NON-CONFIDENTIAL

FINAL OUTCOME REPORT

• ERA Project ID	B0140184
• Title of Project	DROP-IN Fuels made from Alberta Renewable Feedstocks
• Name and information of Recipient contact	Dr. Inder Pal Singh, ips@sbifinechemicals.com
• Name of ERA Project Advisor	Mrs. Mehr Nikoo
• Start date of the Project	July 02, 2015
• Completion date of the Project	May 23, 2023
• Technology Readiness Level (TRL) at Project initiation	5
• TRL at Project completion	8
• Total actual ERA funds received (as outlined in Contribution Agreement including holdback)	
• Non confidential FOR submission date	July 20, 2023
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• Short Project description with high level results for the ERA website (maximum 1000 words)

SBI BioEnergy Inc., an Alberta Corporation, is the inventor of a proprietary disruptive renewable diesel and biodiesel technologies.

The prime objective of this project is to generate the design data necessary to construct design package for a first commercial plant. The aim is to de risk the technology for commercialization. The technology utilizes Alberta's farm non-food products as feed stock to produce low carbon products for use both in Alberta and for export. Potential commercial facilities could replace current renewable fuels imports and help reduce GHG emissions, while diversifying the economy of Alberta

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SBI in collaboration with its technology partner Shell Petroleum Int. developed technical information required for the deployment of the hydrogen-free technology for production of petroleum equivalent DROP-IN fuel, renewable diesel in an economic and environmentally viable way.

The technology development work involved setting up of several heavily instrumented Process Intensified Continuous Flow-Through Reaction (PICFTR) skids with several production capacities to operate in parallel to generate a large set of technical data around the process conditions such as temperatures and pressure operating windows, optimized physical strength of the catalyst formulation.

The use of several commercially available nonfood feed oil composition and impurities and their impact on the catalyst properties, performance and life span was optimized.

SBI instead of using 3rd party toll manufacturer, SBI developed and fabricated a fully automated skid mount unit and produced bulk quantities of the products such as, biodiesel, renewable diesel and cold climate compatible fuels (freeze point below -50°C), which can also found to be suitable for aviation use as well; it meets Jet-A properties defined by ASTM standards.

SBI met all its commitments and met the Milestone objectives and deliverables within agreed time line and well under budget; SBI trimmed budget substantially by developing expertise in house to design, manufacture the catalyst and equipment as well as conducting almost all the analytical work in house. Decision to conduct majority of the work in house led to enhanced training opportunities for the team members in addition to saving precious funds and time.

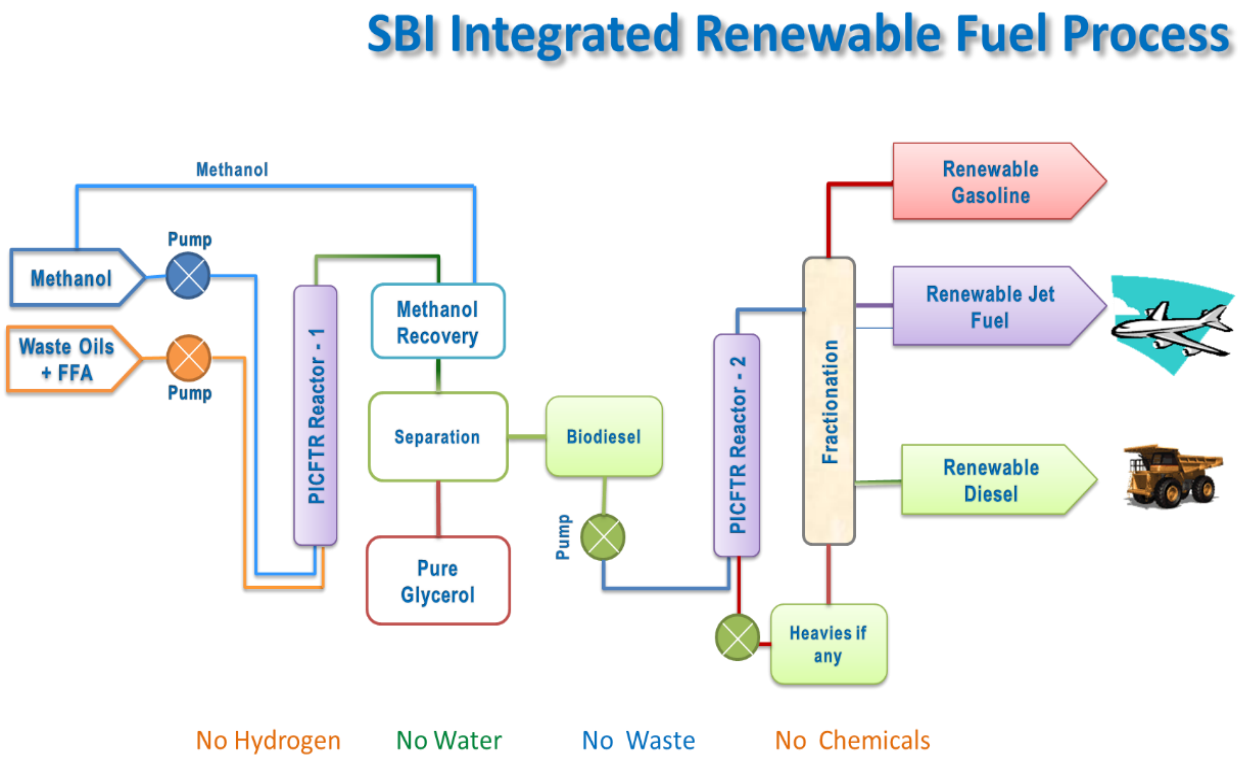
SBI during the project execution employed 15 permanent full time HQPs and trained several engineering CO op students for better start in the future endeavors by providing training and exposures to many unique first of its kind cutting edge technologies.

