced a report on Producing Clean Coal from Western Canadian Coalfields using the Water-Based Roben Jig Process: Application to an Industrial Setting in Geoscience BC Summary of Activities 2020.

   There was one Working Group meeting on use of Biocarbon in Canadian Steel Industry (June 2019) and a meeting to initiate collaborations in Carbon Neutral Ironmaking Research (March 2020).

2. On **Coal resource quality evaluation** (CCRA 90), Phase 2b of Geoscience BC project (2019), '*Producing Clean Coal from Western Canadian Coalfields Using the Water-Based Roben Jig Process: Application to an Industrial Setting*' was completed.

   The work compared coke quality from the Carbolite pilot oven a WCC coal (Ro 1.02, inert 15%, Max Fluidity 460 ddpm) that was washed in an industrial plant and compared to the same coal that was washed in the laboratory using organic liquids and the Roben Jig. Good quality coke was obtained irrespective of the washing method and medium. This is evidence that the misplaced particles in the plant and Jig products did not reduce the quality of the cokes. The work completed, demonstrated that the H_2O-based Roben Jig is definitely the better method and is more suitable than the traditional

coal washing which uses heavy organic liquids, which pose serious safety hazards/risks for laboratory operators and may also negatively impact the coking quality results of the clean coal samples.

Several journal publications are planned (i) comparing coal washing with Roben Jig and conventional Float/Sink highlighting advantages and disadvantages and include coke quality results of a full MWO upon using Roben Jig washing/preparation (ii) operation of the Roben Jig and highlighting the work done at GWIL/Birtley (Heather Dexter's group) to render the Roben Jig a very valuable tool for washing coal (w/o use of nasty/heavy/toxic organic liquids).

Longer-term work (2020-2022) will involve the use of alternate liquids (Novec 7000 series, salts) for washing coal and examining effect on coal properties, i.e., rheology. Also, the plan is to compare coal washing performance of Novec liquids with PCE Float/Sink and Roben Jig and determine the effect on coke quality. Preliminary work carried out so far at GWIL/Birtley lab has shown that Novec treated coal had better fluidity than organic PCE treated (at similar ash levels) and slightly poorer washability (12.5 x 2mm size fraction) compared with traditional organic liquids.

3. On **Performance of Western Canadian coal in stamp charge technology** (CCRA 93), small-scale stamping tests were completed at CanmetENERGY-Ottawa, which showed that moisture and coal size distribution influence the resulting bulk density of stamped cake. A coal cake BD of 1000 kg/m^3 was achieved but required quite a bit of effort.

Following discussions, two blends were designed for stamp charging. A base blend (100% US coals) and a WCC blend (25% Teck Elkview/75% US coals) with similar Ro (1.0 and 0.97) will be used. Both blends predict a coke stability of 52% which allows for significant improvement by stamp charging. In total, four MWO carbonization tests consisting of two gravity charges and two box charges are planned for 2020 Q2 or Q3.

A collaboration study with Université du Québec à Chicoutimi (UQAC) on stamping energy and coal cake strength was proposed. UQAC drafted a proposal to study coal-biocarbon blend stampability and plans to apply for funding from the Transformation of Quebec Forestry Industry. UQAC is seeking CCRA support on providing coal samples for test work and a letter of support.

4. On **Application of small-scale coking** (CCRA 88), the plan is not to build a small-scale oven at CanmetENERGY-Ottawa but rather to pursue work in 2-compartment box charge using the existing Carbolite oven. This will be benchmarked against gravity charge. However, during 2020-21, the CCRA will prioritize the stamp charge work described under CCRA 93 project.

5. On **Mineral matter and coke reactivity** (CCRA 81), the next steps involve developing a Mineral Liberation Analysis (MLA) technique to characterize in-situ minerals in coal at Teck Technical Services, Trail, BC (A. van Staden) and then evaluate potential of using MLA or other technique XRD/SEM-EDS for minerals in coke. Future work will examine how minerals in coal change during transformation into coke. In addition, in-depth analysis of coke textures remains to examine effect of minerals near coke carbon forms on a highly fluid US HV A and the WCC Teck MV ELKV for influence of different fluidity levels in these coals on mineral formations.

6. On **Substitution of Fossil Carbon by Renewable Biocarbon in Pyrometallurgy Processes (CCRA 70)**, research continued in several fronts on the use of biocarbon in the steel sector including (1) PCI (2) Cokemaking (3) EAF steelmaking and (4) Nut coke substitution.

   The CanmetENERGY Bioenegy group was again a strong partner and made valuable contributions on (i) densification of C/D wood and coal/biochar briquette (ii) washing of biochar (iii) exploring the use of pyrolyzed railway ties as a potential source of biochar (iv) development of an ISO Standard for Solid Recovered Fuels (SRF) (v) development of an evaluation program for solid biofuels for the iron/steel industry.

   The CCRA members provided their companies GHG reduction plans and actions in the near future. Going forward, the CCRA Biocarbon for Steel Working Group and its members need to define their plan and vision to 2025 around biomass production, supply, utilization, etc., including potential barriers at each level.

7. On **Carbon Neutral Ironmaking Technology Development (CCRA XX)**, Canada needs to develop a long-term GHG reduction research plan to support the steel sector. This new project stream added to the CCRA research program, whose research plans and projects have not yet been identified and developed, is required to position CSPA and CCRA as global leaders on carbon neutral ironmaking research going forward.

   Following a meeting with the new CanmetENERGY Energy Technology Sector ADM Drew Leyburne in 2019 Q4, a first meeting on carbon neutral ironmaking was held at CanmetENERGY-Ottawa in 2020 Q1. The objective of that meeting was to develop an inventory of people, resources, knowledge, expertise, skills and research facilities /equipment within NRCan /CanmetENERGY, Canada and globally, which could potentially contribute towards the new goal for the steel industry's drive towards carbon-neutral iron/steelmaking by 2040-2050. During 2020-21, the CCRA will have follow up meetings on Carbon Neutral Ironmaking with the CanmetENERGY Energy Technology Sector ADM Drew Leyburne.

8. On **Energy Recovery Coke Oven** (CCRA 77), issues/challenges were encountered during commissioning of the Coal Loading Machine (CLM) as it is not loading/operating properly with the weight of a full charge at 450°C (idling temperature). In addition, a backup generator is needed in

case of a power outage in order to keep the oven at 1200°C-1300°C. CanmetENERGY is to put together a list of tasks remaining in order to complete the commissioning of the oven.

9. On **Blast Furnace Energy Reduction Initiatives Using Auxiliary Fuel Injection (CCRA 91)**, the PCI rig was re-commissioned successfully with its capability enhanced with NG/COG co-injection. Off gas sampling remains to be included. Work also continued on factors affecting PCI coal combustion/burnout. The regression analysis for %burnout was carried out using factors such as the O/C molar ratio, %VM in coal, petrographic components and particle size. Sensitivity analysis found %burnout to increase with O/C molar ratio and %VM in a coal and to decrease with larger coal particle size and %V15-%V20 types in the coal.

10. On **ISO and ASTM Coal and Coke Standards (CCRA 54)**, regular updates were provided on CanmetENERGY's Met Fuels Lab performance in CPA coal petrography, LQSi CSR/CRI, Tumbler Test, MET Coal and HGI Round Robins.

    Results on effect of particle size on fluidity and dilatation and associated temperature ranges for a suite of US coals of different rank was presented at ASTM D05 meeting (October 2019). The next step is to perform the same work on WCC of varying ranks.

    Canada participated in ISO/TC27 meeting in Japan in October 2019. Of interest to the CCRA is the planned revision of several coke standards and the development of ISO standards on automated and manual Sapozhnikov plastometers. The CCRA members were encouraged to join ASTM D05 and participate in future meetings.

    The automated Sapozhnikov plastometer at CanmetENERGY-Ottawa Met Fuels Lab was commissioned in part and a number of repeatability tests were completed on three coal samples spanning a wide range of Maximum Fluidity i.e. 20 to > 30,000 ddpm. Tests to determine reproducibility were initiated but require completion by an external lab. A literature review on the Sapozhnikov plastometer was completed. Designing a proper ruggedness test for Sapozhnikov plastometer is needed – examining (i) sample preparation (consistent manner, 100% -1.5 mm coal with limited fines generation) (ii) initial sample height in holder to determine BD (iii) sample moisture. A research project will be developed to examine a number of test parameters such as particle size distribution, %fines, relation with other rheology tests and the effect of oxidation. It needs to be determined what the Sapozhnikov test adds to demonstrating the technical merits of WCC.

11. On **International research collaboration** (CCRA 75), a study was proposed with UQAC in Chicoutimi, Quebec on stamping energy and coal cake strength. UQAC drafted a proposal to study coal-biocarbon blend stampability and plans to apply for funding for transformation of Quebec forestry industry. UQAC is seeking CCRA support on providing coal samples for test work and a letter of support.

    For University collaboration going forward, better links need to be established identifying which universities to collaborate with, their capabilities and perhaps organize a university day. CCRA first needs to identify defined project(s) from industrial company(ies). In the short to medium term, this could be a good mechanism to find/hire new scientists (Mitacs and other programs) and speed up some of the priority CCRA research work.

    On PCI work, collaboration continued with AM Maizières (France) and Voestalpine (Austria).

12. On **Technical Merits of Western Canadian Coals (CCRA 87)**, an A3 plan for the next phase of work, which includes Australian coals was prepared and forwarded to ACARP Australia in Q1 2020 to seek their interest in participating. ACARP responded in early Q2 2020 to the extent that they would probably engage in the CCRA blending program.

13. On **Factors Affecting Coke Bed Permeability (CCRA 82)**, work began in 2020 Q1 on examining effects of (i) WCC in coal blend on coke size and shape and (ii) stabilization on coke size and shape using a 100% US blend and a 65% US-35% WCC blend (with component coals in WCC blend adjusted to maintain comparable properties for both blends).
    The results obtained to this point indicate that following 1-drop stabilization, mean coke size of the two cokes are very similar, 57 mm for 100% US blend and 58 mm for WCC blend. Extended IRSID has been completed on coke from 100% US blend and are pending on coke from WCC blend. Image analysis work on the two cokes requires completion.
14. On **Modeling of Coal and Coke Properties Using Historical Database (CCRA 76)**, the following suggestions were made: (1) need to analyze CanmetENERGY database for possible relationship between 18" pilot oven wall and gas pressures (2) explore possibility of hiring a data analyst to develop a coal blending model using PCA and (3) explore the worth/benefits of Artificial Intelligence and Industry 4.0, which promotes the computerization of manufacturing.

15. On **Benchmarking of movable wall ovens** (CCRA 92), a historical summary of CanmetENERGY MWO benchmarking results including the most recent tests completed in 2020 Q1 was presented. The latest set of measurements showed that the performance of both MWOs (18" and Carbolite) continue to yield consistent results. The installation of new load cells in 18" pilot oven and functionality tests were completed in 2020 Q1 followed by two carbonization tests on the benchmarking blend. Replacement of 18in oven load cells had no influence on historical data integrity. The effect of Carbolite operation on 18" pilot oven wall pressure measurement was minor. Further tests are required to demonstrate possibility of charging both pilot ovens simultaneously (on same day).

