



Canadian Carbonization Research Association

2018-2019 Annual Report



TABLE OF CONTENTS

Chairman’s Remarks..... 2

Technical Committee Report..... 3

Financial Year in Review 11

Audited Financial Statements 13

CCRA History..... 26

1965-2019 Chair of Board of Directors 35

2018-2019 Board of Directors 36

2018-2019 Corporate Officers..... 37

2018-2019 Technical Committee Members..... 38

Appendix 1 – 2018-2019 CCRA Technical Committee Active Planning Table.....40

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

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 2018-19:

Meeting No.	Location	Date
243	Ottawa, ON	June 26-27, 2018
244	Vancouver, BC	September 10-12, 2018
245	Ottawa, ON	December 4-5, 2018
246	Vancouver, BC	March 26-28, 2019

The 2018-19 Research Program consisted of four main research areas:

1. Fundamentals of coal science
2. Fundamentals of cokemaking and coke quality
3. Energy and CO₂ 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 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).
2. On **Coal resource quality evaluation** (CCRA 90), Phase 2a of Geoscience BC project (2018), which focused on refining the Roben Jig process for mitigating misplaced material by rejigging clean coal and jiggling narrower particle size ranges and comparing to plant product, was completed under budget and on-time. A proposal and budget for Phase 2b (2019) focusing on MWO evaluation of sample prepared by Roben Jig received funding from GBC (March 2019) with work scheduled to begin in June-July 2019.

A journal publication is planned and will cover a comparison between coal washing via Roben Jig and conventional Float/Sink highlighting advantages and disadvantages and include the coke quality results of a full MWO upon using Roben Jig washing/preparation. Longer-term work (2020-2022) will involve examining the use of alternate liquids (Novec 7000 series, salts) for Float/Sink.

3. On **Performance of Western Canadian coal in stamp charge technology** (CCRA 93), coke quality of stamp charges (different compartment boxes) benchmarked against gravity charges at normal Bulk Density, 810 kg/m^3 , was similar. A literature overview found that stamp charge cake strength is dependent on coal blend moisture, size, moisture, and compacting energy. A literature review on current state of stamp charging will be conducted what to learn on what is being done in different regions including Eastern Europe, China, India. Also, gather more information from CPM, France (Dr. Paul Pernot) and Polish institute for chemical processing of coal. A proper blend needs to be formulated and a test plan developed.



4. On **Application of small-scale coking** (CCRA 88), information was provided on coal demand/coke amount to conduct coke quality assessment. A 2-compartment box charge can reduce coal sample demand to 136 kg and produce enough coke sample to carry out assessment following international standard. With a 3-compartment box charge, the coal demand can be further reduced to 90 kg but yields insufficient amount of coke for complete assessment. Equipment is being developed to simultaneously measure gas pressure and center temperature in a two-compartment box.

5. On **Mineral matter and coke reactivity** (CCRA 81), Phase 2 work on addition of coarse and fine minerals to a US HV coking coal for effect on CSR/CRI and related analyses was completed. Main findings from Phase 1 & 2 are:

- (i) Minerals selected affect CSR/CRI in following order:
Calcite \cong Dolomite > Pyrite \geq Siderite > Magnesite \geq Illite
- (ii) Smaller mineral particle size increase CRI and reduce CSR
- (iii) High rheology of US HV coal did not protect the cokes from catalytic effect of minerals.

Remaining is in-depth analysis of coke textures to probe effect of minerals in close proximity to carbon forms and examination of minerals in cokes at U. Alberta.

6. On **GHG reduction using renewable energy for the steel industry** (CCRA 70), research continued on a number of fronts including (1) Biocarbon value-in-use (2) Biomass conversion technology assessment (3) Biocarbon for EAF steelmaking (4) Bio-briquette formation and use for cokemaking and nut coke replacement (5) Biocarbon for PCI substitution (6) Biocarbon test standards (7) Biocarbon production, handling (storage, grindability, densification, acid washing, gas sampling and analysis, pyrolysis process development, C&D wood processing and carbonization, pyrolysis mass/energy balance).

Again, this year, the CanmetENERGY Bioenergy 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.

7. On **Energy Recovery Coke Oven** (CCRA 77), the pilot oven has been idling at 175°C since June 2018 in anticipation of completion of the coal loading machine before proceeding with cool and hot commissioning stages. During 2018-19, several meetings were held with ERCO partners and stakeholders to inform them on the work progress at CanmetENERGY and for discussing plans for doing cool, hot commissioning followed by Gage r&R test work. The Heat Utilization in Steelmaking from ERCO project successfully secured S&T funding until March 2022. Going forward, explore installation of CPM/DMT coke stabilization/screening facilities CanmetENERGY building extension.
8. On **Blast Furnace energy reduction initiatives using auxiliary fuel injection** (CCRA 91), demonstrated that the PCI experimental rig generated repeatable test results, which in large part, is dictated by carefully controlling initial reactor chamber temperature at start of test. The roles played by fundamental coal properties, chemistry, rheology and petrography and how materials transform during PCI process were addressed. The reactivity of combustion residue was shown to depend on coal ash basicity, total burnout and percentage of 'coke' in combustion residue. 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.
9. On **Standards** (CCRA 54), regular updates were presented on CanmetENERGY Met Fuels Lab performance in CPA coal petrography, LQSi /CRI, Tumbler Test, MET Coal and HGI Round Robins.

CanmetENERGY addressed issues of inconsistent Ro measurement by ensuring proper alignment/centering of sample in reading pellet as well as better control of lab environment (temperature and humidity). Also, CanmetENERGY is now exclusively making use of a 1.01 reflectance calibration standard for Ro measurements on all coal and blends.

A paper was written on technical findings of ISO Inter Lab Study on coal dilatation for presentation at Metec/ESTAD 2019 conference.

A paper on coal rheology for monitoring the temperature range to mitigate aging issues arising from storing of various coals will be presented at AISTech 2019 conference. A modified version of this work and including effect of size on maximum fluidity and dilatation on several US Appalachian coals of different rank will be presented at Metec/4thEstad 2019 congress. The bulk of the work on evaluating the effect of size on both Gieseler plastometer and dilatometer results for coals of various rank and origin was completed. It showed that coking properties are only significantly impacted negatively for smaller coal sizes, less than 140 mesh and especially the -200 mesh (combined effect of lower internal gas pressure generated during heating and higher ash levels).

The ASTM CSR standard was updated and published in January 2019, ASTM D5341-19.

ASTM D05 is scheduled to organize an ILS on HGI in 2019-20 in which both CanmetENERGY and AM Dofasco will participate.