5.0 Executive Summary

• Introduction

The prime objective of this project is to generate the design data necessary to construct design package for a first commercial plant. The project will de risk the technology for commercialization. The technology enables utilization of Alberta's farm non-food products as feed stock to produce low carbon products for use both in Alberta and for export. Potential commercial facilities will replace current renewable fuels imports and help reduce GHG emissions, while diversifying the economy of Alberta.

The Technology: SBI's unique technology provides a fully integrated solution to manufacture in one single proprietary designed facility; a combination of DROP-IN renewable diesel fuel from a blend of Non-food oils. SBI has adapted its proprietary Process Intensification and Continuous Flow-Through Reaction (PICFTR) technology it developed for producing advanced pharmaceutical and fine chemical intermediates. This technology is combined with SBI's heterogeneous non-consumable proprietary CGCTM or, "Continuous Green Catalyst" based process.



• Background of the Project

Biofuel (biodiesel and Renewable Diesel) technologies used at the onset of SBI project were consuming vast amounts of consumable chemicals and water and generating a large volumes of chemical waste streams for disposal.

SBI technology intended to replace incumbent polluting technologies by developing proprietary solid non- consumable catalyst to replace multi step processes that used soluble consumable catalyst and eliminating acids, bases and acid and base washing steps from the processes making it a very clean single step process that produces high quality biodiesel and pharmaceutical grade glycerine; conventional process generate impure products that required further cost and labor intensive purification steps.

SBI also developed a hydrogen free technology to produce overall carbon negative high quality Renewable Diesel. Conventional technologies utilize precious metal-based catalysts and petroleum derived hydrogen to accomplish the transformation.

• Project objectives

Prime objectives were to optimize SBI's proprietary biodiesel and renewable diesel technologies, de risk and make it ready for commercial deployment.

7.0 Project Work Scope

The major activities under the Scope of the project were to optimize the already developed TRL 5 level SBI's renewable fuel technology, study impact of using various feed stocks including used cooking oils and waste animal fats etc., improvements as required in the catalyst and the process to accommodate various feed stocks and establish catalyst active life span. In addition, process data generation and collection required for designing a full-scale commercial production plant.

Project execution began with creating an experiment design team at SBI and team of technology partner experts. Experiments were designed to screen and test SBI's proprietary catalyst and process using a large number of PICFTR systems

SBI R&D Lab

SBI's Proprietary PICFTR Reactor Systems

Catalyst samples were screened using the PICFTR reactors operating on 24/7 basis. Observations and results were recorded, tabulated and discussed internally and with our technology partner team on weekly basis via web meetings their North American and European facilities Based on data review new experiments and catalyst modifications were considered. New catalyst designs were manufactured and screened and the entire process was repeated until a candidate catalyst was selected. Selected catalyst design was then used to develop and optimize process conditions and equipment design improvements.