CCRA-CanmetENERGY Conference Proceedings, 2019-2020

1. Ng, K.W., Huang, X., Giroux, L., "*Incorporation of Biocarbon in Cokemaking via Partial Briquetting*", AISTech 2019 conference proceedings, 6-9 May 2019, Pittsburgh, USA.
2. Huang, X., Ng, K.W., Giroux, L., Li, D., "*Biocarbon Materials in EAF Steelmaking*", AISTech 2019 conference proceedings, 6-9 May 2019, Pittsburgh, USA.
3. Ng, K.W., Huang, X., Giroux, L., Todoschuk, T., "*Grindability of Solid Biocarbon*", AISTech 2019 conference proceedings, 6-9 May 2019, Pittsburgh, USA.
4. Ng, K.W., Huang, X., Giroux, L., Todoschuk, T., "*Carbonaceous Materials Transformation in Pulverized Coal Injection*", AISTech 2019 conference proceedings, 6-9 May 2019, Pittsburgh, USA.
5. Zhang, Q., Price J.T., Ryan, B., Giroux, L., Halko, J., "*Effect of Coal Mineral Type and Size on Coke Strength after Reaction*", AISTech 2019 conference proceedings, 6-9 May 2019, Pittsburgh, USA.
6. Todoschuk, T., Giroux, L., *"Coal Rheology - A Practical Approach for Industry"*, AISTech 2019 conference proceedings, 6-9 May 2019, Pittsburgh, USA.
7. Todoschuk, T., Giroux, L., Ng, K.W., *"Coal Rheology – A Practical Approach for Industry"*, Metec-4th ESTAD conference proceedings, 24-28 June 2019, Düsseldorf, Germany.
8. Giroux, L., St. James, J.W, Leeder, W.R., Price, J.T., Halko, J., Kolijn, C.J., Zhang, Q., Todoschuk, T.W., "*Findings of Inter Laboratory Study on Coal Dilatation under ISO/TC27 and Importance of Correcting Experimental Dilatation Results to a Reference Coal Mass*", Metec-4th ESTAD conference proceedings, 24-28 June 2019, Düsseldorf, Germany.
9. Ng, K.W., Huang, X., Giroux, L., Todoschuk, T., "*Effect of Coal Properties on Combustion Behavior during Pulverized Coal Injection*", Metec-4th ESTAD conference proceedings, 24-28 June 2019, Düsseldorf, Germany.
10. Ng, K.W., Huang, X., Giroux, L., Todoschuk, T., "*Incorporation of Biocarbon in Blast Furnace Ironmaking*", Metec-4th ESTAD conference proceedings, 24-28 June 2019, Düsseldorf, Germany.

Published Report, 2019-20

1. Mackay, M.L., Giroux, L., Leeder, R., Dexter, H., Halko, J., Holuszko, M. and Thomas, D. (2020): Producing Clean Coal from Western Canadian Coalfields Using the Water-Based Roben Jig Process: Application to an Industrial Setting; in Geoscience BC Summary of Activities 2019: Minerals and Mining, Geoscience BC, Report 2020-x, 29 pp.

CanmetENERGY-Ottawa Met Fuels Facilities Utilization:

Statistics for 2019-20 showed the following in comparison with 2018-19:

1. Sole-Heated Ovens

a) CCRA – 7 vs 22 trials
b) Coal Companies – 153 vs 125 trials
c) Steel Companies – 145 vs 168

In total, usage of sole-heated ovens in 2019-20 was 305 trials - compared to 315 trials in 2018-19 (3% lower).

2. Sole-Heated Oven Coke Reheats - CSR

a) CCRA – 4 vs 24
b) Coal Companies – 52 vs 11
c) Steel Companies – 43 vs 16

In total, 99 reheats of sole-heated oven cokes for CSR determination – vs 51 in 2018-19 (94% higher).

3. MWO CSR Determination

a) CCRA – 7 vs 8
b) Coal Companies – 95 vs 124
c) Steel Companies – 43 vs 37

In total, 136 MWO CSR evaluations were performed – vs 169 in 2018-19 (20% lower).
In addition, 6 CSRs were done on cokes received at CanmetENERGY-Ottawa Met Fuels (all for CCRA).

Combining SHO, MWO and Cokes received at Met Fuels, 241 CSR tests were done in 2019-20 compared to 227 tests in 2018-19 (2% higher).

4. Movable Wall Ovens

a) CCRA – 11 vs 5 trials (18" and Carbolite)
b) Coal Companies – 108 vs 127 trials (all in Carbolite)
c) Steel Companies – 61 vs 60 trials (all in 18")

In total, usage of movable wall ovens in 2019-20 was 180 trials compared to 192 trials in 2018-19 (6% lower).

5. PCI

a) CCRA – 10 vs 14 tests
b) Coal Companies – 0 test (2019-20 & 2018-19)
c) Steel Companies – 19 vs 11 tests

In total, 29 PCI tests were done in 2019-20 compared to 25 tests in 2018-19 (16% higher).

6. Extended IRSID and Coke Stabilization

a) In total, 8 X-Irsid tests were done in 2019-20 (2 for CCRA and 6 for steel companies).
b) No coke stabilization trials were done in 2018-19

Table 1 - Utilization of CanmetENERGY Facilities

Oven Tests April 1, 2019 – March 31, 2020				
Oven	**CCRA**	**Coal Companies**	**Steel Companies**	**Totals**
Sole – Heated Oven				
SHO1	1	40	64	**105**
SHO2	6	95	68	**168**
SHO3	0	19	13	**32**
Total SHO	**7**	**153**	**145**	**305**
CSR/CRI				
SHO Coke Reheats/CSR	4	52	43	**99**
MWO CSR	7	95	34	**136**
Cokes for CSR	6	0	0	**6**
Total CSR	**17**	**147**	**77**	**241**
Movable Wall Oven				
18 Inch	4	0	61	**65**
Carbolite	7	108	0	**115**
Total MWO	**11**	**108**	**61**	**180**
PCI Injection Test Rig				
PCI	10	0	19	**29**
Stabilization				
XIRSID	2	0	6	**8**

OTHER BUSINESS

1. **CCRA Technical Roadmap**
    a. The roadmap was reviewed and aligned with the Technical Committee planning table. The research activities/streams have been reorganized and updated to better reflect current project work.
    b. The CCRA BOD is responsible for updating and planning the roadmap for the Technical Committee.

2. **CCRA Research Program**
    a. Progress in all CCRA projects now being tracked with A3 plans.

3. **CanmetENERGY Met Fuels Activities**
    a. Revenues for 2019-20, $1.8M
    b. New staffing & training actions was progressed

c. New building construction planned to go ahead in 2020-21 – it will be needed for MFL capacity increase

4. MFL made progress in upgrading some of its facilities:
   a. High-temperature furnace re-commissioning
   b. Coke oven gas analysis
   c. Automatic coke stabilization and screening – conduct small-scale (25 kg) benchmarking tests first to simulate the DMT and CPM designs

5. Publications

A list of CCRA-CanmetENERGY papers for 1990-2020 period was updated and made available on Google Drive. The papers have been split in different categories:

i. Coal
ii. Coal blending
iii. Coal minerals
iv. Coal oxidation
v. Coal rheology
vi. Coal mining and preparation
vii. Coal transportation
viii. Coke fundamental
ix. Coke quality
x. Cokemaking
xi. GHG/GHG biocoke/GHG bio-EAF/GHG bio-PCI
xii. PCI

https://drive.google.com/file/d/1dPmEAnUNYTDj1E_MEU-io9RTEKHvCR7w/view

The updated list of papers will be used to prepare a new version of the CCRA manual. Access to CCRA papers is not currently accessible from the CCRA website but rather from Google Drive due to lack of space on the CCRA website. Members advised that this was not a good solution and suggested to examine possibility of getting a new CCRA website designed/developed that would allow more storage space for papers, CCRA annual reports, documents, files, etc.

6. CCRA website

The CCRA members reiterated the importance of a having a well-designed and maintained website as it is key to advertise the CCRA for connecting with the CSPA, other organizations /companies, and the public. Several quotes have been received from website development companies in the Ottawa area to design a new CCRA website that would allow more storage space for papers, CCRA annual reports, documents, files, etc.

Roben Jig tube filled with coal and water and ready to be jigged.

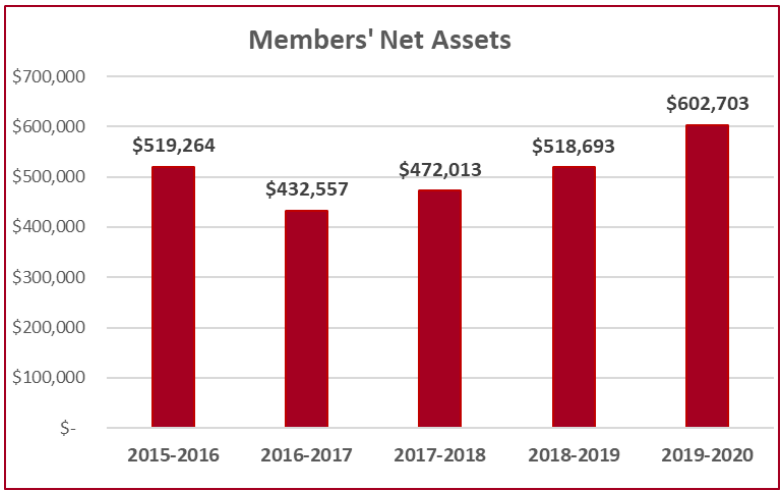
Technicians getting ready to invert the jig tube holding jigged coal.

The first slice of coal is ready to be removed from the cylinder. It has been pushed up from the bottom and will be scraped off into a weighing container for Apparent Relative Density test.

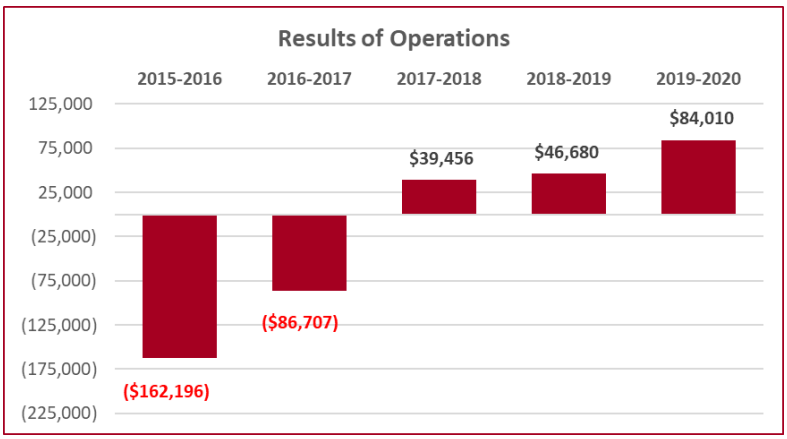
FINANCIAL YEAR IN REVIEW

CCRA ended the 2019-20 fiscal year with an operating surplus due largely to increases in research levies, the addition of a member to the Association and lower than anticipated consulting fees.

Financially, Members' Net Assets at year-end totaled $603K reflecting a 16.2% increase to the level reported at the end of previous fiscal year. These results have left CCRA in a strong financial position to enable it to plan for its 2020-21 fiscal year, $35,000 in funding towards the coal washing research initiative and a $35,000 increase in its research support to CANMET.