Under ISO/TC27, a draft document on Sapozhnikov plastometer will be circulated to SC5/WG10 for comments followed by an ILS and including both automated and manual instruments. Canada will provide test samples and participate.

The next ISO/TC27 meeting will be held October 6-11, 2019 in Tokyo, Japan and Canadian delegation is being finalized.

10. On **International research collaboration** (CCRA 75), CanmetENERGY is seeking to establish link with universities but first need to identify well defined project(s) from industrial companies. 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, established new collaboration with AM Maizières (France) and Voestalpine (Austria).

11. On **Benchmarking of movable wall ovens** (CCRA 92), no work was conducted during 2018-19. Plan is to do this work during Q2 2019-20 using a steelmaker blend and doing duplicate gravity charges in both 18in and Carbolite ovens and also do partial briquetting test in 18in, 2-compartment box charge in Carbolite and an additional duplicate test in 18in following load cell replacement.

CCRA-CanmetENERGY Papers, 2018-2019

1. Ng, K.W., Giroux, L., Todoschuk, T. "Value-In-Use of Renewable Biocarbon for Direct Injection in Blast Furnace Ironmaking", *Ironmaking and Steelmaking* 45(5), 406-411 (2018).
2. Huang, X., Ng, K.W., Giroux, L., "Development of novel method for quantitative determination of carbon chemical reactivity", *Can J Chem Eng* <https://doi.org/10.1002/cjce.23427> (2018).
3. Huang, X., Ng, K.W., Giroux, L., Duchesne, M., "Carbonaceous material properties and their interactions with slag during electric arc furnace steelmaking", *Metall Mater Trans B* (2019).

Conference Proceedings, 2018-19

1. Ng, K.W., Huang, X., Giroux, L. "Application of TGA Technique for Carbon Chemical Reactivity Quantification", AISTech 2018 conference proceedings, Philadelphia, USA.
2. Huang, X., Ng, K.W., Giroux, L. "Pulverized Coal Injection Simulation", ICSTI, 25-27 September 2018, Vienna.
3. Ng, K.W., Giroux, L., T. Todoschuk "Techno-Economic Analysis of Biocarbon Direct Injection in Blast Furnace Ironmaking", ICSTI, 25-27 September 2018, Vienna.

Published Report, 2018-19

1. Mackay, M.L., Giroux, L., Leeder, R., Dexter, H., Halko, J., Holuszko, M. and Thomas, D. (2019): Producing Clean Coal from Western Canadian Coalfields Using the Water-Based Roben Jig Process: Refining the Process; in *Geoscience BC Summary of Activities 2018: Minerals and Mining*, Geoscience BC, Report 2019-1, p. 87–100.

CanmetENERGY-Ottawa Met Fuels Facilities Utilization:

Statistics for 2018-19 showed the following in comparison with 2017-18:

1. Sole-Heated Ovens

- a. CCRA – 22 vs 20 trials (59% SHO2, 36% SHO1, 5% SHO3)
- b. Coal Companies – 125 vs 141 trials (46% SHO2, 14% SHO1, 40% SHO3)
- c. Steel Companies – 168 vs 118 (30% SHO1, 28% SHO2, 42% SHO3)

In total, usage of sole-heated ovens in 2018-19 was 315 trials - compared to 279 trials in 2017-18 (13% higher).

2. Sole-Heated Oven Coke Reheats – CSR

- a. CCRA – 24 vs 15
- b. Coal Companies – 11 vs 19
- c. Steel Companies – 16 vs 32

In total, 51 reheats of sole-heated oven cokes for CSR determination – vs 66 in 2017-18 (23% lower).

3. MWO CSR Determination

- a. CCRA – 8 vs 5
- b. Coal Companies – 124 vs 147
- c. Steel Companies – 37 vs 51

In total, 169 MWO CSR evaluations were performed – vs 203 in 2017-18 (17% lower). In addition, 7 CSRs were done on cokes received at CanmetENERGY-Ottawa Met Fuels (4 CSRs for CCRA and 3 CSRs for Steel Companies). Combining SHO, MWO and Cokes received at Met Fuels, 227 CSR tests were done in 2018-19 compared to 288 tests in 2017-18 (21% lower).

4. Coke Stabilization - No coke stabilization trials were done in 2018-19 nor 2017-18.**5. Movable Wall Ovens**

- a. CCRA – 5 vs 6 trials (All in Carbolite)
- b. Coal Companies – 127 vs 137 trials (126 in Carbolite, 1 in 18-inch oven)
- c. Steel Companies – 60 vs 60 trials (All in 18-inch oven)

In total, usage of movable wall ovens in 2018-19 was 192 trials compared to 203 trials in 2017-18 (5% lower).

6. PCI

- a. CCRA – 14 vs 2 tests
- b. Coal Companies – 0 test (2018-19 & 2017-18)
- c. Steel Companies – 11 vs 0 tests

In total, 25 PCI tests were done in 2018-19 compared to 2 tests in 2017-18.

Table 1 - Utilization of CanmetENERGY Facilities

Oven Tests April 1, 2018 – March 31, 2019				
Oven	CCRA	Coal Companies	Steel Companies	Totals
Sole – Heated Oven				
SHO1	8	17	50	75
SHO2	13	58	47	118
SHO3	1	50	71	122
Total SHO	22	125	168	315
CSR/CRI				
SHO Coke Reheats/CSR	24	11	16	51
MWO CSR	8	125	37	169
Cokes for CSR	4	0	3	7
Total CSR	36	135	56	227
Movable Wall Oven				
18 Inch	0	1	60	61
Carbolite	5	126	0	131
Total MWO	5	127	60	192
PCI Injection Test Rig				
PCI	14	0	11	25

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.

10. CanmetENERGY Met Fuels Activities

- a. Revenues for 2018-19, \$2.1M
- b. New staffing & training actions was progressed
- c. New building construction planned in 2019
- d. S&T funding program (A-base): Presented to ADM and OERD in March 2019 - New funding opportunity for Industry Efficiency projects (For MFL, Biocarbon for Steel Industry and Energy Recovery Cokemaking)

- e. Met Fuels service fees will be increased by 2% starting April 1, 2019

11. CCRA website

- a. The members only page was updated with relevant documentation.
- b. The other pages of the website need improvement.



