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.

CLEAN RESOURCES FINAL PUBLIC REPORT TEMPLATE

1. PROJECT INFORMATION:

Project Title:	**Carbon Fibre Pilot**
Alberta Innovates Project Number:	G2020000404
Submission Date:	December 15, 2021
Total Project Cost:	$247,000
Alberta Innovates Funding:	$75,000
AI Project Advisor:	Paolo Bomben

2. APPLICANT INFORMATION:

Applicant (Organization):	**Exergy Solutions**
Address:	202 6 Avenue Southwest #800 BVS 1, Calgary, AB T2P 2R9
Applicant Representative Name:	David Denton
Title:	Project Engineer
Phone Number:	403-383-7262
Email:	ddenton@exergysolutions.com

3. PROJECT PARTNERS

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

RESPOND BELOW

Exergy would like to acknowledge financial contributions from Suncor Energy, Alberta Innovates, and NGen for making this project possible.

A. EXECUTIVE SUMMARY

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

RESPOND BELOW

A technical feasibility study of a carbon fiber (CF) asphaltene precursor preparation pilot and the associated carbon fiber production line was performed. The combined pilot was designed to produce approximately 60 kg of carbon fiber every three weeks to supply end-users with sufficient quantity for quality verification and analysis. It was determined that asphaltenes present an attractive alternative to polyacrylonitrile (PAN) as a feedstock and that the cost to prepare asphaltenes was not cost prohibitive. The class 3 (+30%/-20%) cost estimate of the pilot facility came in line with previous expectations. The pilot was designed to incorporate operational flexibility with three primary modules identified: asphaltene generation from a hydrocarbon feedstock, treatment of the asphaltenes, and the removal of impurities. Based on discussions with a third-party furnace manufacturer, learnings at the pilot scale will be critical to understanding the properties of the asphaltenes when processed in a continuous manner, as well as to identify differences compared to processing polyacrylonitrile which could lead to significant cost savings. In conjunction, a class 5 (+50%/-30%) cost estimate of a commercial facility was developed using the current knowledge. The commercial facility was sized to produce 7,000 metric tonnes of carbon fiber per year, utilizing two carbon fiber processing lines developed by the third-party furnace manufacturer. This would provide a non-combustion end use for approximately 1,000 barrels of vacuum tower bottoms per day. The preliminary economic evaluation indicated that commercial operation would meet common IRR thresholds and would an attractive economic opportunity for Alberta.

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

Sector introduction:

Alberta's bitumen production is projected to grow from 3.2 million bpd in 2019 to 4.0 million bpd by 2030 and is a major Canadian economic engine.

Bitumen-derived asphaltene conversion to high value carbon fibre (CF) is a significant strategic economic diversification alternative contingent upon developing a low-cost advanced manufacturing method to achieve the specifications. CF production can significantly increase asphaltene value and provide a non-combustion end use.

CF can be incorporated into cement, steel, wood, or plastic products to have superior properties at much lower weight than non-CF containing materials. CF is mainly produced from expensive polyacrylonitrile (PAN) through a complex, capital intensive chemical and mechanical process; the high cost limits CF use to low volume, high value products.

Asphaltene-derived CF could offer a cost reduction due to less expensive feedstock which comprises up to 50% of the cost of CF production. The Alberta Innovates sponsored BBC Phase 2 report indicates asphaltene based CF product (i.e. spooled threads) could fetch between $3,000-$50,000 USD/ton versus $30-40 USD/ton for petcoke (the predominant disposition for asphaltenes currently). The value uplift is potentially 100 to 1,250 times the current value for asphaltenes.

Knowledge or Technology Gaps:

The focus of this study was to understand the next steps required to progress the technology readiness level (TRL) of the processes required to produce asphaltene derived CF. This knowledge and technology gap was filled by developing a process flowsheet and selecting a throughput of a CF pilot plant that would produce sufficient material to test and evaluate performance properties and product value. A pilot plant design included process flow development, equipment design and selection, and the development of a pilot program cost estimate was completed as part of this study.

Using the proposed design for an asphaltene derived CF pilot plant, and based on a set of assumptions that reflect our best understanding of capital cost, operating cost, and product value, market and economics evaluations for a commercial CF manufacturing plant were completed. This provided a roadmap to progress this technology from lab scale to commercial deployment.