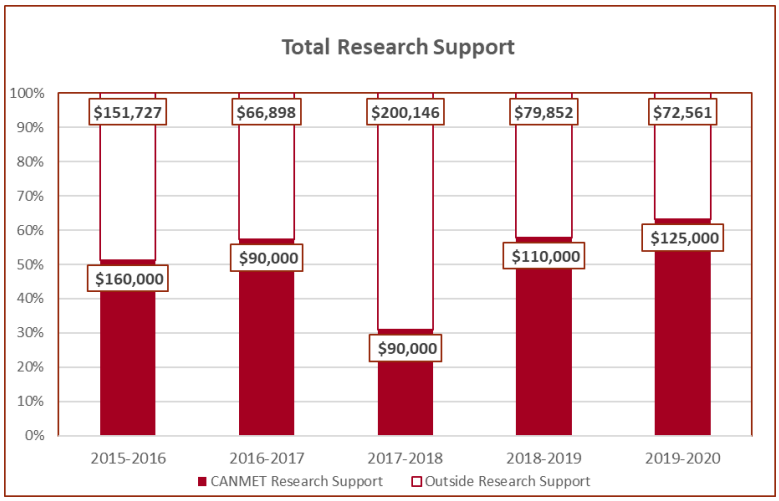
This increase reflects the 2019-20 $84K operating surplus representing the third consecutive modest operating surplus for CCRA following the previous two years of operating deficits. Notwithstanding these recent annual operating surpluses, CCRA continues to operate close to break-even reflecting a cumulative five-year operating deficit of $79,000.



Because of prudent financial planning, CCRA can absorb temporary declines in membership allowing it to continue as a viable Association supporting CanmetENERGY through annual research support payments and confidential oven tests.

In February 2017, CCRA executed an intial funding agreement with Geoscience BC for research funding to study the production of clean coal from Western Canadian Coal Fields using the Water-based Roben Jig Process. By the end of the 2018-2019 fiscal year, CCRA had completed Phase 1 and Phase 2a of this study and had received approval for Phase 2b phase which was substantially completed by the end of the 2019-20 fiscal year.

Over the past five fiscal years, CCRA has invested a total of $1.15M in research support of which $575K or 50.2% was contributed to CanmetENERGY.



With respect to the confidential testing program for Members, CCRA incurred a total of $1.4M in testing during the 2019-20 fiscal year which exceeds the $1.26M annual average program spending over the last five years and is the fourth consecutive year that this program exceeded $1M per year.

CCRA continues to minimize its administrative costs in order to maximize the amounts available to support research programs. During 2019-20, administrative overhead of $28,000 only represented 1.8% of total current year expenditures and were below the levels incurred in 2018-19. This demonstrates CCRA's continued commitment to direct as much of its available resources as possible to research and development inititaives.

In summary, CCRA continues to remain in a strong financial position necessary to support its continued investment in research initiatives supporting the coal and carbonization industries in Canada.

Brian D'Amboise, CPA, CA
Treasurer

AUDITED FINANCIAL STATEMENTS

crawford
smith &
swallow

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Financial Statements

March 31, 2020

crawford smith & swallow

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Financial Statements

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INDEPENDENT AUDITORS' REPORT

To the Members of the
Canadian Carbonization Research Association

Opinion
We have audited the accompanying financial statements of the Canadian Carbonization Research Association, which comprise the statement of financial position as at March 31, 2020, and the statements of operations and changes in members' net assets and cash flows for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements present fairly, in all material respects, the financial position of Canadian Carbonization Research Association as at March 31, 2020, and the results of its operations and its cash flows for the year then ended in accordance with Canadian accounting standards for not-for-profit organizations.

Basis for Opinion
We conducted our audit in accordance with Canadian generally accepted auditing standards. Our responsibilities under those standards are further described in the *Auditors' Responsibilities for the Audit of the Financial Statements* section of our report. We are independent of the Association in accordance with the ethical requirements that are relevant to our audit of the financial statements in Canada, and we have fulfilled our other ethical responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Responsibilities of Management and Those Charged with Governance for the Financial Statements
Management is responsible for the preparation and fair presentation of these financial statements in accordance with Canadian accounting standards for not-for-profit organizations, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, management is responsible for assessing the Association's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the Association or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the Association's financial reporting process.

Auditors' Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditors' report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with Canadian generally accepted auditing standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with Canadian generally accepted auditing standards, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

a) Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

b) Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Association's internal control.

c) Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by management.

d) Conclude on the appropriateness of management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Association's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditors' report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditors' report. However, future events or conditions may cause the Association to cease to continue as a going concern.

e) Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

Niagara Falls, Ontario
June 30, 2020

CRAWFORD SMITH & SWALLOW
CHARTERED PROFESSIONAL ACCOUNTANTS LLP

LICENSED PUBLIC ACCOUNTANTS

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

STATEMENT OF FINANCIAL POSITION

March 31, 2020

Assets	2020 $	2019 $
Current Assets		
Cash	49,322	95,857
Temporary investments	757,607	575,791
Accounts receivable	91,097	17,091
Prepaid expenses	2,496	2,225
	900,522	**690,964**
Liabilities and Members' Net Assets		
Current Liabilities		
Accounts payable and accrued liabilities	32,371	8,961
Government remittances payable	11,511	17,710
Due to CANMET	68,237	
Deferred revenue	185,700	145,600
	297,819	172,271
Members' Net Assets	602,703	518,693
	900,522	**690,964**

Signed on behalf of the Board:

_____ Director

_____ Director

See accompanying notes

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CANADIAN CARBONIZATION RESEARCH ASSOCIATION

STATEMENT OF OPERATIONS AND CHANGES IN MEMBERS' NET ASSETS

for the year ended March 31, 2020

	2020 $	2019 $
Revenue		
Confidential research and development	1,382,493	1,607,390
Research levies	225,000	195,000
Outside research grants	72,561	79,852
Membership fees	800	700
Interest income	10,824	12,795
Other income	3,642	
	1,695,320	1,895,737
Operating Expenses		
Confidential research and development	1,382,493	1,607,390
CANMET research support	125,000	110,000
Consulting	3,000	22,232
Outside research	72,561	79,852
Office	17,853	17,479
Professional fees	7,795	9,539
Insurance	2,608	2,565
	1,611,310	1,849,057
Excess of Revenue over Expenses for the Year	84,010	46,680
Members' Net Assets, Beginning of Year	518,693	472,013
Members' Net Assets, End of Year	**602,703**	**518,693**

See accompanying notes

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CANADIAN CARBONIZATION RESEARCH ASSOCIATION

STATEMENT OF CASH FLOWS

for the year ended March 31, 2020

	2020 $	2019 $
Operating Activities		
Excess of revenue over expenses for the year	84,010	46,680
Changes in working capital components - note 2	51,271	53,649
Funds provided by operating activities	135,281	100,329
Investing Activities		
Increase in temporary investments	(181,816)	(49,430)
Increase (Decrease) in Cash Position	(46,535)	50,899
Cash, Beginning of Year	95,857	44,958
Cash, End of Year	**49,322**	**95,857**

See accompanying notes

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CANADIAN CARBONIZATION RESEARCH ASSOCIATION

NOTES TO FINANCIAL STATEMENTS

for the year ended March 31, 2020

Organization

Canadian Carbonization Research Association (the "Association") is a national organization which initiates, coordinates and provides funding towards research and development having particular importance to the coal and carbonization industries of Canada. The organization was incorporated under the Canada Corporations Act as a not-for-profit association in July 1981. In January 2014, the Association was issued a Certificate of Continuance under the Canada Not-for-profit Corporations Act.

1. Significant Accounting Policies

The financial statements of the Association are the representations of management prepared in accordance with Canadian accounting standards for not-for-profit organizations, consistently applied. Because a precise determination of many assets and liabilities is dependent upon future events, the preparation of periodic financial statements necessarily involves the use of estimates and approximations. These have been made using careful judgement in the light of available information. The financial statements have, in management's opinion, been properly prepared within reasonable limits of materiality and within the framework of the accounting policies summarized below:

Financial reporting framework

The Association, being a not-for-profit organization, chose to establish their financial statements in accordance with Canadian accounting standards for not-for-profit organizations, issued by the Chartered Professional Accountants of Canada.

Revenue recognition

Membership fees, research levies, consulting funding and other income are recognized in the fiscal year for which they have been assessed. Confidential research and development revenues are recognized when the related services are provided.

Financial instruments

The Association's financial instruments consist of cash, temporary investments, accounts receivable, accounts payable and accrued liabilities and due to CANMET. Financial instruments are initially measured at fair value on acquisition and are subsequently measured at amortized cost. Transaction costs and financial fees associated with financial instruments carried at amortized cost are recorded as adjustments to the initial fair value recognized, and amortized over the life of the financial instrument.

Foreign currency translation

These financial statements are presented in Canadian dollars. Assets and liabilities denominated in foreign currencies are translated at the exchange rates in effect at the balance sheet date. Revenues and expenses are translated at rates of exchange prevailing on the transaction date. Gains and losses on translation are reflected in net earnings of the period.

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

NOTES TO FINANCIAL STATEMENTS

for the year ended March 31, 2020

2. Statement of Cash Flows

Changes in working capital components include:

	2020 $	2019 $
Accounts receivable	(74,006)	(17,091)
Sales tax recoverable		2,205
Prepaid expenses	(271)	(500)
Accounts payable and accrued liabilities	23,410	(8,321)
Government remittances payable	(6,199)	17,710
Due to CANMET	68,237	(22,500)
Deferred grant		(63,454)
Deferred revenue	40,100	145,600
	51,271	**53,649**

3. Financial Risks

Transactions in financial instruments expose the Association to certain financial risks and uncertainties. These risks include:

Interest rate risk

Interest rate risk is the risk that future cash flows of a financial instrument will fluctuate due to changes in market interest rates. The Association holds investments that earn income at varying rates of return which are dependent upon market conditions. Accordingly, the Association is exposed to the effects of fluctuations in market rates. Interest received in the year amounted to $ 10,824 (2019 - $ 12,795). As a result of a increase in temporary investments during the year, the Association's exposure to interest rate risk has increased over the prior year.

Credit risk

Credit risk is the risk that a counterparty will be unable to fulfil its obligations on a timely basis or at a reasonable cost. The Association has accounts receivable which are exposed to credit risk. The Association monitors, on an ongoing basis, the credit risk to which the Association is exposed and takes measures to mitigate any risk of loss. Provisions against losses from bad debts are recorded according to credit risk, historical trends, general economic situations and other information. Accounts receivable are net of an allowance of nil. As a result of a increase in accounts receivable during the year, the Association's exposure to credit rate risk has increased over the prior year.

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Schedule 1

UNAUDITED FIVE YEAR FINANCIAL REVIEW

UNAUDITED STATEMENT OF OPERATIONS AND MEMBERS' NET ASSETS

for the year ended March 31, 2020

	2020 $	2019 $	2018 $	2017 $	2016 $
Revenue					
Confidential research and development	1,382,493	1,607,390	1,193,154	1,150,794	944,529
Research levies	225,000	195,000	160,000	90,000	165,000
Outside research grants	72,561	79,852	191,846	6,631	
Consulting funding				3,000	6,425
Membership fees	800	700	400	300	800
Interest income	10,824	12,795	8,094	2,737	5,699
Other income	3,642		1,121		
	1,695,320	1,895,737	1,554,615	1,253,462	1,122,453
Operating Expenses					
Confidential research and development	1,382,493	1,607,390	1,193,154	1,150,794	944,529
CANMET research support	125,000	110,000	90,000	90,000	160,000
Consulting	3,000	22,232	5,800	4,500	3,000
Outside research	72,561	79,852	200,146	66,898	151,727
Meeting					816
Office	17,853	17,479	16,449	19,884	17,192
Professional fees	7,795	9,539	7,045	7,238	7,385
Insurance	2,608	2,565	2,565	855	
	1,611,310	1,849,057	1,515,159	1,340,169	1,284,649
Excess (Deficiency) of Revenue over Expenses for the Year	84,010	46,680	39,456	(86,707)	(162,196)
Members' Net Assets, Beginning of Year	518,693	472,013	432,557	519,264	681,460
Members' Net Assets, End of Year	**602,703**	**518,693**	**472,013**	**432,557**	**519,264**

See accompanying notes

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CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Schedule 1 - continued

UNAUDITED FIVE YEAR FINANCIAL REVIEW

UNAUDITED STATEMENT OF FINANCIAL POSITION

as at March 31, 2020

	2020 $	2019 $	2018 $	2017 $	2016 $
Assets					
Current Assets					
Cash	49,322	95,857	44,958	7,947	261,201
Temporary investments	757,607	575,791	526,361	600,933	682,838
Accounts receivable	91,097	17,091	2,205	4,076	36,669
Prepaid expenses	2,496	2,225	1,725	1,710	
	900,522	**690,964**	**575,249**	**614,666**	**980,708**
Liabilities and Members' Net Assets					
Current Liabilities					
Accounts payable and accrued liabilities	32,371	8,961	17,282	19,940	18,746
Government remittances payable	11,511	17,710			
Due to CANMET	68,237		22,500	22,500	442,698
Deferred grant			63,454	139,669	
Deferred revenue	185,700	145,600			
	297,819	172,271	103,236	182,109	461,444
Members' Net Assets	602,703	518,693	472,013	432,557	519,264
	900,522	**690,964**	**575,249**	**614,666**	**980,708**

See accompanying notes

CCRA HISTORY

The Canadian Carbonization Research Association (CCRA) was formed on September 2, 1965 with the adoption of a Constitution by the Canadian Steel and Coal industries, as a mechanism to promote and establish carbonization research in Canada. Representatives of the major cokemaking steel producers, an independent coke producer, major metallurgical coal miners, coal tar users and the Federal Government Department involved with these Industries were at the table.