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



Technicians getting ready to invert the jig tube holding jugged 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

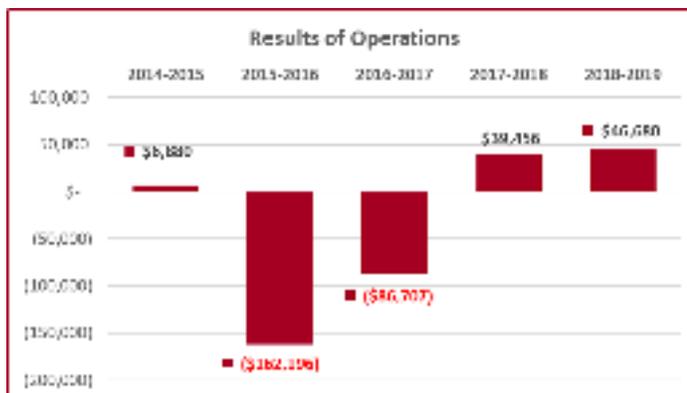
CCRA ended the 2018-19 fiscal year with an operating surplus due largely to increases in research levies and the addition of three members to the Association. Financially, Members’ Net Assets at year-end totaled \$519K reflecting a 9.9% increase to the level reported at the end of the 2017-2018 fiscal year and



\$163K lower than the most recent peak level of \$682K reported at the end of the 2014-2015 fiscal year.

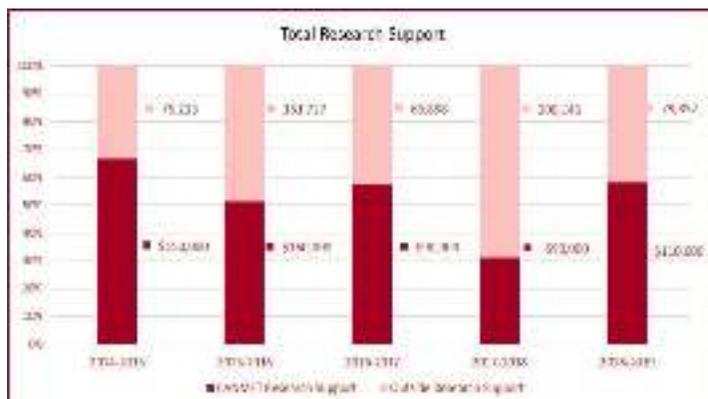
This increase reflects the impact of a \$47K Excess of Revenues over Expenses for 2018-2019 representing the second consecutive modest operating surplus following the two previous consecutive years of operating deficits.

Because of prudent financial planning, CCRA is able to absorb such 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 initial 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 to be completed during the 2019-2020 fiscal year.

Over the past five fiscal years, CCRA has invested a total of \$1.17M in research support of which \$600K or 51.1% was contributed to CanmetENERGY.



With respect to the confidential testing program for Members, CCRA incurred a total of \$1.6M in testing during the 2018-2019 fiscal year which exceeds the \$1.25M annual average program spending over the last five years and is the largest single year for testing during the last decade.



CCRA continues to minimize its administrative costs in order to maximize the amounts available to support research programs. During 2018-2019, administrative overhead of \$30K only represented 1.6% of total expenditures demonstrating CCRA's continued commitment to maximize its research and development investments from available member or third-party funding.

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

Brian D'Amboise, CPA, CA
Treasurer



The Canadian Carbonization Research Association (CCRA) continues to be a source of reliable support to CanmetENERGY activities by investing over the last five years a total of \$600K in direct Research Support plus \$6.22M in member Confidential Testing contributions.

AUDITED FINANCIAL STATEMENTS

*crawford
smith &
swallow*

**CANADIAN CARBONIZATION RESEARCH
ASSOCIATION**

Financial Statements

March 31, 2019



CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Financial Statements

March 31, 2019

Table of Contents

	Page
Independent Auditors' Report	1-3
Statement of Financial Position	4
Statement of Operations and Changes in Members' Net Assets	5
Statement of Cash Flows	6
Notes to Financial Statements	7-9
Unaudited Five Year Financial Review	10-11

Crawford Smith & Swallow
Chartered Accountants

171 Queen Street
Niagara Falls, Ontario
L2E 2M2
Telephone: (905) 268-4928
Fax: (905) 268-2413

Office:
Niagara Falls
St. Catharines
Fort Erie
Niagara-on-the-Lake
Port Colborne

**crawford
smith &
swallow**

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, 2019, 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, 2019, 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.

1

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.

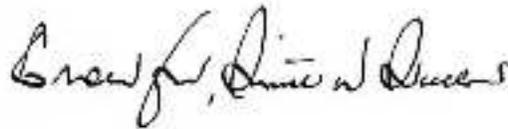
As part of an audit in accordance with Canadian generally accepted auditing standards, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

- 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 7, 2019



CRAWFORD SMITH & SWALLOW
CHARTERED PROFESSIONAL ACCOUNTANTS LLP
LICENSED PUBLIC ACCOUNTANTS

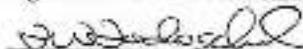
CANADIAN CARBONIZATION RESEARCH ASSOCIATION

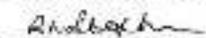
STATEMENT OF FINANCIAL POSITION

March 31, 2019

Assets	2019 \$	2018 \$
Current Assets		
Cash	95,857	44,958
Temporary investments	575,791	526,361
Accounts receivable	17,091	
Sales tax recoverable		2,205
Prepaid expenses	2,225	1,725
	690,964	575,249
Liabilities and Members' Net Assets		
Current Liabilities		
Accounts payable and accrued liabilities	8,961	17,282
Government remittances payable	17,710	
Due to CANMET		22,500
Deferred grant - note 2		63,454
Deferred revenue	145,600	
	172,271	103,236
Contingent Liability - note 7		
Members' Net Assets	518,693	472,013
	690,964	575,249

Signed on behalf of the Board:

 Director

 Director

See accompanying notes

CANADIAN CARBONIZATION RESEARCH ASSOCIATION
STATEMENT OF OPERATIONS AND CHANGES IN MEMBERS' NET
ASSETS
for the year ended March 31, 2019

	2019 \$	2018 \$
Revenue		
Confidential research and development	1,607,390	1,193,154
Research levies	195,000	160,000
Outside research grants	79,852	191,846
Membership fees	700	400
Interest income	12,795	8,094
Other income		1,121
	<u>1,895,737</u>	<u>1,554,615</u>
Operating Expenses		
Confidential research and development	1,607,390	1,193,154
CANMET research support	110,000	90,000
Consulting	22,232	5,800
Outside research	79,852	200,146
Office	17,479	16,449
Professional fees	9,539	7,045
Insurance	2,565	2,565
	<u>1,849,057</u>	<u>1,515,159</u>
Excess of Revenue over Expenses	46,680	39,456
Members' Net Assets, Beginning of Year	472,013	432,557
Members' Net Assets, End of Year	<u>518,693</u>	<u>472,013</u>

See accompanying notes

crowford smith & swallow

5

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

STATEMENT OF CASH FLOWS

for the year ended March 31, 2019

	2019 \$	2018 \$
Operating Activities		
Excess of revenue over expenses	46,683	39,456
Changes in working capital components - note 3	53,649	(77,017)
Funds provided (used) by operating activities	100,329	(37,561)
Investing Activities		
(Increase) decrease in temporary investments	(49,430)	74,572
Increase in Cash	50,899	37,011
Cash, Beginning of Year	44,958	7,947
Cash, End of Year	95,857	44,958

See accompanying notes

crawford smith & swallow

6

CANADIAN CARBONIZATION RESEARCH ASSOCIATION**NOTES TO FINANCIAL STATEMENTS**for the year ended March 31, 2019

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.