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

Knowledge or Technology Description:

The goal of the feasibility study was to determine the pilot plant design and capital and operating costs to inform the go-forward decision. It included a) defining the pilot size and objectives to meet investment requirements for a commercial facility, b) designing and engineering the CF feedstock pretreatment process range for a variety of asphaltene feeds, c) designing and engineering the CF spinning, carbonization, and process, d) producing a Class III cost estimate and schedule for the pilot facility, e) producing a commercial facility Class V screening /scenario level cost estimate and schedule.

Updates to Project Objectives:

The feasibility study was completed meeting all the objectives of the project.

Performance Metrics:

The primary performance metric for this study was to design a pilot carbon fibre facility with a capital cost totaling less than $20MM. The pilot class III cost estimate showed that the pilot design completed as part of this study can be completed for less than $20MM.

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

Pilot design conceptualization:

The design and process objectives of the pilot facility were jointly developed with Suncor to align with current knowledge and projected process development. It was determined that a multi-module, semi-batch process would be most appropriate for asphaltene treatment and processing. Initial siting was assumed to be at an existing Exergy location, but the pilot was designed to be location independent. In conjunction, a carbon fiber production line was sized with a third-party furnace manufacturer to allow the treated asphaltenes to be converted into carbon fiber. The line was sized to produce roughly 60 kg of carbon fiber spools every 3 weeks when operating continuously.

Pilot design and cost estimate:

The pilot was designed with a multi-disciplinary team to meet the process objectives outlined by the partner organizations. The design and cost estimate was performed in accordance with standard front-end engineering and design (FEED) methodologies and outputs.

Commercial design and estimate:

Based on the pilot FEED findings, a commercial design was developed as a continuous process. Differences between the pilot and commercial arose from solids transport steps, but major process objectives remained the same as the pilot. From the design, a class V cost estimate was developed to analyze the preliminary economic feasibility of the process and to explore ways to optimize value.

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

Pilot study and design:

A carbon fiber production pilot was designed with an anticipated output of 60 kg of finished carbon fiber spools every 3 weeks. The pilot can process a variety of feedstocks including dilbit, bitumen, vacuum tower bottoms, as well as raw asphaltenes. The modular design of the pilot increases flexibility and allows for seamless module substitution, rearrangement, or bypassing, depending on the feedstock and processing objectives. Three modules are initially proposed, asphaltene generation, asphaltene treatment, and asphaltene refining. Asphaltene generation is performed with solvent de-asphalting which will produce a semi-upgraded oil as a by-product. The generated (or provided) asphaltenes are subjected to treatment which may include thermal, catalytic, or chemical processes to improve their physical properties. Asphaltene refining involves the selective dissolution of specific asphaltenes in a solvent and their subsequent re-precipitation to remove impurities such as coke, sand, or other contaminants. Following re-precipitation, the asphaltenes are melt spun into green fiber spools for further processing. Altogether, this design provides maximum flexibility, ease of solid handling, and high throughput to allow for experimentation while ensuring that the carbon fiber production line maintains nameplate throughput.

The modular precursor treatment process is anticipated to occupy a footprint of approximately 1,860 ft^2 on a single level to accommodate the ease of cart movement between the processing modules.

A third-party furnace manufacturer was contracted to assist in the design and development of a carbon fiber production line to process the asphaltene green fiber spools into a final carbon fiber product. It was determined that throughput of the overall process would be bottlenecked by the carbon fiber production line and as a result, it is expected to run continuously, split into 3-week product batches. The production line includes oxidation, carbonization, graphitization, and surface treatment. Since processing asphaltene green fiber is different from polyacrylonitrile (PAN) in terms of yield, intermediate physical properties, and impurities, the proposed production line provides flexibility to modify residence time and treatment temperatures, optimizing the values for asphaltenes. Due to the initial properties of the asphaltenes, it is thought that considerable reductions in the oxidation step may be feasible, which would greatly improve the economic attractiveness of the process. In discussions with the third party, the oxidation step was determined to be the most costly, both in terms of capital costs and operating costs.

The carbon fiber production line is anticipated to occupy a footprint of approximately 2,870 ft^2.

Commercial design and study:

A commercial carbon fiber production facility was designed and costed to analyze economic feasibility. After discussions with the third-party furnace manufacturer, it was determined that a throughput of 7,000 metric tonnes per year of carbon fiber was the most optimum for achieving economies of scale in the design. This corresponds to approximately 1,000 BPD of vacuum tower bottoms based on an expected asphaltene content. Feedstocks with lower asphaltene contents would require a higher throughput to produce an equivalent amount of fiber. The commercial facility is sited at two locations, one for processing feedstock into green fiber spools and the other for converting the green fiber into finished carbon fibers. Processing of the feedstock into green carbon fiber is most economically performed in close proximity to a refinery where low value vacuum tower bottoms are readily available by pipeline and can repurchase the de-asphaltenated oil which is produced as a by-product. Production of carbon fiber from green fibers was thought to be most economic in an industrial park where infrastructure exists for the transportation of solid product and labour and land is readily available. In comparison with precursor preparation, the carbon fiber production lines are expected to require an order to magnitude higher land use which would make situating it inside of the existing land allowance of a refinery difficult.