The Association's original members were Algoma Steel Corporation, Canmore Mines Ltd, Crows Nest Industries, Dominion Foundries and Steel Limited, Dominion Tar & Chemicals Ltd, Dosco Steel Ltd, The Steel Company of Canada Ltd and The Mines Branch of Energy, Mines and Resources (EMR).

CCRA is a unique co-operative Research and Development effort between Industry and Government, which has became a model for many other industry/government R&D joint efforts. CCRA members and CANMET have a consensus based program that has and continues to meet its members needs over many fruitful years.

The Canadian Carbonization Research Association (CCRA) was formed on September 2, 1965 – 53 years of Research supporting the Canadian Coal and Carbonization Industries

Numerous members have also done and continue to perform many confidential test programs at CANMET to meet their needs directly.

Over the years, CCRA and CANMET have carried out many R&D programs to improve the metallurgical coal and cokemaking operations of its members. Many of these have had far reaching effects which have been well documented in studies carried out by consultants for the government showing the economic effects of the Joint R&D Program (NRCan Audit and Evaluation Branch report, 2001 and PricewaterhouseCoopers report, 2015). The benefits to Canadian industry have been substantial, however, it could not have taken place without the joint efforts of CANMET and CCRA. Having a laboratory to conduct carbonization research is beyond the feasibility of any one company so the single shared Canadian laboratory at Bells Corners in Ottawa, Ontario has allowed the continuation of R&D in this field in Canada.

The fields of R&D covered by the joint CCRA/CANMET program include energy and fuel conservation and efficiency, stabilization of supply, GHG reduction, mining, processing, transportation, production of iron, environment, and safety. At any specific time the R&D program places priority on the most pressing problems while not ignoring the longer term work necessary to progress in the future.

The Early Years

The original members of CCRA and the senior officials of EMR were successful in convincing the Minister of EMR to establish a coal carbonization laboratory in Canada. The first Laboratory was located at The Mines Branch on Booth Street in Ottawa and centered around a 12-inch pilot coke oven and a newly designed sole heated oven. At first, the operation of the equipment was often performed by personnel from CCRA member companies and later CCRA employed personnel for this purpose. In 1968, with the help from CCRA members, a new laboratory facility location was chosen at Bells Corners, 20 km west of downtown Ottawa. EMR provided the building facilities and CCRA members supplied much of the carbonization equipment. A showpiece for the new facility was a new 18-inch movable wall pilot oven. A

30-pound coke oven was also part of the new facilities. In December 1968, the group at the Mines Branch responsible for coal and ironmaking were also relocated to Bells Corners.

Expanding Activities in the 1970s

The coal preparation plant from Booth Street was moved to Clover Bar, just outside Edmonton, AB. Research work was managed by Mr. Jack C. Botham under the direction of the Technical Committee and centered on coal pipelining, additives to coking charges, hot briquetting, formed coke, and petrographic methods for all coals. Arrangements were made to establish a coking facility at Clover Bar to accommodate the Western Canadian Coal producers. Algoma arranged to donate their Koppers pilot coke oven. A mini fluidized bed was constructed for heating coal for hot briquetting as part of the formed coke project and by 1974, this facility was operational. EMR hired Drs. John Gransden and John Price who became the backbone of the Technical program and have gained international recognition as coal carbonization scientists.

In the early 1970s, a major focus for research was the fact that Western Canadian coal contains a significant amount of reactive semi-fusinite compared to traditional Appalachian coals from the USA. During this period, R&D programs focused on petrographic analysis and coking tests helped place Western Canadian coal at the forefront of having excellent coking behaviour and producing excellent coke quality. CCRA has spent much effort explaining the benefits of these coals by using its research program to develop technical projects and has presented numerous papers supporting the technical merits of Western Canadian coals. This work is ongoing today as membership changes.

When the energy crisis developed in 1973-74 concern about energy self-sufficiency and sustainability became very important. This crisis resulted in several oil companies getting involved in the coal mining business. CCRA membership then included Shell Canada, Esso Resources, BP Canada and Gulf Canada.

The organization underwent a substantial change in 1975 when the movable wall coke oven crew switched from being CCRA employees to EMR term employees, to conform with Government policy. CCRA established a new Treasurer system to handle the organization's financial affairs and research funding. This change resulted in the Treasurer's position becoming an appointed officer with full financial authority for the Association. At the time, Mr. George A. Chapman was appointed as Treasurer.

Incorporation of CCRA & Facility Changes – the 1980s

CCRA was incorporated under The Canadian Corporations Act on July 16, 1981, as a non-for-profit Research Association. Letters patent set out the organizational structure with each member company putting forward a representative to the Board of Directors and a Technical Committee member.

The administration of CCRA is the responsibility of the Board of Directors to whom the Officers and other appointed positions report. The objectives of CCRA are set out in the Letters patent:

1. *To conduct Research and Development of importance to the coal and carbonization industries in Canada,*
2. *To co-ordinate and support Canadian carbonization Research in and related to steel, foundry, smelting and coal industries,*
3. *To affiliate with national and international organizations or associations having similar objectives, for the benefit of Canada.*

In the early 1980's, new research studies centered around the correlation of coke and processing conditions from the movable wall oven with that from industrial ovens. Gas and wall pressure measurements in pilot and industrial coke ovens were emphasized. This area of study included a unique study which took place at Algoma Steel's No. 6 coke battery, which was scheduled to be demolished. The study used the battery to carbonize very high-pressure coking blends to determine what the high coking wall pressures would do to an oven and if it could even cause wall failure.

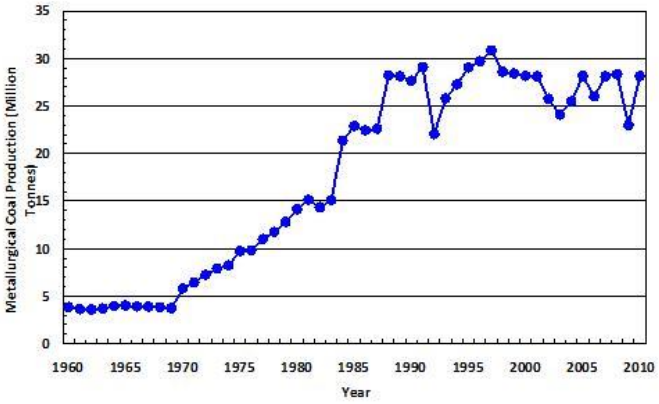
One of the Technical highlights of CCRA at that time was the CCRA/NKK Technical Exchanges between Canada and Japan. Four Technical Exchanges took place, where both sides presented papers on their research work. The delegations generally involved 12 to 15 representatives from each country and was highly successful.

By the latter part of the 1980s, the international energy crisis had subsided, coal and steel prices were dropping, and both industries were entering a period of highly competitive markets. Coal injection into the blast furnace was introduced in Europe and Japan. In that period, many new projects were initiated by the CCRA Technical Committee. Among these were the upgrading of coking quality of Canadian coals through wash plant control, CSR and carbon texture, vertical temperature distribution in a coke oven, and the effect of partial aging/weathering of a component coal on coke quality.

A project to study blast furnace coal injection (PCI) was approved and a special facility was built at Bells Corners. CCRA and Canadian Steel Industries Research Association co-sponsored a study on Strategic Ironmaking with CANMET to review how technologies on ironmaking could evolve in the next 20 years. That study was completed in 1990 and became the road map for the steel industry for many years.

Difficult Times in the Coal and Steel Industries – the 1990s

Canadian coal exports doubled over the 1980s. Research was aimed at reducing the cost of coke and energy for Canadian steelmakers and finding a global niche for Western Canadian coal. With Canadian coke batteries aging, PCI work became very important to coal and steel members. The PCI facilities at Bells Corners was proving its value in the injection program. A CCRA sponsored project at the University of British Columbia on coke oven modeling was completed and the model now resides at CANMET for all to use.



History of Metallurgical Coal Production in Canada

In 1995, CCRA celebrated its 30th anniversary. Because of difficult economic conditions in the Canadian coal and steel industries, membership had declined to eight members and EMR was undergoing a programme review. As a result, CCRA was asked to prepare an impact statement for their review.

By 1997, the CCRA/CANMET fee structure underwent a significant change with confidential oven test work increasing substantially. The Board of Directors approved By-law Number 2 to create a new category of Membership, the Connected Member. This was a category for members who were not financially eligible to join as full members but wished to be part of CCRA.

Consolidation of the Coal Industry and the Challenges of the 2000s

The year 2000 saw another downturn in the steel and coal industries with two of the three Canadian steel members and one coal producer having to discontinue their CCRA memberships because of financial considerations. The reduction in members complicated CCRA's financial situation as the Association had to dip into its limited reserves to maintain its commitments to CANMET. The consolidation of the metallurgical coal producers at the end of 2002 further complicated the financial situation for CCRA as there was now only one coal and one steel member. The Association and CANMET co-operated to keep CCRA as a viable entity and hoped that new members could be attracted when the economy in these industries improved. Dr. Ross Leeder remained as Chairman of the Board of Directors and Mr. Ted Todoschuk as Chairman of the Technical Committee.

The number of metallurgical coal producers was substantially reduced in 2002 with the formation of Elk Valley Coal, which incorporated most of the producers under one organization. That left but only two members to carry the organization with CANMET. The history of important results on coal blend carbonization and the CANMET database that meet members needs made it an easy decision for the remaining ones to carry on.

The CCRA/CANMET R&D program has provided valuable technical information to the Canadian metallurgical coal industry that is accepted by their international customers as reliable, accurate and unbiased. This has allowed Canadian metallurgical coal to compete on the international market against foreign coals and retain jobs in Canada. The export of Canadian coal generates a significant amount of foreign exchange and assists with Canada's balance of payments. Today, Canada is one of the major exporting countries of metallurgical coal globally.

As CCRA celebrated its 40th Anniversary in 2005, the future looked more promising than it had in the last few years, despite the economic ups and downs of the industries represented by the CCRA. The continued CCRA/CANMET partnership benefited Canada as the participating industries gained new information because of the R&D program. International recognition was achieved for the R&D work performed through the CCRA/CANMET partnership.

