ALBERTA INNOVATES

ALBERTA BIO FUTURE PROGRAM

ANNUAL REPORT 2017-18

June 2018

PREPARED BY

ALBERTA INNOVATES – BIO Business Line

Alberta Bio Future Program Team: Steve Price, Christine Murray, Gordon Giles, Pat Guidera, Julia Necheff, Joan Unger
June 2018

This document is available online at albertainnovates.ca by searching for "Alberta Bio Future Program Annual Report 2017-18"

ALBERTA INNOVATES

TABLE OF CONTENTS

1. Executive Summary

Significant efforts and investments have been made to diversify the province's economy to leverage the abundant biomass resources available in Alberta. The Alberta Bio Future program (ABF) highlights the strong partnership between Alberta Innovates and Alberta Economic Development and Trade (EDT) in expanding activities related to our agricultural and forestry fibre, and the bioindustrial sector that relies on those feedstocks.

The ABF program aims to expand a competitive, sustainable and profitable bioindustrial sector. The focus is primarily on projects that add value to biomass in agriculture and forestry and create new and improved bioindustrial products and bioindustrial technologies. ABF is led and managed by the Bio business line of Alberta Innovates.

ABF was launched with funding from Alberta Innovates ($8 million) and Alberta Economic Development and Trade ($12.5 million). The program is outlined in an agreement signed March 27, 2014, by the former Alberta Innovates Bio Solutions (AI Bio) corporation and the former ministry of Innovation and Advanced Education; and in amendments signed August 16, 2016, and March 17, 2017, with the Ministry of Economic Development and Trade.

A mid-term review of the ABF program conducted by a third party in the summer of 2017 determined the program is performing well and should be considered for renewal when its current term ends.

ABF investments are made across the innovation continuum through targeted subprograms, from early-stage research to lab-scale experiments to demonstration and late-stage, pre-commercial scale-ups.

This year saw the continued delivery of a number of funding efforts under Alberta Bio Future, and also a realignment of some subprograms to create a clearer and more predictable progression of funding support for those seeking to engage with us. During the 2017-18 fiscal year, we launched four new subprograms and had 78 active projects in various stages of development, from initiation through to completing their final reports. This report provides insight into our approach, describes our activities under the various subprograms, highlights a number of the projects we are involved in, and finally, identifies relevant opportunities we see emerging.

---

2. Strategic Overview

The province has broad research capacity and infrastructure, both in publicly supported post-secondary and government institutions and in private industry. In addition, Alberta has significant industrial production capacity in agriculture, forestry and the burgeoning bioindustrial sector. Alberta is the third largest jurisdiction producing forest products in Canada, and one of this country's top agricultural producers (with the highest level of farm cash receipts of all provinces in 2017). The ability to scale up technologies is proven at laboratory and pilot scales. In both cases, there are interested, engaged and willing partners with which to collaborate.

With its mandate to catalyze research and innovation, Alberta Innovates plays a central role in providing strategic and financial support to bridge the work of researchers and the needs of industries. Aligning "real-world" issues faced by Alberta industry with the research capacity available to address those issues will improve the province's competitiveness, ensure environmental sustainability and reduce environmental footprints.

In addition, there is no shortage of available bioindustrial feedstock in Alberta. According to the Bio-resource Information Management System (BRIMS), Alberta's forests are a source of almost two billion tonnes of woody biomass from the "green" sustainably managed forested zone, along with byproduct and co-product volumes from bush and mill operations, and the "white" agricultural zone. Alberta's agriculture industry is the source of about 58 million tonnes of biomass annually from crops and livestock, including byproducts. Municipal solid waste is also available as a source of biomass, with more than 800,000 tonnes delivered annually to Alberta's landfills. But, as a land-locked, commodity-producing jurisdiction, Alberta companies are often challenged competitively to get their products to market. To remain competitive and maximize the return on value of our renewable natural resources, it is critical for Alberta to pursue opportunities as high up the value chain as possible. Identifying practical, new opportunities for adding value to our agricultural and forest biomass is at the heart of Alberta's bioindustrial strategy and at the core of the Alberta Bio Future program.

Bio-Resource Information Management System (BRIMS)

Source: Silvacom

Entrepreneurs and investors are encouraged to approach Alberta's forest and agricultural industries, and municipalities, to negotiate sources of biomass supply for business ventures.

Quantities of biomass are available from a new online tool called the Bio-Resource Information Management System (BRIMS), which launched on Jan. 25, 2018. It is a world-class, publicly available data and information management system of Alberta biomass, ecosystem services and land-use data, which can be accessed for free at **www.brims.ca**.