The economic evaluation determined that there is an economic case of the commercial process and that it was able to meet standard IRR thresholds.

Project Success Metrics

Metric	Project Target	Comments
Pilot Cost Estimate	Completed	Required to construct Pilot facility and move to TRL 6
Pilot Schedule	Completed	Required to construct Pilot facility and move to TRL 6
Commercial Screening Level Study	Completed	Required to construct Pilot facility and move to TRL 6
Pilot Design Basis	Completed	Required to construct Pilot facility and move to TRL 6
Estimated demonstration line cost	$20,000,000	Completed estimate less than $20 million.

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

Pilot study:

It was determined that a production rate of 60 kg every 3 weeks would be sufficient to meet end-user testing requirements. The pilot was designed to be able to extract critical process data including yields, exhaust compositions, physical properties, and chemical properties so that a commercial facility can be optimized to minimize risk and maximize economics returns. More broadly, the pilot will provide additional insights on asphaltene handling, including at elevated temperatures, which will be valuable for other end uses of asphaltenes beyond carbon fiber.

For the carbon fiber production line, the pilot will be critical for optimizing the processing recipe. Oxidation/stabilization of the green fibers is a highly capital and energy intensive process and any optimizations around this processing step will have an outsized influence on the overall project economics. The scale of the pilot allows sufficient flexibility to vary line speed, residence times, and temperatures while still processing the fibers in a continuous manner. The ability to process green fibers to carbon fiber continuously is key to developing end user support as product consistency is critical due to certification processes. While emerging markets such as automotive applications may be more flexible, aerospace applications require a robust and intensive certification process, so much so that some manufacturers prefer to order previous furnace models rather than more optimized models purely due to previous certification.

Commercial design and study:

Asphaltenes are an economic alternative precursor feedstock to PAN. A commercial facility to process raw asphaltenes into carbon fiber is an economically viable project that can provide additional value to Alberta's hydrocarbon resources through both an end-use of low value asphaltenes and partially upgrading oil during the asphaltene extraction process. The scale of a commercial facility is dictated by the economies of scale for the carbon fiber production line and 7,000 metric tonnes per year is believed to be the optimum throughput with 2 parallel fiber lines being deployed. This represents an end-use for approximately 1,000 BPD of vacuum tower bottoms. When comparing both the capital and operating costs of a vacuum bottoms to carbon fiber facility, the carbon fiber production line requires significantly more than precursor preparation. As a result, it was determined that producing asphaltene green fiber spools to displace PAN would be highly attractive once the physical properties of the final product are verified. This approach would also be able to leverage the experience of each party as existing manufacturers are well versed in the nuance of fiber production which is labour intensive. At the same time, this would allow existing hydrocarbon producers to focus on precursor preparation which is more similar to traditional bulk chemical manufacturing and production.

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

Project Outcomes and Impacts:

One of the study's goals is to generate information to decide whether to proceed with continued pilot, product, and commercial development. If the pilot is built, it will serve as a test facility for improving the production method, for testing a variety of feedstocks, and will potentially support future technology and product development, adoption, and scaleup. If the pilot demonstrates technical and commercial viability, the project could lead to asphaltene-derived CF commercialization in Alberta and Canada.

Clean Energy Metrics:

Installation of asphaltene-derived CF commercial facilities could create a new market for bitumen co-products, and offer broad social and environmental benefits to Alberta and Canada. Low-cost CF can generate new CF composite material businesses and the social benefit of increased jobs, along with a significant reduction in GHG emissions related to displacing cement and steel manufacturing tonnage with CF. These low-cost Canadian CF materials could drive innovation in multiple industries and sectors spread across Alberta and Canada including construction, automotive, aerospace, sporting goods, chemical processing, and additive manufacturing.

Exergy has engineered the pilot manufacturing scale up, design, construction, and provides lab infrastructure to move the technology from TRL 4 to 6. With the construction and operation of the pilot, up to $20MM of capital investment will be required that will require approximately 14 highly qualified personnel (HQP) to operate for the duration of the piloting test program.

This study, in providing a pathway from R&D to piloting and eventual commercialization, is an important step in realizing these clean energy objectives.