International recognition has been achieved for the R&D work performed though the CCRA/CANMET partnership

At the end of 2006, Dr. Ross Leeder, the longest serving member of the Board retired from Elk Valley Coal Ltd. Ross had joined the Technical Committee in 1971 when he was a member of the CANMET staff at Bells Corners. He chaired the Technical Committee before moving to the Board of Directors. Ross became Chairman of the BOD in 1989-90 and again in 1999-2006. During the 35 years of his association with CCRA, Ross presented numerous papers on the industry and on the technical merits of Western Canadian coals at Canadian and international conferences.

In 2007, two new coal companies joined as Connected Members, Anglo American Peace River Coal and Western Canadian Coal Corp. and Dr. Barry Ryan, B.C. government geologist, joined as an Individual Connected Member.

In 2008, George Chapman celebrated his 30th anniversary as Treasurer of the Association. Peace River Coal became a full member of the Association and Essar Steel Algoma Inc. joined as a Connected Member. That same year, after a career spanning 35 years, Dr. John Price took retirement from his position as Senior Research Scientist and Manager of Energy for High Temperature Processes at CANMET.

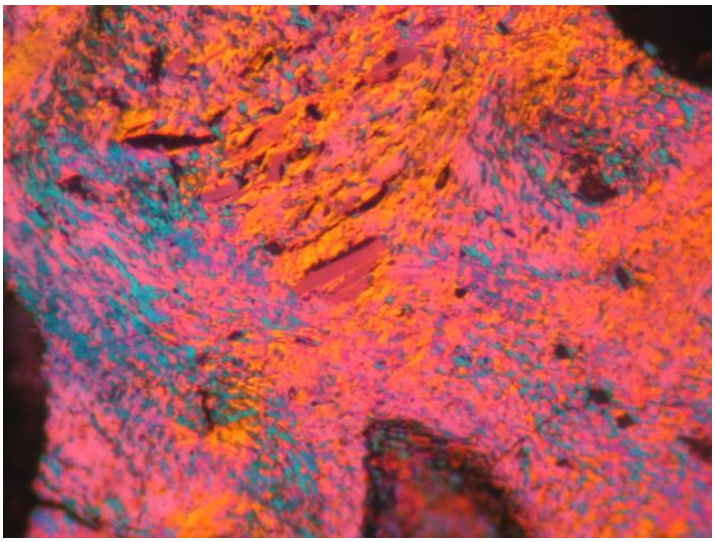
In early 2009, Dr. John Gransden, also Senior Research Scientist in coal carbonization, retired from CANMET. Dr. Gransden received the AIST Joseph Becker Award for career accomplishments in cokemaking research for CCRA and CANMET. The departure of Drs. Price and Gransden, both dedicated research scientists, represented a significant loss to the CCRA within a very short time period. . Furthermore, Dr. Barry Ryan retired from the B.C. Government Ministry of Energy, Mines and Petroleum Resources and, as there was no replacement named, the B.C. Government abandoned its membership.

For several years prior to 2008-09, the Greenhouse gas (GHG) file, as driven by the federal government, became a major thrust of the joint R&D program and the research program reflected that reality.

In 2009, the Technical Committee and the Board of Directors spent a significant amount of time and effort gathering information on the development and financing of a pilot Energy Recovery Pilot coke oven for the joint CCRA/CANMET program to examine this alternative/new cokemaking technology. This endeavour is an excellent example of how CCRA adapts to the changes facing industry.

CCRA's 45th Anniversary - 2010

The 45th anniversary of CCRA's foundation was celebrated in 2010. In 2010-2011, the Association started on a very ambitious project to carry out engineering, design, construction and commissioning of an Energy Recovery Pilot Coke Oven (ERCO) at Bells Corners coal and coke facilities. The ERCO technology is an alternate approach to traditional slot coke oven technology and the fact that pilot facilities using ERCO technology are essentially non-existent, R&D cannot be carried out. CCRA's goal for this project was to put Canada at the leading edge of this technology by having a facility where its members could be able to investigate how coal behaves in this type of oven and generate valuable data to allow the Canadian steel industry to evaluate this alternative technology. This facility would also be used to showcase the cokemaking merits of Western Canadian coals using this technology globally as well as making use of it to conduct research on the incorporating of in coal blends for assessing coke quality.



Due to the capital costs to finance such a large project, CCRA members contributed to a special fund. CCRA also signed a Non-Repayable Contribution Agreement with Natural Resources Canada to assist with the costs. The Canadian Steel Producers Association (CSPA) also contributed to the project. The goal was to secure the funding to enable the construction of the facility. In 2011-12, SunCoke Energy, USA was invited to join CCRA as a strategic partner in developing the energy recovery cokemaking programme as they have owned and operated commercial ovens using this technology for many years.

The 2011–2012 fiscal year saw a growth in CCRA members as US Steel Canada, SunCoke Energy, Inc. joined. Grande Cache Coal Corp., Alberta also rejoined the Association after being absent for some years.

During the 2013/2014 fiscal year, CCRA was obligated to transition from its original letters patent legal structure to comply with the requirements of the new Not-for-Profit Corporations Act. As of January 1, 2013, CCRA received its Certificate of Continuance as Corporation Number 117455-0 Industry Canada.

In 2014-2015, the CCRA with CanmetENERGY's cooperation, provided a website for the Canadian Carbonization Research Association. The website is accessible at *http://www.cancarb.ca/wordpress/* and contains timely information on the CCRA/CanmetENERGY R&D programs and other information related to the Canadian Coal and Coke industry as a whole.

The CCRA celebrated its 50th year milestone of providing research support to the Canadian Coal and Carbonization industries on September 2, 2015.

On September 30, 2016, Mr. George Chapman retired as Treasurer of CCRA. During his 40-year tenure in that function, Mr. Chapman provided important financial and administration stewardship of CCRA and support to the Board of Directors and Members. The Board of Directors appointed Mr. Brian D'Amboise CPA, CA to succeed Mr. Chapman as Treasurer effective October 1, 2017. Mr. D'Amboise has over 25 years of involvement with CCRA as the former external auditor to the Association and provided Mr. Chapman valuable assistance in completing the 2016-17 fiscal year end and related tax returns.

CCRA pursued a number of outside research initiatives during the 2016-17 fiscal year. The Association continued work on the ISO Inter Laboratory Study on Coal Dilatation initiated in 2015-2016 and entered into a new research funding arrangement with Geoscience B.C. to support a study aimed at producing clean coal from Western Canadian Coal Fields using the water-based Roben Jig process. In addition, further studies on coal stamp charging and small-scale coking were developed to meet members future needs.

During 2017-18 fiscal year, the CCRA wrote four papers for presentation at AISTech 2017 in Nashville, USA and a report on Producing Clean Coal from Western Canadian Coalfields using the Water-Based Roben Jig Process in Geoscience BC Summary of Activities 2017. It made a presentation on this work at CoalSMART 2018 and organized two Working Group meetings on use of Biocarbon in Canadian Steel Industry (November 2017 and January 2018).

As well, the new PCI experimental rig at CanmetENERGY-Ottawa was upgraded to allow for better control of coal feeding rate and hot blast composition. A new approach was developed in processing the experimental data including the introduction of two new parameters to quantify the extent of gasification of coal Volatile Matter and Fixed Carbon and a new approach using TGA was developed to quantify the reactivity of combustion residues. Going forward, work will focus on enhancing the rig's capability in terms of NG/COG co-injection, blast gas moisture control and off-gas analysis.

On the use of renewable energy for the steel industry, research was pursued on several fronts including (1) Pyrolysis Technology Evaluation (2) Bio-Carbon for EAF Steelmaking (3) Bio-Briquette Formation (4) Bio-Carbon for Direct Injection in Blast Furnace Ironmaking (5) Biochar Production and Handling.

In 2018-19, the CCRA published three papers in peer-reviewed journals on (i) *"Value-In-Use of Renewable Biocarbon for Direct Injection in Blast Furnace Ironmaking"* in Ironmaking and Steelmaking journal (ii) *"Development of novel method for quantitative determination of carbon chemical reactivity"* in Canadian Journal of Chemical Engineering and (iii) *"Carbonaceous material properties and their interactions with slag during electric arc furnace steelmaking"* in Metallurgical and Materials Transactions B**;** it wrote papers for presentation at AISTech 2018 in Philadelphia, USA, for 8th International Conference on Science and Technology of Ironmaking in Vienna, Austria and a report on Producing Clean Coal from Western Canadian Coalfields using the Water-Based Roben Jig Process: Refining the Process in Geoscience BC Summary of Activities 2018. It made a presentation on this work at Western Canadian Coal Society in February 2019 and organized four Working Group meetings on use of Biocarbon in Canadian Steel Industry (April, June and November 2018 and March 2019).

Again in 2018-19, the CanmetENERGY Bioenegy group was a strong partner and made valuable contributions in assessing existing biomass conversion technologies, in the handling and cleaning and processing and carbonization. The Biocarbon for Iron and Steel production and other large emitters' project successfully secured S&T funding until March 2022.

In 2018-19, four meetings of the CCRA-Biocarbon for Steel Working Group were held at CanmetENERGY-Ottawa. These meetings were successful in advancing the discussion and interest level among the numerous project partners.

Going forward, the CCRA Biocarbon for Steel Working Group and its members need to better define their plan and vision to 2025 around biomass production, supply, utilization, etc., including potential barriers at each level.

CCRA's key accomplishments through the years

The CCRA and its members can be very proud of its accomplishments over the five decades since its inception. It is difficult to list all the accomplishments, but numerous papers and presentations have been made available to interested research organizations. Significant highlights include:

- The 2015 PricewaterhouseCoopers report showed the value of the research program and the significant positive financial impact of CCRA research on the Canadian GDP.
- Enhancing the understanding of the technical merits of Western Canadian coals in international markets leading to significant sales globally.
- Metallurgical coal resource development in Canada using CanmetENERGY-Ottawa pilot scale coal and coke facilities, equipment and expertise.
- Development of unique coal and coke testing techniques to support CCRA member needs.
- Lower fuel rates and GHG reductions in the Canadian steel industry with coke quality improvements.
- Improved energy efficiency for Canadian Ironmakers with the use of pulverized coal injection.
- Development of a biocarbon strategy to significantly reduce GHG emissions in the steel sector through multiple pathways.
- Engagement with strategic biocarbon supply chain producers to initiate a bio economy with the steel sector.
- Ensuring the development of suitable coal and coke quality standards to support the competiveness of the Canadian coal and steel industries.

Going Forward

The uniqueness of the CCRA program is that it is able to adapt well to current and future needs of its members. The CCRA has recently embarked on R&D projects with international researchers in Australia, France, Japan, Sweden, USA and this has allowed the development of global partners and programs. In addition, the CCRA is pursuing significant GHG reduction initiatives with both the coal and steel sectors as this is fast becoming a very significant global directive for these industries. In brief, the CCRA is examining ways to achieve carbon-neutral ironmaking in the middle to long-term (2030-2040) by partnering with Canadian and international partners.

Aligning the R&D Program with current and future needs of its members and industry, the CCRA has developed the following program areas:

Program Title	Program Objectives
Fundamentals of Coal Science	• To understand the fundamental science of metallurgical coal for supporting efficient exploration and product quality improvement to improve global competiveness of Western Canadian Coal.
Blast Furnace Ironmaking Carbon Efficiency Enhancement	• To advance pulverized coal injection technology for improving carbon efficiency of blast furnace ironmaking. • To improve quality of metallurgical coke by understanding the fundamental science of cokemaking and coke utilization for supporting high carbon efficiency blast furnace ironmaking.
Substitution of Fossil Carbon by Renewable Biocarbon in Pyrometallurgy Processes	• To reduce GHG emissions associated with pyrometallurgical metal production processes in Canada. • To develop technology for enabling substitution of fossil carbon by biocarbon in pyrometallurgical sectors. • To develop biocarbon supply chain to support metal production sectors.
Carbon Neutral Ironmaking Technology Development	• To develop technology for achieving carbon neutrality ironmaking in Canada by embracing different technologies (BioCarbon, H_2, Electron, CCUS).