SBI also successfully transferred catalyst technology to technology partner and trained their scientists and technicians for manufacturing the catalyst. Catalyst samples produced by technology partner were tested in SBI facility, technology

partner's facility and several 3rd party facilities in parallel to confirm the usefulness, reproducibility and reliability for a long period of up to five years continuous production and durability test runs.

Renewable fuels samples generated using SBI technology were tested in house and several local 3rd party facilities (Innotech Alberta, Canmet Energy, Intertech and Fluid Life, Trend Analysis Labs) in Edmonton and at 3rd party screening facilities in US and Europe against ASTM fuel standards.

Equipment Scale up:

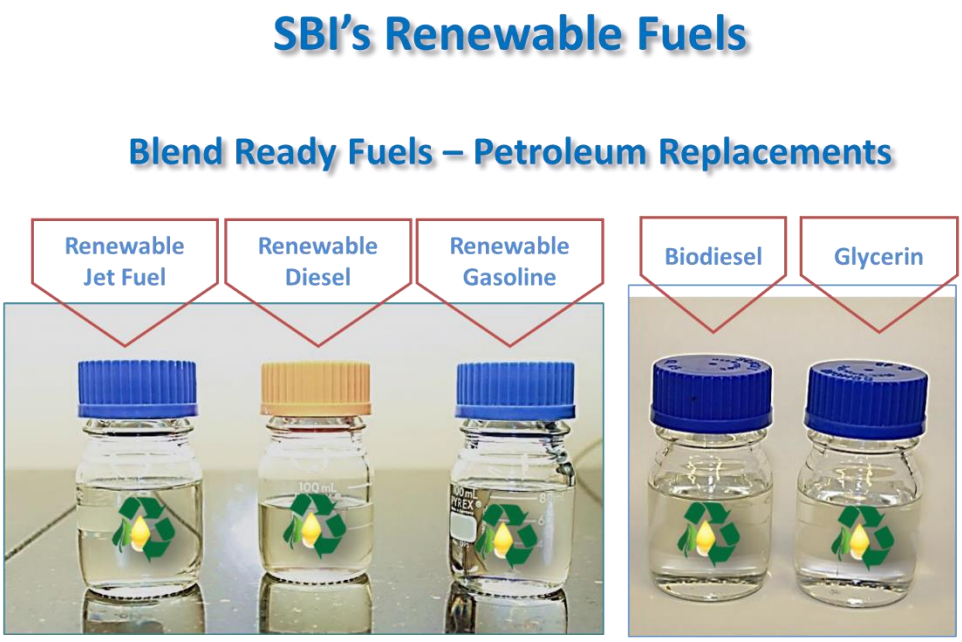
Developed catalyst, process and PICFTR equipment were scaled up in-hose to produce bulk quantities to blend with petroleum diesel and were tested by 3rd party to confirm to meet the ASTM 975-14 standards.

Modified Deoxygenation Pilot Reactor Equipment Skid

Renewable Fuel Analytical Results:

All samples produced were tested inhouse and by 3rd party service providers in Edmonton, US and Holland.

Here are the pictures of the SBI final products below:



Renewable diesel and jet fuel specification test report

SBI produced renewable diesel product successfully met the ASTM D975-14 and ASTM D 1655-15 Jet Fuel A specification for normal and cold temperature use in road transport internal combustion diesel engine use as well as us as an aviation fuel.

8.0 Commercialization

SBI successfully licensed technology to Shell Petroleum International for non-exclusive commercialization. SBI partnered with Shell to generate data and information required for designing a commercial production plant. SBI retained rights to find a local partner to set up a commercial production plant in Alberta.

Description of technology advancement over the course of the Project

Catalyst Life Time determination

- Catalyst tested to operate over three yrs.; it was originally targeted to operate for 2 months only.

- Produced fuel not only meets the cold temperature fuel properties, it exceeds even Jet-Fuel -A1 specifications as well; under the Success Metrics expectations.

Feed oil Specifications

- Use of non-food oils such as high FFA oils, animal fats and used cooking oils was optimized and demonstrated

Product Quality

- High quality renewable diesel obtained, tested and found suitable as a 50% or even as 100% unblended fuel.

9.0 Lessons Learned

Project was approved in Feb 2015. It took more than two years to arrange a technology partner and sign the Contribution Agreement. The Contribution Agreement was executed on October 18th, 2017.