Clean Resources Metrics

Metric	Project Target	Comments
TRL advancement	Advance A-CF from TRL 4 to TRL 6	The completed study was the first step in building a pilot facility to create Asphaltene derived carbon fibre (A-CF) advancing the TRL to 6.
Future Capital Investment	~$20 million pilot facility	A cost estimate was completed and the total capital investment required for the pilot facility is estimated to be less than $20 million.
Field pilots/demonstrations	Design basis and estimates for pilot facility	As part of this study, a design basis and cost estimate for a pilot facility were completed.
Sector HQP Trained	4	Achieved, HQSP were utilized in the completion of this project.

Program Specific Metrics:

Suncor supported this work and had input into this pilot design, but once commercialized multiple end users, asphaltene producers, CF manufacturers, or companies that utilize CF could be involved or partnered with.

The precursor segment of the pilot has been designed to facilitate adding new processes, lengthening processes to test new conditions, and attempting new experimental conditions while avoiding postponement of a CF production line campaign. Due to the equipment sizes in the precursor preparation section, this operational flexibility and functionality is achieved with minimal additional capital cost. The CF pilot facility incorporates flexibility to:

- Adjust operating conditions (wide range of operating temperature and pressure).

- Incorporate, eliminate, or substitute methods to pre-treat the feed and enhance final CF product properties.
- Enable processing sequence re-arrangement, including adding or skipping stages.

This design will allow for the testing and development of unique products and process specifically designed to produce asphaltene derived carbon fibre.

Program Specific Metrics

Metric	Project Target	Comments
# of End Users participating	Suncor is the only end user participating at this time	Suncor is developing this technology with support from Exergy, but once commercialization, multiple end users, asphaltene producers, CF manufacturers, or companies that utilize CF could be involved
Unique product/process	Yes	This project has produced a pilot facility design required to scale up and prove the creation of A-CF, a unique product produced using a unique process
$/bbl product uplift		This feasibility project has shown that material, significant asphaltene value uplift is possible, but this metric will ultimately be determined by evaluating the results obtained from operating the pilot facility.
# commercial BBC products	0	Products that could be commercialized include: CF reinforced concrete, CF laminated wood products, CF 3D printed materials, and new CF materials, depend on the pilot testing results.

Project Outputs:

The pilot study has delivered an engineering and commercial decision package by executing the following deliverables using Exergy's agile engineering and Suncor's stage gate process:

- Pilot Study
    - Feedstock characteristics and production requirements
    - Flexible thermal, chemical, physical, and/or catalytic precursor treatment
    - Estimated mass balance and BFD
    - Specify and design the pilot CF pre-treatment and fibre treatment and spinning, carbonization and treating pilot equipment and layout
    - 3D model
- Schedule development
    - Pilot detailed engineering, procurement, construction, commissioning and operation
    - Commercial facility estimate

- Cost Estimating
  - Class III CF pre-treatment, fibre treatment and spinning pilot equipment total installed cost including utilities and infrastructure
  - Pilot facility operating cost
- Class V commercial scale screening / scenario level total installed cost and operating costs.

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:

The feasibility study is required to move the technology to the next stage of TRL development and eventually to commerciality, where the major economic benefit to Albertans and Canadians and the consortium member companies could be achieved.

Further economic benefit could occur for Alberta companies once Pilot execution is approved by providing the engineering, construction, and operation services for Alberta's first asphaltene-derived CF pilot plant. Likewise, Alberta companies could benefit from providing business development services to refine the economic analysis of the commercial scale CF manufacturing plant, informed by the pilot execution. If the pilot demonstrates technical viability and generates sufficient product for commercial product viability testing, the oilsands sector could continue to use the pilot facility as a CF product development centre of excellence to inform next steps for a commercial facility to generate asphaltenes for CF manufacturing (the study would inform the economic impact of commercial plant construction).

Once the commercial plant is built, the spin-off opportunities include manufacturing CF composite materials and forms. The study will lay the groundwork for industrial CF manufacturing technology implementation across Alberta and Canada and potentially enable multiple spin-off business opportunities.

Environmental:

Bitumen-derived asphaltene conversion to high value carbon fibre (CF) is a significant strategic economic diversification alternative contingent upon developing a low-cost advanced manufacturing method to achieve the specifications. CF production can significantly increase asphaltene value and provide a non-combustion end use.