1965-2020 CHAIR OF BOARD OF DIRECTORS

Year	Name	Company
1965 – 1966	C.W. Draker	Algoma Steel Limited
1967 – 1968	F.J. Pearce	The Steel Company of Canada Limited
1969 – 1970	J.E. Ludberg	Dominion Foundries and Steel Limited
1971 –1972	J.S. Anslow	The Steel Company of Canada Limited
1973 – 1974	J.O. Thomas	DEVCO
1975 –1976	A.M. Cameron	Algoma Steel Limited
1977-1977	J.T. Collier	DEVCO-SYSCO
1978 – 1979	W.A. Riva	Kaiser Resources Limited
1980 – 1980	J.E. Ludberg	Dofasco Limited
1981 – 1982	A. Johnson	Gulf Resources Limited
1983 –1984	A.W. Kay	Stelco Inc.
1985 – 1986	R. Sagi	Denison Mines Limited
1987 – 1988	W. Becken	Dofasco Inc.
1989 – 1990	W.R. Leeder	Denison Mines Limited
1991 – 1992	K. Carnes	Fording Coal Limited
1993 – 1994	H. Stelmach	Line Creek Resources Limited
1995 –1996	T. Benner	Dofasco Inc.
1997 –1998	W. Jonasson	Algoma Inc.
1999 – 2000	W.R. Leeder	Teck Corporation
2001 – 2002	W.R. Leeder	TeckCominco Corp.
2003 – 2006	W.R. Leeder	Elk Valley Coal Limited
2007 – Current	T. Todoschuk	ArcelorMittal Dofasco Inc.

2019-2020 BOARD OF DIRECTORS

COMPANY	NAME	PHONE (FAX)
Algoma	Mr. Cory Evans Superintendent, Cokemaking Algoma 105 West Street Sault Ste. Marie, ON, P6A 7B4 cory.evans@algoma.com	705-297-0555 (705-945-4189)
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CanmetENERGY	Dr. Brian Farnand S&T Director, Industrial Innovation Group CanmetENERGY Natural Resources Canada 1 Haanel Drive Ottawa, ON, K1A 1M1 bfarnand@nrcan.gc.ca	613-996-7977 (613-995-9728)
Elkem Métal Canada Inc.	M. Jean-Denis Tremblay Engineering/Maintenance Manger Elkem Chicoutimi, Foundry Products 2020, chemin de la resérve Chicoutimi, QC G7J 0E1 jean-denis.tremblay@elkem.com	418-549-9917 ex. 260 Cell: (418)-820-6612
North Coal	Mr. Toby Stier Resource Geologist North Coal 5000 Hwy 43 Sparwood, BC V0B 2G1 tstier@northcoal.ca	Cell: 250-423-1312
Stelco	Mr. John D'Alessio Director - Process Technology Stelco - Lake Erie Works BF Control Building, 2nd Floor 2330 Regional Road #3 Nanticoke, ON N0A 1L0 john.dalessio@stelco.com	(519) 587-4541 Ext. 5270 Cell: (905)-308-1253
SunCoke Energy, Inc.	Dr. John Quanci Vice President, Engineering and Technology SunCoke Energy, Inc. Suite 600, 1011 Warrenville Road Lisle, IL USA 60532 jfquanci@suncoke.com	630-824-1941 Cell: 610-496-5989
Teck	Dr. Rob Stephens Director, Applied Research and Technology Teck Metals Ltd. PO Box 2000 Trail, BC V1R 4S4 rob.stephens@teck.com	250-364-4295 Cell: 250-521-0136 (250-364-4339)

2019-2020 CORPORATE OFFICERS

CCRA Position	COMPANY	NAME	PHONE (FAX)
Chairman	**ArcelorMittal Dofasco Inc.**	Mr. Ted Todoschuk Principal Researcher ArcelorMittal Dofasco Global R&D - Hamilton 1390 Burlington St. E Hamilton, ON, L8N 3J5 *ted.todoschuk@arcelormittal.com*	905-548-4796 (905-548-4653)
Vice Chair	**Teck**	Dr. Rob Stephens Director, Applied Research and Technology Teck Metals Ltd. PO Box 2000 Trail, BC V1R 4S4 *rob.stephens@teck.com*	250-364-4295 Cell: 250-521-0136 (250-364-4339)
Secretary	**CanmetENERGY**	Dr. Louis Giroux Research Scientist CanmetENERGY Natural Resources Canada 1 Haanel Drive Ottawa, ON K1A 1M1 *louis.giroux@canada.ca*	613-996-7638 (613-995-9728)
Treasurer	**Brian G. D'Amboise Chartered Professional Accountant**	Mr. Brian D'Amboise, CPA, CA Chartered Professional Accountant *BGDCA@sympatico.ca*	905-938-2984

2019-2020 TECHNICAL COMMITTEE MEMBERS

COMPANY	NAME	PHONE (FAX)	ALTERNATE OR CO-MEMBER
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ArcelorMittal Dofasco Inc.	***VICE CHAIR:*** Mr. Ted Todoschuk Principal Researcher ArcelorMittal Dofasco Global R&D - Hamilton 1390 Burlington St. E. Hamilton, ON L8N 3J5 ted.todoschuk@arcelormittal.com	905-548-4796 (905-548-4653)	Mr. Graeme Scott Researcher ArcelorMittal Dofasco Global R&D - Hamilton 905-548-7200 x6619 graeme.scott1@arcelormittal.com
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Teck	Dr. Qun Zhang Senior Researcher Teck Metals Ltd. PO Box 2000 Trail, BC V1R 4S4 qun.zhang@teck.com	250-364-4422 Cell: 250-921-4269 (250-364-4400)	Mr. Shea Ferguson Senior Engineer Supervisor, Quality Teck Coal, Technical Marketing 609 Douglas Fir Rd, P.O. Box 3000 Sparwood, B.C. V0B 2G0 Cell: 250-433-7102 shea.ferguson@teck.com
Stelco	Mr. John D'Alessio Director - Process Technology Stelco - Lake Erie Works BF Control Building, 2nd Floor 2330 Regional Road #3 Nanticoke, ON N0A 1L0 john.dalessio@stelco.com	519-587-4541 Ext. 5270 Cell: 905-308-1253	Ms. Nancy Ward Process Engineer - Process Technology Stelco - Lake Erie Works BF Control Building, 2nd Floor 2330 Regional Road #3 Nanticoke, ON N0A 1L0 519-587-4541 Ext. 5012 Cell: 519-410-3453 nancy.ward@stelco.com
Algoma	Mr. Anurag Talati Chemical Engineer Coke Making Technical Raw Material and Process Specialist 105 West Street Sault Ste. Marie, ON P6A 7B4 anurag.talati@algoma.com	705-206-1160	TBD

COMPANY	NAME	PHONE (FAX)	ALTERNATE OR CO-MEMBER
SunCoke Energy, Inc.	Dr. Jonathan Perkins Senior Scientist SunCoke Energy, Inc. Suite 600, 1011 Warrenville Road Lisle, IL USA 60532 jhperkins@suncoke.com	630-824-1938 Cell: 610-858-7706	Dr. John Quanci Vice President, Engineering and Technology SunCoke Energy, Inc. Suite 600, 1011 Warrenville Road Lisle, IL USA 60532 Cell: 610-496-5989 jfquanci@suncoke.com
North Coal	Mr. Toby Stier Resource Geologist North Coal 5000 Hwy 43 Sparwood, BC V0B 2G1 tstier@northcoal.ca	Cell: 250-423-1312	TBD
Elkem Métal Canada Inc.	M. Jean-Denis Tremblay Engineering / Maintenance Manager Elkem Chicoutimi Foundry Products 2020, chemin de la réserve Chicoutimi, QC G7J 0E1 jean-denis.tremblay@elkem.com	418 549-9917 ext. 260 Cell: 418 820-6612	TBD
Pearson Coal Petrography	Dr. David Pearson Founder & CEO, Pearson Coal Petrography #1-740 Discovery St., Victoria, BC V8T 1H2 dpearson@coalpetrography.com	778-433-2982 Cell: 312-953-7900	Mr. Rich Pearson President, Pearson Coal Petrography #1-740 Discovery St., Victoria, BC V8T 1H2 Cell: (312) 953-7996 rpearson@coalpetrography.com
CCRA Guest Member	Ms. Melanie Mackay Professional Geoscientist 3360 Georgia Street Richmond, BC, V7E 2R6 mmackaygeo@gmail.com	604-323-6692	Not Applicable
CCRA Consultant	Dr. Barry Ryan 62 Larson Road Gibsons, BC V0N 1V3 bryan@islandnet.com	604-886-1906	Not Applicable
CCRA Consultant	Dr. John Price 28 Nanook Crescent Ottawa, ON K2L 2A7 j.t.price@rogers.com	613-592-4397	Not Applicable
Sr Technical Consultant Teck Coal Ltd.	Dr. Ross Leeder 12686 Ocean Cliff Drive Surrey, BC V4A 6N1 ross.leeder@teck.com	604-531-1944 Cell: 604-317-7412	Not Applicable

Appendix 1 - 2019-2020 CCRA Technical Committee Active Planning Table				
Program	**Projects**	**Project Objectives**	**Project Tasks**	
Fundamentals of Coal Science	CCRA 80: Characterization of Coal Washing Plant Streams and Product Quality Upgrade	To characterize the metallurgical properties of mine circuits to better understand how to improve coke quality and hence energy efficiency for both the coal and steel industries. To determine which "oxidation/aging" parameters best reflect the caking/coking ability of each circuit and coal.	**On Hold**	**On Hold**
	CCRA 86: Performance of Canadian Coals in High Inert Blends	To understand how Western Canadian coals, behave/work in high inert blends.	**On Hold**	A report to be prepared by Ross and John to summary the results of stage 1 and 2 of the projects
	CCRA87: Technical Merits of Western Canadian Coals	To develop fundamental studies that show the technical merits of Western Canadian coals. To package existing technical information/data and gather new analysis data for highlighting the fact that Canadian coals prove to make high quality coke for modifying perception of marketing representatives.	**On Hold**	AIST 2013: Predictive Model for Blending Coking Coals Part 1 Canadian Coal AIST 2015: Predictive Model for Blending Coking Coals Part 2 US Coal METEC 2015 Predictive Model for Blending Coking Coals to Produce High Strength Coke
	CCRA 90: Exploration Sample	To investigate alternative environmentally	**Preliminary Study**	Effects of Organic Liquids on Western Canadian Coking Coals Fuel Processing Technology 2017: Effects of organic liquids on coking properties of a higher-inert Western Canadian Coal

