ALBERTA INNOVATES

CLEAN RESOURCES FINAL REPORT PACKAGE

Project proponents are required to submit a Final Report Package, consisting of a Final Public Report and a Final Financial Report. These reports are to be provided under separate cover at the conclusion of projects for review and approval by Alberta Innovates (AI) Clean Resources Division. Proponents will use the two templates that follow to report key results and outcomes achieved during the project and financial details. The information requested in the templates should be considered the minimum necessary to meet AI reporting requirements; proponents are highly encouraged to include other information that may provide additional value, including more detailed appendices. Proponents must work with the AI Project Advisor during preparation of the Final Report Package to ensure submissions are of the highest possible quality and thus reduce the time and effort necessary to address issues that may emerge through the review and approval process.

Final Public Report

The Final Public Report shall outline what the project achieved and provide conclusions and recommendations for further research inquiry or technology development, together with an overview of the performance of the project in terms of process, output, outcomes and impact measures. The report must delineate all project knowledge and/or technology developed and must be in sufficient detail to permit readers to use or adapt the results for research and analysis purposes and to understand how conclusions were arrived at. It is incumbent upon the proponent to ensure that the Final Public Report **is free of any confidential information or intellectual property requiring protection**. The Final Public Report will be released by Alberta Innovates after the confidentiality period has expired as described in the Investment Agreement.

Final Financial Report

The Final Financial Report shall provide complete and accurate accounting of all project expenditures and contributions over the life of the project pertaining to Alberta Innovates, the proponent, and any project partners. The Final Financial Report will not be publicly released.

Alberta Innovates is governed by FOIP. This means Alberta Innovates can be compelled to disclose the information received under this Application, or other information delivered to Alberta Innovates in relation to a Project, when an access request is made by anyone in the general public.

In the event an access request is received by Alberta Innovates, exceptions to disclosure within FOIP may apply. If an exception to disclosure applies, certain information may be withheld from disclosure. Applicants are encouraged to familiarize themselves with FOIP. Information regarding FOIP can be found at http://www.servicealberta.ca/foip/. Should you have any questions about the collection of this information, you may contact the Manager, Grants Administration Services at 780-450-5551.

ALBERTA INNOVATES

CLEAN RESOURCES FINAL PUBLIC REPORT

1. PROJECT INFORMATION:

Project Title:	**Carbon Fibre from Suncor Bitumen Feedstock(s) – Lab scale**
Alberta Innovates Project Number:	G2020000392
Submission Date:	February 28, 2022
Total Project Cost:	$1,219,791
Alberta Innovates Funding:	$609,896
AI Project Advisor:	Paolo Bomben

2. APPLICANT INFORMATION:

Applicant (Organization):	**Suncor Energy Services Inc.**
Address:	150 6 Ave SW, Calgary, AB T2P 3E3
Applicant Representative Name:	Todd Pugsley
Title:	Director, Enterprise Technology
Phone Number:	(403) 875-4674 (Cell), (403) 296-8062 (office)
Email:	TPugsley@suncor.com

3. PROJECT PARTNERS

Please provide an acknowledgement statement for project partners, if appropriate.

RESPOND BELOW

Alberta Innovates and Suncor were only entities that provided funding support for this project. No project partners for this project.

A. EXECUTIVE SUMMARY

Provide a high-level description of the project, including the objective, key results, learnings, outcomes and benefits.

RESPOND BELOW

Carbon fibres from bitumen feedstock was identified as one of the four highest value opportunities for economic diversification of the oil sands in the BBC Phase 2 report from Stantec. Suncor has established a technology development program to evaluate the opportunity to convert portions of the bitumen barrel, starting with asphaltenes, to general purpose, activated and high performance carbon fibre.
Alberta Innovates is an ideal partner to advance and accelerate Suncor's efforts to commercialize a carbon fibre process using Athabasca bitumen. The current project focusses on lab scale feedstock preparation and generation of carbon fibre threads with the objective to provide suitable process configurations and data to decide whether to advance to the next phase of development.