Social:

Successful pilot execution will require industry, academia, and Alberta Innovates collaboration to achieve the best results. Participants in the Alberta Innovates Carbon Fibre Grand Challenge could also be consulted on preparing the pre-treatment system, along with other researchers Suncor may be engaging. Installation of asphaltene-derived CF commercial facilities will create a new economy for Alberta, offset the downturn in the oil sector, and offer broad social and environmental benefits to Alberta and Canada. Low-cost CF can generate new CF composite material businesses and the social benefit of increased jobs, along with a significant reduction in GHG emissions related to displacing cement and steel manufacturing tonnage with CF. These low-cost Canadian CF materials can drive innovation in multiple industries and sectors spread across Alberta and Canada including construction, automotive, aerospace, sporting goods, chemical processing, and additive manufacturing.

Building Innovation Capacity:

The study has demonstrated that the construction and operation of a CF manufacturing pilot is technically and economically feasible, fifteen full time positions will be created for the engineering design and construction of the pilot, with an additional 14 full time positions required on an ongoing basis to operate the test facility.

Successful pilot product development, demonstration, and economics will enable proceeding to a commercial facility which has the potential to transform the Alberta economy, as the CF product line segment will generate significant new economics and a new industry platform. Pilot facility execution will increase Exergy, Suncor's, and Albertans asphaltene-derived CF product knowledge base, and seek to prove the product can be manufactured to required specifications.

Completion of the feasibility study precedes execution of a pilot project that has the potential to have broad implications for the collaboration ecosystem. New skills development will only occur in the Pilot execution. During the study, Exergy has been interacting with Suncor who is managing a parallel research effort to advance the CF pretreatment step. Exergy has also interacted with a third party carbon fibre equipment manufacturer to define the CF spinning process design and cost estimates.

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

Construction of the proposed pilot facility would represent the next step in the development of the asphaltene to carbon fiber production technology. The pilot will allow key learnings to be gained on the properties and performance of different asphaltene treatment and processing steps. By developing both the precursor preparation and carbon fiber production line at the same time, feedback between the treatment steps and final fiber properties will be rapid and conducive to iterative learning. This facility would be able to implement process concepts developed at bench scale, both privately and through universities, to be able to accelerate their testing and promise. Currently, work is limited to laboratory scales which makes process design difficult to scale up. By deploying ideas at a larger scale, key physical and chemical properties will be able to be analyzed and optimized to swiftly high-grade the most attractive process alternatives.

Long-term, leveraging partnerships with existing carbon fiber manufacturers would speed market uptake and acceptance of asphaltene derived carbon fibers as an alternative to PAN. The production of treated asphaltene green fiber would be a logical end point for existing hydrocarbon producers and would allow them to market the product as a PAN alternative to multiple customers without having to go up the steep learning curve of carbon fiber production lines. Traditional hydrocarbon producers will have a competitive advantage in the production of asphaltene green fiber due to their experience processing bulk hydrocarbons when compared with existing carbon fiber manufacturers. This would allow them to add significant value to Alberta’s asphaltene resources as PAN substitution is believed to be economically attractive. The proximity to green fiber, as well as Alberta’s abundant energy, would also make siting a carbon fiber production line attractive and may eventually be a source of foreign direct investment within the province.

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

Knowledge gained from the study will assist Suncor in deciding how to proceed with technology development in this aspect. If a pilot is built, it will serve as a test facility for improving the production method, for testing a variety of feedstocks, and will potentially support future technology and product development, adoption, and scaleup. If the pilot demonstrates technical and commercial viability, the project could lead to asphaltene-derived CF commercialization in Albert and Canada.

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

The study has delivered a pilot facility design and commercial capital, economic, and employment information to support decisions related to technology development required to move the technology from TRL 4 to 6. If the pilot is built, it will serve as a test facility for improving the production method, for testing a variety of feedstocks, and will potentially support future technology and product development, adoption, and scaleup. If the pilot demonstrates technical and commercial viability, the project could lead to asphaltene-derived CF commercialization in Alberta and Canada. The flexible design of the pilot plant will enable pilot scale testing for a variety of asphaltene or pitch sources.

The commercial study has produced an economic model based on asphaltene feedstock, helped develop an understanding of the key variables affecting the commercial business case and economic return, and prepared several scenarios for analysis. This model has demonstrated that there are scenarios that make the commercialization of asphaltene derived carbon fibre favorable, but ultimately economics will be dictated by the yield, quality, and processing steps that will be determined during pilot operation.

The overall technology commercialization unlocks new development and growth opportunities for both for Suncor and Exergy. Finding a high value, growing, beneficial, non-combustion use for asphaltenes is strategic and can become a major new economic diversification for Alberta and Canada’s manufacturing sector.