	Assessment for Current and New Mines in Canada	friendly methods to prepare/produce exploration coal samples for further assessment.		Preliminary evaluation of Australian Boner Jig facility performance on WCC Completed: The jig worked (2016)
			Roben Jig Technology Development	• Phase 1: Roben Jig Facility Setup in Canada ○ Completed: Commissioning with 4 coal samples (3SEBC and 1 NEBC) (2017)
				• Phase 2a: Performance of Roben Jig on clean coal sample preparation ○ Completed Able to make a clean coal composite that matched the plant sample Misplace material in the Jig was found and measured Jigging with narrow size fraction was impractical Re-jigging helped to remove some misplaced material. +1.54SG material decreased from 6% to 2%
				• Phase 2b: MWO evaluation of coking performance of sample prepared by Roben Jig (A3) ○ Single seam plant coal samples collection Raw coal feed and clean coal Raw coal feed process Organic liquid and Roben jig Coal properties comparison: Plant clean coal vs Organic liquid vs Roben jig Bulk jigging Develop methodology for jigging large mass of raw coal MWO carbonization Coke quality comparison: Plant clean coal vs Organic liquid vs Roben jig
			Alternate liquid for Float/Sink coal washability study	Potential alternative liquid candidate (A3) Novec 7000 (1.40 SG) and Novec 7700 (1.797 SG) Mix to form solution with SG 1.40 to 1.797 Collect clean coal samples from mine site wash plant Potential candidates screening Treat clean coal in potential candidates Compare coal properties before and after treatment Eliminate if coal properties change Alternative liquid performance evaluation Collect raw coal sample: several type Treat raw coal with traditional PCE float/sink, Roben jig and alternative liquid Compare coal properties after treatment Carbonization of treated coal and compare coke quality
	CCRA 93: Performance of Western Canadian Coal in Stamp Charge Technology	To develop stamp charge capability in CanmetENERGY To assess the performance of Western Canadian Coal in stamp charge	**Canmet Stamp charge capability development**	Apparatus fabrication and procedure development Completed: Can achieve 978 kg/m^3 dry BD without crushing down the coal
				Benchmark single compartment box stamp charge with gravity charge results (A3) Completed: Gravity charge vs box charge at 810 kg/m3 vs box charge at 925 kg/m3
			Stampability of WCC and Coal Cake Strength Characterization (A3)	Base stamp charge coal blend selection Formulation of base blend for carbonization test Data on CPM stamp charge study was shared with TECK Lit review: CCRA 91:001/2019: A Review of Literatures on Stamp Charge Technology Marketing review (TECK) Ted will lead the discussion among steel members for compiling available coal data Data will be sent to Teck for discussion on possible stamp charge base blend formulation Canmet will conduct small scale stamping test with coal at 100% <1/8" at 10% moisture for achieving 1000 kg/m3 BD (dry)

				Teck will develop a carbonization test plan and stampability test plan for discussion in Dec meeting
				Establish collaboration with University NSERC Grant Application UQAC Equipment Description ON HOLD: Funding option with 100% NSERC not ready for apply yet
			Coking performance of WCC in stamp charge technology	Carbonization Plan Development Pilot scale stamping equipment develop in Canmet Define carbonization test parameters Develop factorial experimental design
				Experimental plan execution Not started yet
Fundamentals of Cokemaking and Coke Quality	CCRA 81: Mineral Matter and Coke Reactivity	To understand the effect of mineral type and size on coke quality To understand the mineralogy characteristics of in-situ mineralogy of Western Canadian Coal To understand the role of washing in coal mineralogy control	**Preliminary Study**	ISS-AIME Ironmaking 1994: Minerals in Coal and High Temperature Properties of Coke AIST 2014: Mineral Matter Transformation in Small-Scale Coke Oven for Evaluation of CSR/CRI
			Effect of mineral type and size on coke quality (A3)	Mineral addition at small and large mineral size Completed: SHO carbonization of WC MV and US HV with 1% mineral addition at different size AIST 2017 Effect of Coal Mineral Type and Size on Coke Strength After Reaction Eurocoke 2019: Effects of Mineral Type and Size on Coke Quality AIST 2019: Effect of Coal Mineral Type and Size on Coke Strength After Reaction Effect of mineral addition on resultant texture
				Mineral Type and Size Characterisation Technique Development Coal Mineral Characterisation MLA technique demonstration completed CCRA Report: To be prepare by Qun Zhang MLA technique overview Examples to illustrate interpretation of MLA data for type and size characterisation Coke Mineral Characterisation Send coke sample to U of A for technique development Role of mineral type and size on CSR prediction (A3) Select coal samples (US and WCC) with CSR do not align with prediction One US LV and one WCC coal samples were selected Coal properties analysis in progress SHO carbonization of the selected samples Completed: US LV (CSR: 49.9; CRI: 34.2). WCC (CSR:70.6; CRI:23.5) Perform MLA analysis of both coal and resultant coke Coal and coke samples were sent to U of A for MLA analysis MLA analysis of both coal and coke samples for mineral size and type characterisation Determine role of mineral type and size on prediction discrepancy
			Characteristics of in-situ minerals in Western Canadian Coal and resultant coke	Not yet started

			Inclusion of mineral type and size effect in CSR prediction model	Not yet started
			Coal mineral control	Not yet started
	CCRA 82: Factors Affecting Coke Bed Permeability	To understand the effect of coke size and shape on bed permeability and coke strength measurement	**Image analysis technique to characterize size and shape of coke**	Completed AIST 2013 Coke Size and Shape Characterisation for Bed Permeability Estimation
			Relationship between coke size and shape and bed permeability	Completed AIST 2017 Factors Affecting Coke Bed Permeability
			Coke size and shape evolution in stabilization (A3)	Carbonization for coke sample preparation To be carried out in 2019 oven benchmarking 100%US 65%US-35%WCC Effect of WCC on fissure free size Pick 25kg IRSID coke sample for extended IRSID Effect of WCC on size and shape evolution in stabilization Pick 50kg IRSID sample to perform image analysis for determining size and shape characteristics Drop sample from 10 ft Redo image analysis on stabilized sample Repeat process up to 5 drops
			Effect of coal properties on coke size and shape	To be discussed
	CCRA 84: Coke Degradation Mechanisms	To understand the effect of coal properties, carbonization conditions and handling on coke degradation mechanism	**On-hold**	AIST 2005 Stabilization of Blast Furnace, Sampling Station, Wharf And Pilot Oven Cokes from Canadian Steel Mills AIST 2011 Implementation of Coke Stabilization at ArcelorMittal Dofasco AIST 2017 CanmetENERGY's Experience on Performing High-Temperature Dilatation Measurements
	CCRA 88: Application of Small Scale Coking	To develop and demonstrate carbonization methods for small (<350kg) coal samples	**Preliminary Study: SHO CSR**	Completed Fuel 2013: Small scale determination of metallurgical coke CSR
			Minimum oven capacity	Assessment of coke size distribution of pilot scale oven Completed
				Requirement of coke with particular size for different quality assessment Completed
				Development of coke quality assessment strategy with limited sample Completed
				Recommendation on minimum oven capacity 90 kg coal charge Produce sufficient coke sample to conduct quality analysis CSR/CRI + Single drum ASTM tumbler + ASG + (IRSID or JIS) Report on assessment of ACARP MWO round robin Conclusion:

				NOT to build another a new small oven Use multicompartment box charge to reduce coal demand
			Canmet multi-compartment box charge capability development	Development of box charge technology in CanmetENERGY Completed
				Multi-compartment box charge capability demonstration (A3) Completed: First set of MWO tests Gravity, 1 compartment, 2 compartment and 3 compartment charge Demonstrate capability to conduct multi-compartment box charge
			Benchmarking of multi-compartment box charge with gravity charge	Benchmarking of multi-compartment box charge with gravity charge (A3) Gas pressure and center temperature measurement Instrumentation Completed: Design, fabricate and functionality test of combine P and T combined measurement probe Equipment test in 2019 oven benchmarking Two compartment carbonizations Coal Sample Selection Select 3 WCC samples for testing Schedule for 2 compartment box charge and gravity charge carbonization tests Carbonization tests Benchmark with gravity charge Measure gas pressure and center temperature of both compartments during carbonization Eliminate stabilization step to allow direct comparison between compartments Add extended IRSID to coke evaluation for fissure free size determination Determine variability in coke quality between compartments Three compartment carbonizations Not yet started
	CCRA 94: High Temperature Properties of Coke	To understand the high temperature (>1100C) properties of coke	**On Hold**	
Energy and CO2 Reduction in Cokemaking and Ironmaking	CCRA 70: GHG Reduction Using Renewable Energy for the Steel Industry	To minimise GHG emissions in the Canadian steel industry To explore the potential of reducing GHG footprint of Canadian metallurgical coal for export To explore the use biocarbon for nonferrous metallurgy in Canada To promote bio-based carbon in	**Preliminary Study**	METEC 2011: Biofuel Ironmaking Strategy from a Canadian Perspective: Short-Term Potential and Long-Term Outlook AIST 2010: Direct Injection of Biofuel in Blast Furnace Ironmaking Iron and Steel Technology 2012: Combustibility of Charcoal for Direct Injection in Blast Furnace Ironmaking SCANMET IV 2012: SELECTION OF BIOFUEL FOR DIRECT INJECTION IN BLAST FURNACE IRONMAKING AIST 2012: Incorporation of Charcoal in Coking Coal Blend – A Study of the Effects on Carbonization Conditions and Coke Quality Fuel Processing Technology 2011: Reactivity of bio-coke with CO2 AIST 2011: Biofuel Use in Ironmaking From a Lifecycle Analysis Perspective AIST 2012: Wood Pellets for Ironmaking From a Life Cycle Analysis Perspective
			Raw Biomass Supply	Evaluate feedstock type, location, quality, and quantity Quebec forestry residue: Completed: Quebec woodchip association report Ontario sawmill residue: To be completed by Ralph Spaan and CRIBE

		Canadian bioeconomy To develop a value chain for use of bio-materials for Canadian industry		C&D wood supply Complete: Ecostrat report Possibility of using Lignin as feedstock On Hold
			Pyrolysis Technology Assessment and Development (Project Owned by Bioenergy Group)	Assessment of existing pyrolysis technologies Completed Bioenergy Group Report: Biomass Carbonization Technology, Producers and Products
				Establish benchmark reference on effect of feedstock (Saw dust, Roadside, Barks and C&D Wood) and pyrolysis technology (torrefaction, fast pyrolysis and HTC) on product properties Completed CCRA Report (CCRA70:001/2018): Pyrolysis Technology Benchmarking Research Report
				Further develop HTC process CanmetENERGY 20L HTC performance on C&D wood On hold due to focusing on H&M balance work
				Rail Ties/Decommissioned Poles for PCI (A3) Removal of Creosote from railway ties Small scale pyrolysis of chipped railway ties 450 C;450 C: 30 min Solid product contains no creosote Creosote content in liquid and gas stream: TBD Next step: to be define
				Explore feasibility to utilize pyrolysis co-product in steel production H&M balance study of C&D "A" and "B" grade wood pyrolysis Lab scale experiment completed Benchmarking with industrial scale measurement Report
				Integrated Carbonization and Densification (ICD) Development On-going (Guy's Group)
				Develop technology for ash content control Acid washing of CHAR biocarbon sample produced from C&D "A" grade wood with Acetic Acid (1.3% and 8.0%) and synthetic wood vinegar (Acetone + Methanol) Can reduce total ash content up to 30-40% Ca and Mg account for majority of ash reduction Na, K and P content not significant affected by acid washing CCRA Report (CCRA70:009/2019) Effect of washing biochar with various acidic media on ash content and composition Incorporate acid wash result in H&M balance calculation to examine implication of acid wishing in blast furnace operation CCRA Report (CCRA70:010/2019) Effect of Biocarbon Acid Washing on Blast Furnace Operation Study the mineral form of ash in before and after wash samples Examine effect of temperature on acid removal efficiency Washing raw feedstock vs washing of pyrolysis product
			Utilization of Solid Biocarbon in Steel Production	Develop biocarbon VIU in evaluation methodology Completed AIST 2017: Suitability of Bio-Chars from Different Production Technologies for Direct Blast Furnace Injection