I. 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. Non-recovery contributions are voluntary in nature and recognized in the year of receipt.

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.

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

NOTES TO FINANCIAL STATEMENTS

for the year ended March 31, 2019

2. Deferred grant

Deferred grant represents unspent resources externally restricted for various purposes and restricted funding received in the current year to be spent at some point in the future. Changes in the deferred grant balance are as follows:

	2019	2018
	\$	\$
Balance, beginning of year	63,454	139,669
Add: restricted amounts received in the year	16,398	115,631
Less: recognized in income during the year	(79,852)	(191,846)
Balance, end of year	63,454	63,454

3. Statement of Cash Flows

Changes in working capital components include:

	2019	2018
	\$	\$
Accounts receivable	(17,091)	
Sales tax recoverable	2,205	1,871
Prepaid expenses	(590)	(15)
Accounts payable and accrued liabilities	(8,321)	(2,658)
Government remittances payable	17,710	
Due to CANMET	(22,390)	
Deferred grant	(63,454)	(76,215)
Deferred revenues	142,600	
	53,649	(77,017)

4. 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 \$ 12,795 (2018 - \$ 7,665). 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.

CANADIAN CARBONIZATION RESEARCH ASSOCIATION**NOTES TO FINANCIAL STATEMENTS**for the year ended March 31, 2019

5. Related Party Transactions

Fees amounting to \$ 16,891 (2018 - \$ 15,308) were paid to the treasurer of the Association during the year for management and accounting services.

These transactions were recorded at the exchange amount.

6. Taxation Status

The Association is exempt from income taxes as it has complied with the necessary provisions of the Federal and Provincial Tax Acts. Consequently, no provision for income taxes is reflected in the accounts.

7. Contingent Liability

As at March 31, 2019, the Association has an outstanding claim against it relating to interest on overdue accounts payable in the amount of \$ 49,599. This amount has not been accrued for in the financial statements. It is the Association's assertion that adequate defences are in effect for the settlement of these amounts.

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Schedule 1

FIVE YEAR FINANCIAL REVIEW

UNAUDITED STATEMENT OF OPERATIONS AND MEMBERS' NET ASSETS

for the year ended March 31, 2019

	2019	2018	2017	2016	2015
	\$	\$	\$	\$	\$
Revenues					
Confidential research and development	1,607,390	1,193,154	1,150,794	944,529	1,326,422
Research levies	195,000	160,000	90,000	165,000	190,000
Outside research grant	79,852	191,846	6,631		
Consulting funding			3,000	6,425	6,425
Membership fees	700	400	300	800	800
Interest income	12,795	8,094	2,737	5,699	8,481
Other income		1,121			55
PWC funding					60,000
	1,895,737	1,554,615	1,253,462	1,122,453	1,592,183
Operating Expenses					
Confidential research and development	1,607,390	1,193,154	1,150,794	944,529	1,326,422
CANMET research support	110,000	90,000	90,000	160,000	150,000
Consulting	22,252	5,800	4,500	3,000	8,857
Outside research	79,852	200,146	66,898	151,727	75,213
Meeting				816	834
Office	17,479	16,449	19,884	17,192	17,562
Professional fees	9,539	7,045	7,238	7,385	6,415
Insurance	2,565	2,565	855		
	1,849,057	1,515,159	1,340,169	1,284,649	1,585,303
Excess (Deficiency) of Revenues over Expenses	46,680	39,456	(86,707)	(162,196)	6,880
Members' Net Assets, Beginning of Year	472,013	432,557	519,264	681,460	674,580
Members' Net Assets, End of Year	518,693	472,013	432,557	519,264	681,460

See accompanying notes

Crawford Smith & Swallow

10

CANADIAN CARBONIZATION RESEARCH ASSOCIATION

Schedule 1 - continued

FIVE YEAR FINANCIAL REVIEW

UNAUDITED STATEMENT OF FINANCIAL POSITION

as at March 31, 2019

	2019	2018	2017	2016	2015
	\$	\$	\$	\$	\$
Assets					
Current Assets					
Cash	95,857	44,958	7,947	261,201	277,171
Temporary investments	575,791	526,361	600,953	682,338	1,350,413
Accounts receivable	17,091	2,205	4,076	36,669	32,784
Prepaid expenses	2,225	1,725	1,710		
	690,964	575,249	614,666	980,708	1,660,368
Liabilities and Members' Net Assets					
Current Liabilities					
Accounts payable and accrued liabilities	8,961	17,282	13,940	18,746	10,200
Government remittances payable	17,710				
Due to CANMET		22,500	22,500	442,698	968,708
Deferred grant		63,454	139,669		
Deferred revenue	145,600				
	172,271	103,236	182,109	461,444	978,908
Members' Net Assets	518,693	472,013	432,557	519,264	681,460
	690,964	575,249	614,666	980,708	1,660,368

See accompanying notes

crawford smith & swallow

11

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 become 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.

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

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

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.



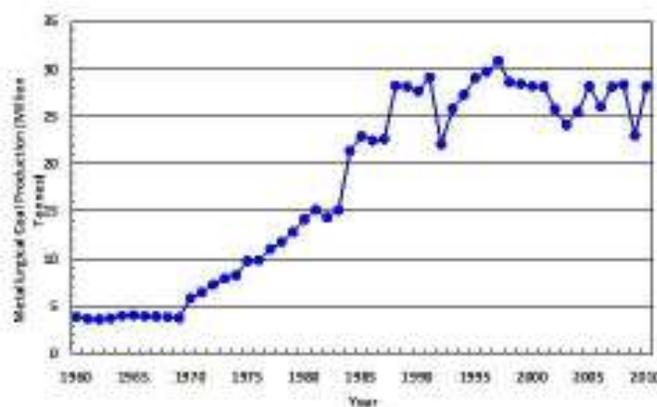
By the latter part of the 1980s, the international energy crisis had subsided, coal and steel prices were dropping, and both industries were entering a period of highly competitive markets. Coal injection into the blast furnace was introduced in Europe and Japan. In that period, many new projects were 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.