1. Major changes were made in discussion with the technology partner and agreed in the Millstones from the original application. Accordingly, it was decided to scrap the idea of making a 10 MML capacity demonstration plant and replace the Objective with using PICFTR reactor systems to conduct extensive catalyst, process and processor optimization experiments. It was determined that SBI's proprietary, smaller skid mount PICFTR reactor systems would be more agile and generate better quality process data than the one large 10 MML capacity demonstration plant that was originally envisioned in discussion with some potential local partners with much less new technology development experience.

2. **Catalyst Production**: The process is based on proprietary catalyst developed in-house. Due to the novelty of the catalyst design, the process to manufacture was best designed, developed and perfected by SBI Scientists.

3. **Catalyst Life Time Assessment:** Generally, a catalyst is considered to be ready for commercial use if it passes approximately 2000 hours (little over 2.5 months) of continuous use without deterioration; SBI catalyst were tested in SBI lab, technology partner as well as 3rd party labs for over 2years of continuous use that proved the robustness of the catalyst. One set up was operated for over 5yrs. continuously at SBI facility without deterioration.

4. **PICFTR Unit Fabrication**: The catalyst testing and process optimization required several SBI proprietary PICFTR) units fabricated. First unit was outsourced to a Canadian reputed skid manufacturer. It took over six-month

time to get one unit fabricated with a big price tag. Overall, over 30 small and medium size units were needed to efficiently conduct all the screening in timely manner. It would have cost dearly in terms of time and money to get all the units with different configuration if outsourced.

SBI team decided to design and fabricate all the PICFTR units and did the automation as well. SBI built units performed for months for each test on continuous basis without a single failure of any time. Two units were tested for over two to five years periods, proving their mechanical durability as well as catalyst life time superiority over competing technologies.

5. **3rd party analysis**: The project envisioned using 3rd party analytical services. In the beginning SBI used Innotech, Canmet Labs, U of A and Intertek labs for its analytical needs. But the number of samples that were being generated became a real challenge in controlling the project costs. Therefore, it was decided to expand SBI's own analytical facility. SBI expanded analytical facilities to make itself-sufficient in supporting almost all of the analytical needs. It definitely made SBI one of the best equipped privately owned R&D facility in Alberta.

6. **3rd party bulk manufacturing**: Manufacturing of the bulk product required to meet project objectives was originally planned be outsourced to a toll manufacturer. It is normally an easier way to get bulk production done at a relatively low expenses if the product is one of the commercial products or if it involves standardized industrial equipment and processes.

   In SBI's case the catalyst, the process and the processor, all are novel and proprietary and that's why it was very difficult to find a toll service provider with existing very similar catalyst and equipment configurations that could easily be modified or reconfigured into adapting to SBI's technology to meet the technological advancements SBI's technology presents.

   In absence of any suitable toll manufacturer, it was, in the best interest of the project and to control the budget, decided to design and create a new pilot skid that will accommodate the novelties of SBI process.

   Pilot Unit Fabrications: The lead time required for this unit was beyond one year due to Covid and supply chain disruption reasons. SBI decided once again to build the unit in house. In house built pilot unit successfully generated the volumes of the fuel required. Product met all ASTM specification for the renewable diesel. The pilot unit was modified to accommodate the catalyst and process required to manufacture bulk low freeze point renewable diesel fuel, which also met the low freeze point criteria as well as ASTM specifications required for Jet Fuel-A1 fuel.

7. **Feed Oil Specification**: original project was designed around use of canola oil, an Alberta farm produce. To align with the LCFS and related requirements or mandates, it was decided to expand the scope from use of canola to all other locally available oils in various global locations. The scope for use included, sunflower, soybean, corn, rapeseed, used cooking oil, waste fats and high FFA waste greases etc., sourced from various parts of the world. SBI learned that though each feed stock had its own character and required some changes in the equipment and process, but the catalyst remained largely unchanged, proving SBI's invention's universal utility.

8. **Product Quality**: The original scope of the project was limited to the scale up of the biodiesel and renewable diesel technologies only. During the execution of the project and review of the product quality obtained, it appeared that the produced renewable diesel destined to low temperature northern climates had characteristics of aviation fuel as well. In addition, at the time various international governments were also pushing for cutting down on the aviation carbon foot print; SBI SAF sounded like a perfect solution for reducing GHG emission from air travel. SBI's renewable diesel product was perfect for the road transportation, the catalyst and process required modifications and optimization to make it more compatible with low temperature uses. SBI's modified catalyst and process now can generate colder climate use as well as for aviation use. The change was largely driven by the changing social cautiousness around the global warming and willingness of the governments to act on checking the temperature rise.