				Ironmaking and Steelmaking 2018: Value-In-Use of BioCarbon Fuel for Direct Injection in Blast Furnace Ironmaking
				Handling and Storage of Biocarbon Bio-pellet/briquette quality evaluation standard procedures development (Guy's Group) OPG Bio-Pellet Assessment Program result Comparison between established standard for coke and/or iron ore with standard to be developed for densified biocarbon Co-grinding of biocarbon and HV-LV coal (A3) Rolling ball grinding using HGI apparatus Loose vs briquetted biocarbon Fixed sample mass (50g) vs Fixed sample volume (75ml) Conclusion: Follow ASTM HGI procedure for Biocarbon or Coal-Biocarbon mixture AIST 2019: Grindability of Solid Bio-Carbon CCRA Report (CCRA 70:007/2019): Rolling Mill Co-Grinding of Biocarbon and Coal
				Incorporation of Solid Biocarbon in Cokemaking by Briquetting with Coal Incorporation of biocarbon via partial briquetting SHO carbonization (A3) Completed AISTech 2019: Incorporation of BioCarbon in Cokemaking via Partial Briquetting METEC 2019: Incorporation of biocarbon in blast furnace ironmaking MWO test with 20% bio-briquette (A3) To be conducted with 2019 oven benchmarking (CCRA 92) Bio-Briquette to be prepared by biocarbon supplier Bio-Briquette successfully produced Confirm with supplier bio-briquette composition needs to be changed from originally planned 50%Coal-38%Biochar-12%Bio-Oil to 50% Coal-25%Biochar-25Bio-Oil to produce acceptable briquette using supplier facilities If true, need to examine the effect of increase in binder on coking performance SHO carbonization will be performed for validation prior to MWO test
				Direct Injection of Solid Biocarbon in Blast Furnace Bio-char injection rig test: Substitution of HV PCI Coal (A3) Completed CCRA Report (CCRA 70:002/2019): 25% Substitution of High Volatile PCI Coal by Biocarbon CCRA Report (CCRA 70:004/2019): 50% Substitution of High Volatile PCI Coal by Biocarbon Substitution of HV vs LV in HV-LV PCI Coal Mixture (A3) Substitution by Loose Biocarbon CCRA Report (CCRA 70:006/2019):Substitution of HV-LV PCI Coal Mixture by Loose Biocarbon Effect of Biocarbon Composition on Suitability for PCI Substitution (A3) Completed Effect of Biocarbon Densification on PCI Substitution Performance (A3) Completed CCRA Report (CCRA 70:008/2019): Effect of Physical and Chemical Properties of Biocarbon on Suitability for Direct Injection in Blast Furnace Ironmaking

				Optimization of PCI coal substitution by densified high FC biocarbon (A3) 0%, 25%, 50%, 75% and 100% substitution HGI Injection rig test Blast furnace modeling
				Nut coke replacement Small Scale Bio-Pellet Strength Evaluation (A3) Completed CCRA Report (CCRA70: 003/2019): Bio-Pellet for Nut Coke Replacement Large Scale Bio-Pellet Strength Evaluation (A3) Bio-Pellet Compressive strength Completed: Bio-nut coke strength is about 1/2 of nut coke 1/5 MICUM tumbling test with iron ore pellet Completed: Break down and fine generation is similar between iron ore with 5% nut coke and 5%bio-nut coke 1/5 MICUM tumbling test of nut coke and bio-nut coke Compare result to standard ASTM drum tumbling Set up HTF for reducibility test Require HTC (See HTC re-commissioning update)
				EAF Steelmaking Substitution of Charge carbon by biocarbon Completed: No effect on steel and slag composition Substitution of Injection carbon by biocarbon Poor wetting results in very limited foaming Injection test on hold until wetting issue is resolved Report CCRA Report (CCRA 70: 005/2019): Biocarbon for EAF Steelmaking Met Trans B 2019: Carbonaceous Material Properties and their Interaction with Slag during Electric Arc Furnace Steelmaking AIST 2019 Biocarbon Materials in EAF Steelmaking Effect of raw biomass feedstock and densification on wetting behavior Softwood biocarbon shows better wetting by slag than hardwood biocarbon Densification further enhance wetting behavior of softwood biocarbon Hypothesis: Biocarbon is too reactive and reduce Fe_2O_3 in slag at temperature below melting point of Fe Formation of solid Fe at biocarbon/Slag interface Prevent further reaction to occur that leads to poor foaming performance Molten Fe wet on biocarbon surface Prevent contact of biocarbon and slag even at temperature above Fe melting point Validation of hypothesis (A3) Factsage model: liquidus temp vs Fe_2O_3 content in slag Repeat Tensiometer experiment with softwood biocarbon/slag up to 1450 C Check experiment product by EDX to confirm formation of Fe at interface Perform Tensiometer experiment with softwood biocarbon/Fe to observe wetting behavior
				Proof of concept trials Support industrial partners for demonstration trials

				Assist in determining technical resources required to develop bio-economy
			Future work	Life Cycle Analysis Establish university collaboration
				Biocarbon application in Canadian Non-ferrous metal production Biocarbon for Ni production
				Monitoring international activities Literature review on alternate ironmaking technology development
	CCRA 77: Energy Recovery Cokemaking	To prepare Canadian steel industry transition to ERCO cokemaking technology To improve energy efficiency and reduce criteria air contaminates and particulates emissions of Canadian steel industry	**Pilot Scale ERCO Construction**	Completed: Idling at 150 C AIST 2014: Energy Recovery Pilot Coke Oven Design
			Mechanical System Commissioning (Plan)	Coal Loading Machine Construction CLM Fabrication Electrical part fabrication and programming Mechanical work to attach and align CLM to ERCO Functionality testing Conduct ram motion test outside ERCO Conduct ram motion test inside ERCO Gantt chart Coal loading and coke pushing contingency plan **Milestone: CLM construction complete**
				Cool Operational dry runs Familiarize operation crew on CLM and ERCO operation Conduct ERCO charging dry run with no coal Conduct ERCO pushing dry run with no coal Conduct ERCO charging and pushing dry run with full load (coke) Conduct globar change dry run **Milestone: Handover equipment to operating crew** **Milestone: Start ERCO heat up**
			Oven temperature ramp up	ERCO functionality testing during temperature ramp Up Conduct burner control testing Conduct power transfer testing Exhaust system integrity **Milestone: ERCO reach idle temp (1200)**
				Hot Operational dry run Conduct ERCO charging and pushing with full load coke Conduct globar change dry run **Milestone: Mechanical system commissioning completed**

			Establish standard carbonization parameters	Standard carbonization parameters development Develop oven control strategy CCRA Report: CCRA 77:001/2019 CanmetENERGY Pilot Scale ERCO Control Description Develop CFD model to establish starting parameters Define initial standard operating parameters and control
				Commissioning carbonization tests Conduct carbonization test with ¼ charge Conduct carbonization test with ½ charge Conduct carbonization test with full charge Develop coke handling strategy Refine standard operating conditions after each carbonization test
				Benchmarking with Suncoke Document to outline test plan, conditions and rationales Conduct carbonization test plan Benchmarking coke quality with Suncoke oven Refine operating conditions **Milestone: Pilot scale ERCO produce coke with similar quality as industrial oven**
			Gage r&R (A3)	Document to outline test plan, conditions and rationale Report and A3
				Benchmark with 18" or carbolite
	CCRA 91: Blast Furnace Energy Reduction Initiatives using Auxiliary Fuel Injection	To develop analytical method for monitoring the combustion efficiency of pulverized coal injection in industrial blast furnace To determine the roles of coal rheology and petrographic properties on pulverized coal combustibility	**Preliminary Study**	AIST 2015: Evaluation of PCI Coals in New Injection Facility at CanmetENERGY-OTTAWA
			PCI rig setup	Standard rig test procedure Establish repeatability of PCI rig test: Completed Apply carbon type differentiation (CTD) TGA technique to rig combustion residues: Completed Develop new methodology to examine reactivity of combustion residues: Completed Validate ash tracer assumption for burnout calculation: Completed Report CCRA Report (CCRA 91:001/2018): CanmetENERGY Pulverized Coal Injection Rig Repeatability Tests
				Rig capability enhancement Natural gas/Coke oven gas- Coal co-injection (A3) CCRA Report (CCRA 91:003/2019): Re-Commissioning of Natural Gas-Coal Co-Injection Capability CCRA Report (CCRA 91:004/2019): Effect of Natural Gas Co-Injection on Pulverized Coal Combustion Blast moisture control Setup completed Off gas sampling On hold
			Develop relationship between coal properties (petrography, rheology) and combustion behaviour	Collection of coal properties data and combustion behavior CCRA Report (CCRA91:002/2019): Carbonaceous Materials Transformation during Pulverized Coal Injection AIST 2019: Carbonaceous Materials Transformation in Pulverized Coal Injection METEC 2019: Effect of Coal Properties on Combustion Behavior during Pulverized Coal Injection

Database, Standards and Procedures	CCRA 54: ISO and ASTM Coal and Coke Standards	Development of standards and procedures pertaining to Canadian Coal and Steel industries	**Effect of coal particle size on rheology measurement**	Fluidity and dilatation measurement of US coal samples at different size (A3) METEC 2019: Coal rheology - A Practical Approach for Industry AIST 2019: Coal Rheology — A Practical Approach for Industry Fluidity and dilatation measurement of Canadian coal samples at different size (A3) Teck will select 3 WCC sample for analysis Perform fluidity and dilatation measurement of selected WCC at different size fraction Add Prox for each size fraction
			Sapozhnikov plastometer commissioning (A3)	Equipment Handover Operating Procedure Development Benchmarking with Pearson Lab Participation in LQSi-SGS Proficiency Testing Program and in ISO/TC27 Inter Laboratory Study Repeatability Establishment
			Examination of coal oxidation information	Not started yet
			Identify both ASTM and ISO up for review	On-going
			ISO Inter Lab Study on Dilatation	Final Report: Inter Laboratory Study on Coal Dilatation under ISO/TC27 Summary Report METEC 2019: Findings of inter laboratory study on coal dilatation under ISO/TC27 and importance of correcting experimental dilatation results to a reference coal mass
	CCRA 75: Development of Research Collaboration opportunities	To establish technical exchanges or co-operative research studies with National and International Research group	**Develop relationship with universities and research institutes on Bio carbon and ERCO**	On-going
			Explore Mitacs for building partnership between academia, industry	
			Expose CanmetENERGY globally	On-going
			Engage with ACARP, BHP/CSIRO (QCAT), MEFOS, DMT, Aachen, NSSMC, CPM, VTT	Discussion with MEFOS(Sweden) and VTT(Finland) on who is doing what in biocarbon research
	CCRA 76: Modeling of Coal and Coke Properties using Historical Database	To develop relationships for coal and coke properties from existing CanmetENERGY data. To generate Industrial Intelligence from historical data.	**On Hold**	**On Hold**
	CCRA 92: Benchmarking of Movable Wall Ovens	To ensure the reliability and repeatability of CanmetENERGY pilot scale coke ovens	**Conduct 3 carbonization tests in 18in oven and 3 carbonization tests in Carbolite with same coal blend**	Q2 2019 (A3) Coal blend AMD standard blend Number of tests Gravity charge 18-inch Oven x 2 Gravity charge Carbolite Oven x 2

				Additional tests Biocarbon for cokemaking Incorporation of 10% loose biocarbon in coal blend Incorporation of 10 % biocarbon via bio-briquette in coal blend 2 compartment box charge in Carbolite oven x 1 After 18-inch oven load cells replacement x 2 Generate coke sample for size and shape characterization in Carbolite x 2