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.



History of Metallurgical Coal Production in Canada

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 through 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 Bioenergy 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 competitiveness 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	<ul style="list-style-type: none"> To understand the fundamental science of metallurgical coal for supporting efficient exploration and product quality improvement to improve global competitiveness of Western Canadian Coal.
Blast Furnace Ironmaking Carbon Efficiency Enhancement	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> To develop technology for achieving carbon neutrality ironmaking in Canada by embracing different technologies (Biocarbon, H₂, Electron, CCUS).

1965-2019 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.

2018-2019 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)
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)
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 réserve 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)

2018-2019 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

2018-2019 TECHNICAL COMMITTEE MEMBERS

COMPANY	NAME	PHONE (FAX)	ALTERNATE OR CO-MEMBER
CanmetENERGY	CHAIR: 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)	Mr. Ka Wing Ng Research Scientist CanmetENERGY Natural Resources Canada 1 Haanel Drive Ottawa, ON K1A 1M1 613 996-8712 kawing.ng@canada.ca
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
CanmetENERGY	SECRETARY: 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)	Mr. Kirby Wittich Research Engineer CanmetENERGY Natural Resources Canada 1 Haanel Drive Ottawa, ON K1A 1M1 613 943-8235 kirby.wittich@canada.ca
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 – 2018-19 CCRA TECHNICAL COMMITTEE PLANNING TABLE				
Program	Projects	Project Objectives	Project Tasks	Deliverables
Fundamentals of Coal Science	CCRA 80: Characterization of Coal Washing Plant Streams and Product Quality Upgrade	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> To understand how Western Canadian coals, behave/work in high inert blends. 	On Hold	On Hold
	CCRA87: Technical Merits of Western Canadian Coals	<ul style="list-style-type: none"> 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	On Hold
	CCRA90: Exploration Sample Assessment for Current and New Mines in Canada	<ul style="list-style-type: none"> To investigate alternative environmentally friendly methods to prepare/produce exploration coal samples for further assessment. 	Preliminary Study <ul style="list-style-type: none"> Effects of Organic Liquids on Western Canadian Coking Coals Preliminary evaluation of Australian Boner Jig facility performance on WCC 	Preliminary Study <ul style="list-style-type: none"> Effects of Organic Liquids on Western Canadian Coking Coals <ul style="list-style-type: none"> Completed: Paper published in Fuel Processing (Jan 2017) Preliminary evaluation of Australian Boner Jig facility performance on WCC <ul style="list-style-type: none"> Completed: The jig worked (2016)

			<p>Roben Jig Technology Development</p> <ul style="list-style-type: none"> • Phase 1: Roben Jig Facility Setup in Canada • Phase 2a: Performance of Roben Jig on clean coal sample preparation • Phase 2b: MWO evaluation of coking performance of sample prepared by Roben Jig <p>Alternate liquid for Float/Sink coal washability study</p> <ul style="list-style-type: none"> • Potential candidates' evaluation 	<p>Roben Jig Technology Development</p> <ul style="list-style-type: none"> • Phase 1: Roben Jig Facility Setup in Canada <ul style="list-style-type: none"> ○ Completed: Commissioning with 4 coal samples (3SEBC and 1 NEBC) (2017) • Phase 2a: Performance of Roben Jig on clean coal sample preparation <ul style="list-style-type: none"> ○ 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 <ul style="list-style-type: none"> ○ Test second sample ○ SHO carbonization of OL sample and Jig sample ○ MWO carbonization of plant sample, OL sample and Jig sample <p>Alternate liquid for Float/Sink coal washability study</p> <ul style="list-style-type: none"> • Potential candidates' evaluation <ul style="list-style-type: none"> ○ Novec 7000 (1.40 SG) and Novec 7700 (1.797 SG) <ul style="list-style-type: none"> ○ Mix to form solution with SG 1.40 to 1.797 ○ Compare washing between Novec solution and traditional organic liquid
	<p>CCRA 93: Performance of Western Canadian Coal in Stamp Charge Technology</p>	<ul style="list-style-type: none"> • To develop stamp charge capability in CanmetENERGY • To assess the performance of Western Canadian Coal in stamp charge 	<p>Stamp charge technology development</p> <ul style="list-style-type: none"> • Apparatus fabrication and procedure development • Benchmark single compartment box stamp charge with gravity charge results <p>Coking performance of WCC in stamp charge technology</p> <ul style="list-style-type: none"> • Base stamp charge coal blend selection • Research Plan development • Carbonization Tests 	<p>Stamp charge technology development</p> <ul style="list-style-type: none"> • Apparatus fabrication and procedure development <ul style="list-style-type: none"> ○ Completed: can achieve 978 kg/m³ dry BD without crushing down the coal • Benchmark single compartment box stamp charge with gravity charge results <ul style="list-style-type: none"> ○ Completed: box charge at 810 kg/m³ and box charge at 925 kg/m³ <p>Coking performance of WCC in stamp charge technology</p> <ul style="list-style-type: none"> • Base stamp charge coal blend selection <ul style="list-style-type: none"> ○ Review typical industrial stamp charge blend (TECK)

			<p>Effect of coal blend composition and properties on specific energy input in stamp charge</p> <p>Coal cake strength Characterisation</p>	<ul style="list-style-type: none"> ○ Formulation of base blend for carbonization test (TECK) ○ Appalachian PCI coal to be considered ● Research Plan Development ○ Canmet coal cake formation capacity <ul style="list-style-type: none"> ○ Establish coal size vs BD relation using existing stamp charge equipment ○ Determine max achievable BD ○ Define carbonization test parameters: %WCC, BD, Moisture, Coal particle size ○ Develop factorial experimental design ● Carbonization tests <ul style="list-style-type: none"> ○ TBD <p>Effect of coal blend composition and properties on specific energy input in stamp charge</p> <ul style="list-style-type: none"> ○ Establish collaboration with University <p>Coal cake strength characterisation</p> <ul style="list-style-type: none"> ○ Establish collaboration with University
<p>Fundamentals of Cokemaking and Coke Quality</p>	<p>CCRA81: Mineral Matter and Coke Reactivity</p>	<ul style="list-style-type: none"> ● 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 	<p>Effect of mineral type and size on coke quality</p> <ul style="list-style-type: none"> ● Mineral addition at small and large size ● Role of mineral type and size on coke quality <p>Characterisation of in-situ mineral of Western Canadian Coal</p> <ul style="list-style-type: none"> ● Technique development ● Analysis of WCC <p>Inclusion of mineral size effect in CSR prediction model</p>	<p>Effect of mineral type and size on coke quality</p> <ul style="list-style-type: none"> ● Mineral addition at small and large mineral size <ul style="list-style-type: none"> ○ Completed: SHO carbonization of WC MV and US HV with 1% mineral addition ○ To be completed: coke properties evaluation (CSR, texture, ASG, TSG etc) ● Role of mineral type and size on coke quality <ul style="list-style-type: none"> ○ Interpretation of experimental result <ul style="list-style-type: none"> ○ Role of minerals in coke formation ○ Catalytic effect of minerals (may be TGA or CRI) <p>Characteristics of in-situ minerals in Western Canadian Coal</p> <ul style="list-style-type: none"> ● Technique Development <ul style="list-style-type: none"> ○ Send coke samples from mineral addition study to U of A for MLA (Sample sent) ○ Include MLA results in data interpretation ● Analysis of WCC <ul style="list-style-type: none"> ○ Selection of coal from different geographic location and formation for analysis <p>Inclusion of mineral type and size effect in CSR prediction model</p> <ul style="list-style-type: none"> ○ Not yet started