9. **Spin off technologies**: SBI's process is based on hydrogen free thermo-catalytic transformation of the feed oils. The transformation occurred by the in-situ generated hydrogen within the reactor system and therefore required no additional hydrogen, which usually are from a fossil origin, making SBI renewable diesel to be a carbon negative fuel. The renewable diesel formed was meeting ASTM standards for normal drop-in fuel with -15^{0}C freeze point properties. To make it compatible with colder climate use, it required a negligible amount of added hydrogen. SBI developed a technology to generate a carbon negative hydrogen process to generate the hydrogen from a bio methanol or bioethanol. Generated hydrogen was injected into the process to obtain a below -52^{0}C freeze point fuel, which also met Aviation ASTM Jet-A1 specifications and can be used a drop-in aviation fuel.

   During execution of the planned project two new technologies were developed or spin-off making a pipeline of new global warming combating carbon negative products; Sustainable Aviation Fuel and non-fossil hydrogen.

10. **Manufacturing Costs Comparison with conventional HVO technologies**: SBI's process proved to provide significant cost savings when compared with conventional HVO technologies. Technoeconomic study conducted by tech partner team demonstrated considerable benefits in using SBI technology. Here below a brief table provides some insight into the cost structure and savings of over USD 3.05/gal:

11. **Overall Project Cost Saving**:

Technically, the technology development we as planned and phased no material challenge. The major challenge was phased in getting the bulk quantities of fuel manufactured by a 3rd party vendor. The quantity was too small for a custom or toll manufacturer to justify the cost of changing their conventional equipment to modify to meet a radically new technology process and fitting the project in their schedule. SBI solved this challenge by deciding, in discussion with ERA, to build a pilot unit to produce the required quantities in-house. Accordingly, we redesigned and fabricated a new scaled up PICFTR equipment skid and manufactured bulk fuel and then again to manufacture bulk low temperature compatible fuel that met Jet Fuel A1 specifications successfully.

Another challenge was to conduct experiments nonstop on 24/7 basis with a limited staff without exceeding the approved project budget. SBI developed expertise in automation and control design, development and execution, enabling to operate the experiments unattended overnight and over the weekends saving funds and time and expedited the development. With automation, SBI was able to operate on 24/7 basis with only staff of 15 compared with required around 60 to 75 to operate round the clock in three shifts with a minimum of 60 or up to 75 staff members; leading to substantial cost savings.

Additionally, the analytical facilities available from 3rd parties were too time taking and expensive and impractical and was found to be a major challenge and a hurdle in conducting the research activities. To solve this problem, SBI decided to invest in building a state-of-the-art analytical suite with most modern instruments and train its employees to operate them, saving time, accelerate the pace of research activities and save considerable amount of funds.

Commercialization of any new technology, let alone a ground breaking and first of its kind faced road blocks and hurdles well known in the markets. SBI learned that it is very important to have a big commercial partner to be successful. However, the same partner can sometime slow down the process and increases the time to market. SBI learned that a small company should try to target a market sector that may have several potential mid-size or small customers requiring smaller modular units that require smaller upfront costs and therefore reduced risks.

All of above resulted in around $4 million (>20%) reduction in the overall project budget and 50% of it in ERA payables.

10.0 Environmental Benefits.

10.1Emissions Reduction impact (LCA Analysis)

Since no commercial plant has been set up or are operating at this time the potential for GHG benefits remain the same as projected at the time of the grant application. During the project itself no new evaluation was conducted as there was no change in principle in the technology and the process. Original assessment was based on the information LCA analysis exercise conducted by S&T Squared, a 3rd party service provider (report attached)

11.0 Economic and Social Impacts

During the execution period SBI employed, trained and retained 15 HQPs for the execution.

1. Fifteen full time highly qualified personnel supported their families and supported several peripheral jobs in the community and supported local economy.
2. Attracted many potential clients and signed with development and commercialization deal with Shell Petroleum company.
3. Enhanced SBI's capacity and capabilities to World class level in conducting cutting edge research and product development.
4. Developed collaborations with several local service providers, such as Canmet Energy, Innotech Alberta, Olds College, King's University College, Univ. of Alberta, Intertek and Fluid Analytical Labs to name some.
5. Built state of the art R&D and quality assurance and analytical facilities to assist and accelerate research and product development to shorten the development time line.
6. SBI is an equal opportunity employer with inclusive policies, staff includes people of color, females and new Canadians. SBI accommodates to their personal or faith-based requirement.