The value of high-performance carbon fibres is about two orders of magnitude greater than diluted bitumen, gasoline and diesel. This is the potential increase in market value that carbon fibres represent to Alberta's oil and gas exports. Also, carbon fibre products do not require pipelines to reach export markets, thus improving Alberta's bitumen market access. Conversion of asphaltenes to carbon fibre is an encouraging opportunity to increase value of exported bitumen derived products by 25%.

For this stage of development, third party lab scale facilities were leveraged to analyze, research and test promising routes to commercial grade carbon fibre from asphaltenes. The following results were obtained:

- General purpose quality and activated general purpose carbon fibre has been created from asphaltenes.
- 2 Bulk quantities of general purpose carbon fibre were manufactured and used to create composites
- Composite blend of polymer plus asphaltene derived carbon fibre successfully created

- Carbon fibre with properties better than general purpose also created.
- Market research performed by consultant indicates multiple current and potential markets for asphaltene derived carbon fibre is possible.

Learnings from this stage of the project has provided Suncor confidence to consider advancing research in this area further.

B. INTRODUCTION

Please provide a narrative introducing the project using the following sub-headings.

- **Sector introduction:** Include a high-level discussion of the sector or area that the project contributes to and provide any relevant background information or context for the project.
- **Knowledge or Technology Gaps:** Explain the knowledge or technology gap that is being addressed along with the context and scope of the technical problem.

RESPOND BELOW

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There is no commercial process to convert asphaltenes to carbon fiber. The project attempts to address at lab scale the technical gap of what process(es) are feasible for modifying asphaltenes to make carbon fibre for both general purpose and higher performance carbon fibre.

C. PROJECT DESCRIPTION

Please provide a narrative describing the project using the following sub-headings.

- **Knowledge or Technology Description:** Include a discussion of the project objectives.
- **Updates to Project Objectives:** Describe any changes that have occurred compared to the original objectives of the project.
- **Performance Metrics:** Discuss the project specific metrics that will be used to measure the success of the project.

RESPOND BELOW

Project Objectives:

1. Demonstrate if can make general purpose carbon fibre
2. Demonstrate if can make higher quality carbon fibre.

No changes to project objectives

Performance metrics:

1. Create carbon fibre under lab scale conditions that provides confidence could translate to commercial operation.

D. METHODOLOGY

Please provide a narrative describing the methodology and facilities that were used to execute and complete the project. Use subheadings as appropriate.

RESPOND BELOW

Multiple researchers in Canada and the US were solicited to collaborate on the project objectives. Entities with existing asphaltene, pitch, and/or coal conversion lab facilities and capabilities and entities with carbon fibre spinning through to carbonization facilities were part of the research team.

E. PROJECT RESULTS

Please provide a narrative describing the key results using the project's milestones as sub-headings.

- Describe the importance of the key results.
- Include a discussion of the project specific metrics and variances between expected and actual performance.

RESPOND BELOW

The following results were obtained:

- General purpose quality and activated general purpose carbon fibre has been created from asphaltenes <-- meets first project objective
- 2 Bulk quantities of general purpose carbon fibre were manufactured and used to create composites <-- meets first project objective
- Composite blend of polymer plus asphaltene derived carbon fibre successfully created <-- meets second project objective
- Carbon fibre with properties better than general purpose also created. <- meets second project objective
- Market research performed by consultant indicates multiple current and potential markets for asphaltene derived carbon fibre is possible. <-- helps with business case for justifying next stage of development.

Learnings from this stage of the project has provided Suncor confidence to consider advancing research in this area further.

F. KEY LEARNINGS

Please provide a narrative that discusses the key learnings from the project.

- Describe the project learnings and importance of those learnings within the project scope. Use milestones as headings, if appropriate.
- Discuss the broader impacts of the learnings to the industry and beyond; this may include changes to regulations, policies, and approval and permitting processes

RESPOND BELOW

Asphaltenes can be converted to at minimum general purpose carbon fibre (~500 MPa tensile strength and ~50GPa tensile modulus). Activated carbon fibre and fibres with properties better than general purpose carbon fibre have been achieved but not to the high performance threshold of >~3,000 MPa tensile strength and >~250GPa tensile modulus.