			<p>Coal mineral control</p> <ul style="list-style-type: none"> • Through mining and blending • Through washing 	<p>Coal mineral control</p> <ul style="list-style-type: none"> • Through mining and blending <ul style="list-style-type: none"> ○ Not yet started • Through washing <ul style="list-style-type: none"> ○ Not yet started
CCRA 82: Factors Affecting Coke Bed Permeability	<ul style="list-style-type: none"> • To understand the effect of coke size and shape on bed permeability and coke strength measurement 	<p>Image analysis technique to characterize size and shape of coke</p> <p>Relationship between coke size and shape and bed permeability</p> <p>Effect of oven and charge method on coke size and shape</p> <p>Effect of coke size and shape on coke strength measurement</p> <p>Effect of coal properties on coke size and shape</p>	<p>Image analysis technique to characterize size and shape of coke</p> <ul style="list-style-type: none"> ○ Completed <p>Relationship between coke size and shape and bed permeability</p> <ul style="list-style-type: none"> ○ Completed <p>Effect of oven and charge method on coke size and shape</p> <ul style="list-style-type: none"> ○ On-hold <p>Effect of coke size and shape on coke strength measurement</p> <ul style="list-style-type: none"> ○ On-hold <p>Effect of coal properties on coke size and shape</p> <ul style="list-style-type: none"> ○ Proposed project: coal thermal conductivity of WCC 	
CCRA 84: Coke Degradation Mechanisms	<ul style="list-style-type: none"> • To understand the effect of coal properties, carbonization conditions and handling on coke degradation mechanism 	<p>On Hold</p>	<p>On Hold</p>	
CCRA 88: Application of Small-Scale Coking	<ul style="list-style-type: none"> • To develop and demonstrate carbonization methods for small (<350kg) coal samples 	<p>Minimum oven capacity</p> <ul style="list-style-type: none"> • Assessment of coke size distribution of pilot scale oven • Requirement of coke with particular size for different quality assessment • Development of coke quality assessment strategy with limited sample • Recommendation on minimum oven capacity <p>Reduction in sample amount requirement by multi-compartment box charge in pilot scale MWO</p> <ul style="list-style-type: none"> • Development of box charge technology in CanmetENERGY 	<p>Minimum oven capacity</p> <ul style="list-style-type: none"> • Assessment of coke size distribution of pilot scale oven <ul style="list-style-type: none"> ○ Completed • Requirement of coke with particular size for different quality assessment <ul style="list-style-type: none"> ○ Completed • Development of coke quality assessment strategy with limited sample <ul style="list-style-type: none"> ○ Completed • Recommendation on minimum oven capacity <ul style="list-style-type: none"> ○ Completed: 90 kg <p>Reduction in sample amount requirement by multi-compartment box charge in pilot scale MWO</p> <ul style="list-style-type: none"> • Development of box charge technology in CanmetENERGY 	

		<ul style="list-style-type: none"> • Apparatus fabrication for multi-compartment box charge • Benchmarking of multi-compartment box charge with gravity charge 	<ul style="list-style-type: none"> ○ Completed • Apparatus fabrication for multi-compartment box charge ○ Completed • Benchmarking of multi-compartment box charge with gravity charge ○ First set of MWO tests completed (Gravity, 1 compartment, 2 compartment and 3 compartment charge) ○ Gas pressure and center temperature measurement instrumentation <ul style="list-style-type: none"> ○ Design of instrument for instantaneous measurement of P and T in each compartment ○ (Completed) ○ Focus on 2 compartment charge but ensure can be extended to 3 compartment charge ○ (Completed) ○ Fabrication and installation of equipment ○ (Completed) ○ Functionality testing <ul style="list-style-type: none"> ○ Few trials have been performed. Difficult to achieve consistent gas pressure reading ○ Two compartment carbonizations <ul style="list-style-type: none"> ○ Not yet started ○ Three compartment carbonizations <ul style="list-style-type: none"> ○ Not yet started 	
	<p>CCRA 94: High Temperature Properties of Coke</p>	<ul style="list-style-type: none"> • To understand the high temperature (>1100C) properties of coke 	<p>On Hold</p>	<p>On Hold</p>
<p>Energy and CO₂ Reduction in Cokemaking and Ironmaking</p>	<p>CCRA 70: GHG Reduction Using Renewable Energy for the Steel Industry</p>	<ul style="list-style-type: none"> • 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 Canadian bio-economy 	<p>Raw Biomass Supply</p> <ul style="list-style-type: none"> • Evaluate feedstock type, location, quality, and quantity • Develop technology for raw biomass ash content control 	<p>Raw Biomass Supply</p> <ul style="list-style-type: none"> • Evaluate feedstock type, location, quality, and quantity <ul style="list-style-type: none"> ○ Quebec forestry residue: Completed ○ Ontario sawmill residue: Who - OMNRF? ○ C&D wood supply: Ecostrat report ○ Possibility of using Lignin as feedstock <ul style="list-style-type: none"> ○ Inform DOMTAR on use of lignin information ○ Waiting for response from DOMTAR ○ Collect lignin sample from DOMTAR • Develop technology for raw biomass ash content control <ul style="list-style-type: none"> ○ Acid washing of C&D wood with HNO₃ and wood vinegar