12.0 Scientific Achievements

- Many major conferences were attended and presentations made globally.
- Filed 15 global Patent Applications:

13.0 Overall Conclusions

Project completed with achieving all of the Milestone objectives. It enhanced SBI team's scientific and R&D capabilities and capacities

Major outcome was the catalyst selection, scale up of catalyst manufacturing, production of bulk quantities of renewable diesel and cold climate compatible diesel fuel with Jet Fuel A1 specification. Generation of process data required for making commercial production plant.

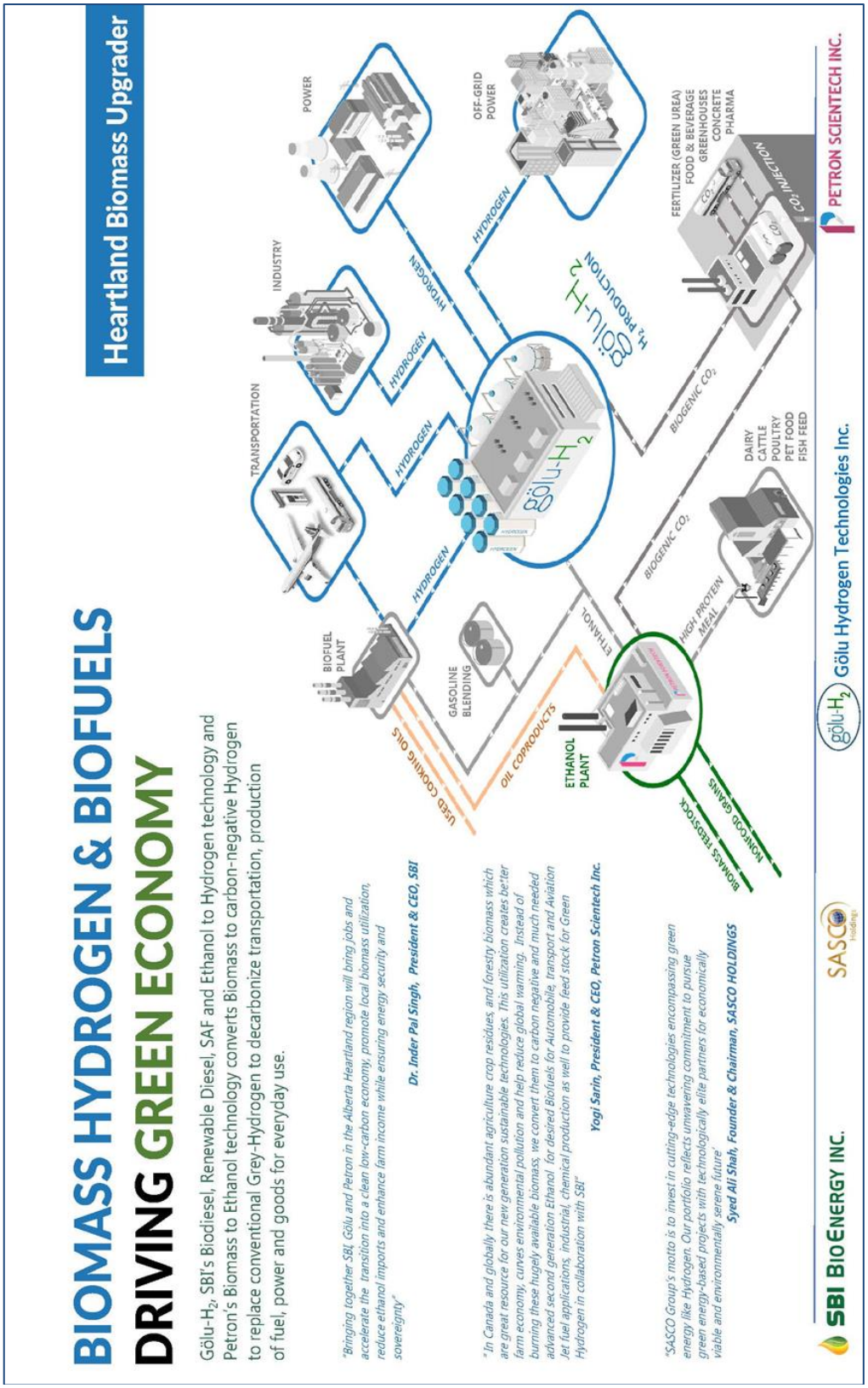
In addition, a side product, renewable hydrogen manufacturing technology for off grid hydrogen generation for transportation and microgrid operations.