G. OUTCOMES AND IMPACTS

Please provide a narrative outlining the project's outcomes. Please use sub-headings as appropriate.

- **Project Outcomes and Impacts:** Describe how the outcomes of the project have impacted the technology or knowledge gap identified.
- **Clean Energy Metrics:** Describe how the project outcomes impact the Clean Energy Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Program Specific Metrics:** Describe how the project outcomes impact the Program Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Project Outputs:** List of all obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project. As appropriate, include attachments.

RESPOND BELOW

H. BENEFITS

Please provide a narrative outline the project's benefits. Please use the subheadings of Economic, Environmental, Social and Building Innovation Capacity.

- **Economic:** Describe the project's economic benefits such as job creation, sales, improved efficiencies, development of new commercial opportunities or economic sectors, attraction of new investment, and increased exports.
- **Environmental:** Describe the project's contribution to reducing GHG emissions (direct or indirect) and improving environmental systems (atmospheric, terrestrial, aquatic, biotic, etc.) compared to the industry benchmark. Discuss benefits, impacts and/or trade-offs.
- **Social:** Describe the project's social benefits such as augmentation of recreational value, safeguarded investments, strengthened stakeholder involvement, and entrepreneurship opportunities of value for the province.
- **Building Innovation Capacity:** Describe the project's contribution to the training of highly qualified and skilled personnel (HQSP) in Alberta, their retention, and the attraction of HQSP from outside the province. Discuss the research infrastructure used or developed to complete the project.

RESPOND BELOW

Economic – Carbon fibre from Asphaltenes at this stage of analysis appears to have potnetila to meet corporate economic targets.

Environmental – IF successful, Asphaltenes may be diverted from current pathway of combustion for power generation if coke is not sequestered.

Social –

a) Increase Value and Market Access – Carbon fibre from asphaltenes can provide a new higher value revenue stream for Alberta oil sands producers and a new building block material from bitumen molecules that have the potential to catalyze new Canadian markets for carbon fibre (ex. auto parts, recreational products, reinforced building materials).

b) Advanced Manufacturing and Materials - Carbon fibre is an advanced material for consumer, industrial and military products, which is not currently a commercial value chain in Canada. It is expected that portions of bitumen can be an inexpensive and reliable feed source for carbon fibre production. Along this new value chain, new Canadian businesses could be created, or existing ones expand

Building Innovation Capacity – Multiple PhD's, and engineers were employed in Alberta during this project with these individuals increasing the knowledge base for this subject. Learnings can be built upon in the future to advance the technology.

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I. RECOMMENDATIONS AND NEXT STEPS

Please provide a narrative outlining the next steps and recommendations for further development of the technology developed or knowledge generated from this project. If appropriate, include a description of potential follow-up projects. Please consider the following in the narrative:

- Describe the long-term plan for commercialization of the technology developed or implementation of the knowledge generated.
- Based on the project learnings, describe the related actions to be undertaken over the next two years to continue advancing the innovation.
- Describe the potential partnerships being developed to advance the development and learnings from this project.

RESPOND BELOW

Next stage of the program is to finish the lab scale research to maximize carbon fibre properties and update business case to justify the next stage of development (pilot stage).

There are many points in the carbon fibre value chain that Suncor may be involved in with all options still being considered.

J. KNOWLEDGE DISSEMINATION

Please provide a narrative outlining how the knowledge gained from the project was or will be disseminated and the impact it may have on the industry.

RESPOND BELOW

A patent application has been submitted to both the Canadian and US patent offices. Once open to the public, content in the application will be available to appreciate current knowledge on how to take asphaltenes to carbon fibre.

K. CONCLUSIONS

Please provide a narrative outlining the project conclusions.

- Ensure this summarizes the project objective, key components, results, learnings, outcomes, benefits and next steps.

RESPOND BELOW

Carbon fibres from bitumen feedstock was identified as one of the four highest value opportunities for economic diversification of the oil sands in the BBC Phase 2 report from Stantec. Suncor has established a technology development program to evaluate the opportunity to convert portions of the bitumen barrel, starting with asphaltenes, to general purpose, activated and high performance carbon fibre.
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