		<ul style="list-style-type: none"> To develop a value chain for use of bio-materials for Canadian industry 	<p>Pyrolysis Technology Assessment and Development</p> <ul style="list-style-type: none"> Assessment of existing pyrolysis technologies 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 Further develop HTC process Develop technology for pyrolysis solid biocarbon product upgrade Explore feasibility to utilize pyrolysis co-products in steel production Integrated Carbonization and Densification (ICD) Development Bio-pellet/briquette quality evaluation standard procedures development <p>Utilization of Solid Biocarbon in Steel Production</p> <ul style="list-style-type: none"> Develop biocarbon VIU in evaluation methodology Handling and Storage of Bio-Pellet Incorporation of Solid Biocarbon in Cokemaking by Briquetting with Coal Direct Injection of Solid Biocarbon in Blast Furnace Nut coke replacement Solid biocarbon for EAF Steelmaking Proof of concept trials 	<ul style="list-style-type: none"> Report to be released on Mar 12 Meeting <p>Pyrolysis Technology Assessment and Development</p> <ul style="list-style-type: none"> Assessment of existing pyrolysis technologies <ul style="list-style-type: none"> Completed (Bioenergy Group Report) 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 <ul style="list-style-type: none"> Completed (CCRA Report) Further develop HTC process <ul style="list-style-type: none"> CanmetENERGY 20L HTC performance on C&D wood Develop technology for fast pyrolysis solid biocarbon product upgrade <ul style="list-style-type: none"> Fast pyrolysis of C&D "B" grade wood <ul style="list-style-type: none"> (Report to be released at Mar 12 Meeting) Explore feasibility to utilize pyrolysis co-product in steel production <ul style="list-style-type: none"> H&M balance study of C&D "A" and "B" grade wood pyrolysis <ul style="list-style-type: none"> (Report to be released at Mar 12 Meeting) Integrated Carbonization and Densification (ICD) Development <ul style="list-style-type: none"> Peter Gaudet Master's thesis in progress Bio-pellet/briquette quality evaluation standard procedures development <ul style="list-style-type: none"> OPG study Comparison between ISO and ASTM biocarbon analysis standards <p>Utilization of Solid Biocarbon in Steel Production</p> <ul style="list-style-type: none"> Develop biocarbon VIU in evaluation methodology <ul style="list-style-type: none"> Completed (Paper Published in Ironmaking and Steelmaking Journal) Handling and Storage of Biocarbon <ul style="list-style-type: none"> Co-grinding of biocarbon and coal (A3) <ul style="list-style-type: none"> rolling ball grinding using HGI apparatus Vary %biocarbon Loose vs briquetted biocarbon Incorporation of Solid Biocarbon in Cokemaking by Briquetting with Coal <ul style="list-style-type: none"> Incorporation of biocarbon via partial briquetting SHO carbonization <ul style="list-style-type: none"> Completed (AISTech 2019 Paper)
--	--	---	--	--

			<p>Future work</p> <ul style="list-style-type: none"> • Life Cycle Analysis • Biocarbon application in Canadian Non-ferrous metal production • Monitoring international activities 	<ul style="list-style-type: none"> ○ MWO test with 20% bio-briquette ○ To be conducted together with oven benchmarking (CCRA 92) in Q1 2019 • Direct Injection of Solid Biocarbon in Blast Furnace ○ Bio-char injection rig test: <ul style="list-style-type: none"> ○ <u>Substitution of HV PCI Coal (A3)</u> ○ Completed ○ Substitution of HV-LV PCI Coal Mixture <ul style="list-style-type: none"> ○ First injection rig test completed • <u>Nut coke replacement (A3)</u> <ul style="list-style-type: none"> ○ Compressive strength of biocarbon briquette <ul style="list-style-type: none"> ○ Completed ○ 1/5 MICUM tumbling test with iron ore pellet <ul style="list-style-type: none"> ○ to be completed before CCRA meeting ○ Industrial briquette strength evaluation ○ Set up HTF for reducibility test • EAF Steelmaking <ul style="list-style-type: none"> ○ Substitution of Charge carbon by biocarbon <ul style="list-style-type: none"> ○ No effect on steel composition ○ Gas evolution profile in CMAT ○ Substitution of Injection carbon by biocarbon <ul style="list-style-type: none"> ○ Poor wetting results in very limited foaming <ul style="list-style-type: none"> ○ Determine maximum substitution while maintaining acceptable foam height • Proof of concept trials <ul style="list-style-type: none"> ○ Support industrial partners for demonstration trials ○ Assist in determining technical resources required to develop bio-economy <p>Future work</p> <ul style="list-style-type: none"> • Life Cycle Analysis <ul style="list-style-type: none"> ○ Establish university collaboration • Biocarbon application in Canadian Non-ferrous metal production <ul style="list-style-type: none"> ○ Biocarbon for Ni production • Monitoring international activities <ul style="list-style-type: none"> ○ Literature review on alternate ironmaking technology development
--	--	--	--	--

	<p>CCRA 77: Energy Recovery Cokemaking</p>	<ul style="list-style-type: none"> • To prepare Canadian steel industry transition to ERCO cokemaking technology • To improve energy efficiency and reduce criteria air contaminants and particulates emissions of Canadian steel industry 	<p>Pilot Scale ERCO Construction</p> <p>Documentation</p> <ul style="list-style-type: none"> • Standard Operating Procedures and THA • Failure Modes & Effects Analysis <p>Commissioning of pilot scale ERCO</p> <ul style="list-style-type: none"> • Mechanical system (coal loading and coke pushing) demonstration • Establish standard operating conditions (BD, moisture, heating profile, etc) • Hot commissioning <p>Benchmarking with Industrial Oven</p> <ul style="list-style-type: none"> • Conduct carbonization test to benchmark resultant coke quality with industrial coke 	<p>Pilot Scale ERCO Construction</p> <ul style="list-style-type: none"> ○ Completed: Idling at 150 C <p>Documentation</p> <ul style="list-style-type: none"> • Standard Operating Procedures and THA <ul style="list-style-type: none"> ○ Charging the consumable box, loading and pushing including off-normal procedure <ul style="list-style-type: none"> ○ Ready for MFL review ○ Carbonization <ul style="list-style-type: none"> ○ 60% complete • Failure Modes & Effects Analysis <ul style="list-style-type: none"> ○ 6 of 12 sections have been reviewed internally <p>Commissioning of pilot scale ERCO</p> <ul style="list-style-type: none"> • Mechanical system (coal loading and coke pushing) demonstration <ul style="list-style-type: none"> ○ Loading and pushing of wood chips (or coke) test at 150 C: Anticipated date: Oct 2018 ○ Ramp up to idle temperature <ul style="list-style-type: none"> ○ Anticipated start date: Nov 2018 ○ Anticipated end date: Dec 2018 • Establish standard operating conditions (BD, moisture, heating profile, etc) <ul style="list-style-type: none"> ○ Discussions with SunCoke and AM Chicago • Hot commissioning <ul style="list-style-type: none"> ○ Carbonization <ul style="list-style-type: none"> ○ ¼ Charge ○ ½ Charge ○ Full charge ○ Coke handling procedure development <ul style="list-style-type: none"> ○ Separation of coke sample into 2 batches (coke side and push side) ○ Consider line splitting of coke to obtain representative sample for tests ○ Complete coke analysis of both batches ○ Comparison between coke side and push side <p>Benchmarking with Industrial Oven</p> <ul style="list-style-type: none"> • Conduct carbonization test to benchmark resultant coke quality with industrial coke – April 2019 <ul style="list-style-type: none"> ○ Acquire coal and coke sample from SunCoke ○ Full charge carbonization ○ Benchmarking of coke quality with industrial coke sample
--	--	--	--	---