14.0 Next Steps

SBI in association with Petron Scientech continue to work on a project in Alberta heart land to set up a biorefinery complex using SBI's core technologies to produce biodiesel (FAME) and Fatty Acid Ethyl Ester (FAEE), Renewable Diesel and SAF in one integrated pant.

SBI is in discussion with and has signed or renewed NDAs and is in discussion with several potential licensees. SBI has signed a MOU with Petron Scientech and a finance company SASCO Holdings of Toronto to set up a renewable diesel manufacturing plants using SBI technology. The planned complex shall produce biodiesel (FAME and FAEE) and renewable diesel and SAF applying SBI's technologies; produce green low carbon Cellulosic Ethanol and Green hydrogen applying SBI's Gölu-H2 technologies.

In partnership with Petron Scientech and SASCO Holdings, a Canadian institutional investment firm, a large biofuel plant complex is being planned to be constructed in the Alberta Heartland. The estimated project cost is $525 million. SASCO has already made a commitment for $225 million in equity and remaining funds are being arranged using various financial instruments. The Proposed Industrial Complex will use SBI's biodiesel, renewable diesel and aviation fuel manufacturing technologies and SBI's Gölu-H2 technology for producing carbon negative hydrogen. Project is expected to complete and start production during year 2024-25


Heartland Biomass Upgrader
BIOMASS HYDROGEN & BIOFUELS
DRIVING GREEN ECONOMY
Gölu-H2, SBI's Biodiesel, Renewable Diesel, SAF and Ethanol to Hydrogen technology and Petron's Biomass to Ethanol technology converts Biomass to carbon-negative Hydrogen to replace conventional Grey-Hydrogen to decarbonize transportation, production of fuel, power and goods for everyday use.
"Bringing together SBI, Gölu and Petron in the Alberta Heartland region will bring jobs and accelerate the transition into a clean low-carbon economy, promote local biomass utilization, reduce ethanol imports and enhance farm income while ensuring energy security and sovereignty"
Dr. Inder Pal Singh, President & CEO, SBI
" In Canada and globally there is abundant agriculture crop residues, and forestry biomass which are great resource for our new generation sustainable technologies. This utilization creates better farm economy, curves environmental pollution and help reduce global warming. Instead of burning these hugely available biomass, we convert them to carbon negative and much needed advanced second generation Ethanol for desired Biofuels for Automobile, transport and Aviation Jet fuel applications, industrial, chemical production as well to provide feed stock for Green Hydrogen in collaboration with SBI"
Yogi Sarin, President & CEO, Petron Scientech Inc.
"SASCO Group's motto is to invest in cutting-edge technologies encompassing green energy like Hydrogen. Our portfolio reflects unwavering commitment to pursue green energy-based projects with technologically elite partners for economically viable and environmentally serene future"
Syed Ali Shah, Founder & Chairman, SASCO HOLDINGS
SBI BIOENERGY INC.
SASCO
Gölu Hydrogen Technologies Inc.
PETRON SCIENTECH INC.
POWER
INDUSTRY
TRANSPORTATION
OFF-GRID POWER
HYDROGEN
HYDROGEN
HYDROGEN
HYDROGEN
Gölu-H2
H2 PRODUCTION
FERTILIZER (GREEN UREA)
FOOD & BEVERAGE
GREENHOUSES
CONCRETE
PHARMA
CO2 INJECTION
BIOGENIC CO2
BIOGENIC CO2
DAIRY
CATTLE
POULTRY
PET FOOD
FISH FEED
BIOFUEL PLANT
GASOLINE BLENDING
USED COOKING OILS
OIL COPRODUCTS
ETHANOL
ETHANOL PLANT
HIGH PROTEIN MEAL
BIOMASS FEEDSTOCK
NONFOOD GRAINS

15.0 Communications plan

Developed technology information were presented at many conferences and trade shows and audiences from many collaborators etc., via presentations in person or via web meetings including filing patent applications as listed above.

SBI now is in discussion for setting up another commercial biofuel plant in New Castell in Australia.

SBI also in process of finalization a Term Sheet with a Switzerland based multinational to deploy SBI's technologies globally under license to produce.