	<p>CCRA 91: Blast Furnace Energy Reduction Initiatives using Auxiliary Fuel Injection</p>	<ul style="list-style-type: none"> 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 	<p>PCI rig setup</p> <ul style="list-style-type: none"> Standard rig test procedure Establish repeatability of PCI rig test Apply blast furnace dust and sludge carbon type differentiation (CTD) TGA technique to rig combustion residues Develop new methodology to examine reactivity of combustion residues Validate ash tracer assumption for burnout calculation <p>Develop relationship between coal properties (petrography, rheology) and combustion behaviour</p> <p>Promote CanmetENERGY PCI rig to increase cost recovery benefits</p>	<p>PCI rig setup</p> <ul style="list-style-type: none"> Standard rig test procedure Establish repeatability of PCI rig test <ul style="list-style-type: none"> Completed (CCRA Report) Apply blast furnace dust and sludge carbon type differentiation (CTD) TGA technique to rig combustion residues <ul style="list-style-type: none"> Completed (CCRA Report) Develop new methodology to examine reactivity of combustion residues <ul style="list-style-type: none"> Completed (CCRA Report) Validate ash tracer assumption for burnout calculation <ul style="list-style-type: none"> Completed (CCRA Report) Rig capability enhancement <ul style="list-style-type: none"> Natural gas/Coke oven gas co-injection (A3) <ul style="list-style-type: none"> Installation completed Blast moisture control <ul style="list-style-type: none"> Installation in progress, waiting for specification from client Off gas sampling <ul style="list-style-type: none"> Setup needs modification. Cannot close mass balance <p>Develop relationship between coal properties (petrography, rheology) and combustion behaviour</p> <ul style="list-style-type: none"> Collection of coal properties data and combustion behavior <ul style="list-style-type: none"> CCRA Report on transformation mechanism of PCI Coal <p>Promote CanmetENERGY PCI rig to increase cost recovery benefits</p> <ul style="list-style-type: none"> Paper in ICSTI 2018 Vienna Paper in AISTech 2019 and METEC 2019
<p>Database, Standards and Procedures</p>	<p>CCRA 54: ISO and ASTM Coal and Coke Standards</p>	<ul style="list-style-type: none"> Development of standards and procedures pertaining to Canadian Coal and Steel industries 	<p>Effect of coal particle size on rheology measurement</p> <p>Sapozhnikov plastometer commissioning</p> <p>Examination of coal oxidation information</p> <p>Identify both ASTM and ISO up for review</p>	<p>Effect of coal particle size on rheology measurement</p> <ul style="list-style-type: none"> Fluidity and dilatation measurement of US coal samples at different size Require selection of WCCs for study <p>Sapozhnikov plastometer commissioning</p> <ul style="list-style-type: none"> On Hold <p>Examination of coal oxidation information</p> <ul style="list-style-type: none"> Not started yet <p>Identify both ASTM and ISO up for review</p> <ul style="list-style-type: none"> On-going

			Paper on findings of ISO Inter Lab Study on Dilatation	Paper on findings of ISO Inter Lab Study on Dilatation ○ In preparation for METEC 2019
CCRA 75: Development of Research Collaboration opportunities	<ul style="list-style-type: none"> To establish technical exchanges or co-operative research studies with National and International Research group 	<p>Develop relationship with universities and research institutes on Bio carbon and ERCO</p> <p>Explore Mitacs for building partnership between academia, industry</p> <p>Expose CanmetENERGY globally</p> <p>Engage with ACARP, BHP/CSIRO (QCAT), MEFOS, DMT, Aachen, NSSMC, CPM, VTT</p>	<p>Develop relationship with universities and research institutes on Bio carbon and ERCO</p> <p>Explore Mitacs for building partnership between academia, industry</p> <p>Expose CanmetENERGY globally</p> <p>Engage with ACARP, BHP/CSIRO (QCAT), MEFOS, DMT, Aachen, NSSMC, CPM, VTT</p> <p>○ Discussion with MEFOS(Sweden) and VTT(Finland) on who is doing what in biocarbon research</p>	<p>○ On-going</p> <p>Explore Mitacs for building partnership between academia, industry</p> <p>Expose CanmetENERGY globally</p> <p>○ On-going</p> <p>Engage with ACARP, BHP/CSIRO (QCAT), MEFOS, DMT, Aachen, NSSMC, CPM, VTT</p> <p>○ Discussion with MEFOS(Sweden) and VTT(Finland) on who is doing what in biocarbon research</p>
CCRA 76: Modeling of Coal and Coke Properties using Historical Database	<ul style="list-style-type: none"> To develop relationships for coal and coke properties from existing CanmetENERGY data. To generate Industrial Intelligence from historical data. 	On Hold	On Hold	On Hold
CCRA 92: Benchmarking of Movable Wall Ovens	<ul style="list-style-type: none"> 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	Conduct 3 carbonization tests in 18in oven and 3 carbonization tests in Carbolite with same coal blend ○ Q1 2019 ○ Coal blend ○ AMD standard blend with 30% WCC ○ Number of tests ○ Gravity charge 18-inch Oven x 3 ○ Gravity charge Carbolite Oven x 3 ○ 2 compartment box charge in Carbolite oven x 1 ○ Other test ○ Use same coal blend for bio-partial briquetting test in 18-inch oven	Conduct 3 carbonization tests in 18in oven and 3 carbonization tests in Carbolite with same coal blend ○ Q1 2019 ○ Coal blend ○ AMD standard blend with 30% WCC ○ Number of tests ○ Gravity charge 18-inch Oven x 3 ○ Gravity charge Carbolite Oven x 3 ○ 2 compartment box charge in Carbolite oven x 1 ○ Other test ○ Use same coal blend for bio-partial briquetting test in 18-inch oven