This online tool is the culmination of more than seven years of collaborative development by partners Alberta Innovates and the Edmonton-based company Silvacom, along with data partners Alberta Biodiversity Monitoring Institute and Agriculture Financial Services Corporation. ABF funded two BRIMS-related projects: ABI-16-004 and BIO-14-015.

As the province's flagship initiative to advance the bioeconomy, Alberta Bio Future is intended to expand a competitive, sustainable and profitable bioindustrial sector (advanced biomaterials, biochemicals and bioenergy) through an integrated program with a strong industry focus.

Supporting bioindustrial innovation helps to support provincial economic diversification. It also strengthens the agriculture and forestry sectors, which employ more than 70,000 Albertans and provide a stable economic base for rural communities across the province.

Alberta's innovation system, bolstered by investments made in infrastructure and capacity-building over many years, is well-positioned to collaborate with industry to deliver diversification opportunities to carry the province forward to take advantage of new and emerging markets in the bioeconomy.

Alberta Innovates' strategic bioindustrial investments are focused on figuring out how to extract more value from the province's natural resources. Working with in collaboration with partners, its collective efforts aim to:

- Develop scientifically sound and economically viable higher-value products and technologies derived from Alberta's significant renewable biomass volumes.
- Pursue new domestic and export markets for newly developed and existing products.
- Assist Alberta companies in improving their production processes to remove bottlenecks, reducing costs and improving efficiencies to increase competitiveness.

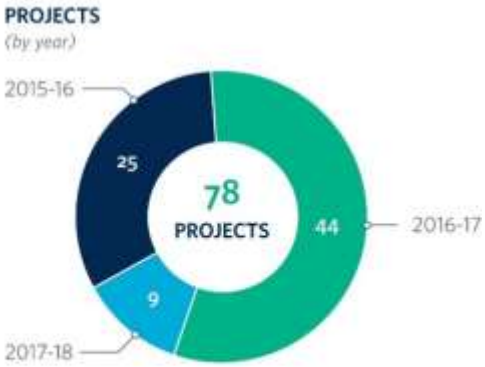
In 2017-18, ABF continued to provide funding in two strategic priority areas: research and innovation, and product and technology commercialization. ABF started funding projects through the Opportunities and Biomaterials Pursuit subprogram and conducted a strategic evaluation of efforts in the Equipment Utilization subprogram.

ABF supports the research, development and scale-up of a wide range of industrial bioproducts and technologies. Strategic areas of focus that offer immense value-added opportunities for Alberta include the development of technologies and bioproducts related to the biomass resources of cellulose nanocrystals (CNC) and lignin. The province has leading-edge facilities for both CNC production and lignin recovery that can be used to develop a wide range of renewable, sustainable products for application in many industrial markets. Alberta Innovates continued with this strategy in 2017-18 by launching two ABF subprograms, CNC Challenge 3.0 and Lignin Challenge 1.0, for applied research into CNC and lignin production and product applications, and further development of these materials into high-value bioproducts. These two subprograms, and others, will be discussed in more detail in Section 5, Grant Subprogram Details.

Alberta Bio Future Overview

April 1, 2015 to March 31, 2018

(Adapted from Alberta Bio Future Program Formative Evaluation, August 2017. Top pie chart indicates the year during which projects were initiated.)



3. Program Delivery

The Alberta Bio Future program is a partnership between Alberta Innovates and Alberta Economic Development and Trade. Delivery of the Alberta Bio Future program is accomplished through a series of subprograms, administered by the Bio business line in Alberta Innovates.

The objectives and eligibility of each ABF subprogram are designed to allow for maximum flexibility as technologies and processes are developed, but also for a clear line of sight toward future development and funding opportunities if projects demonstrate progress. As efforts in particular areas of study show success, ABF offers support to leverage upon those successes and help the projects develop further. This is a prudent approach to ensuring the investments made are well-spent and with the effective support needed to ultimately have the best chance of moving the bioindustrial sector forward.

After a rigorous internal and external review process, project funding is awarded both through competitive processes and open direct selection of projects. The following sections of this document contain details of each subprogram and a short description of the projects active during the 2017-18 reporting period. A few other projects are included for context, since they are significant to projects subsequently supported. Depending on the individual project characteristics, ABF funding is provided either up front, in instalments or upon project completion. To view funding over the length of the project, see the project list in Appendix B.

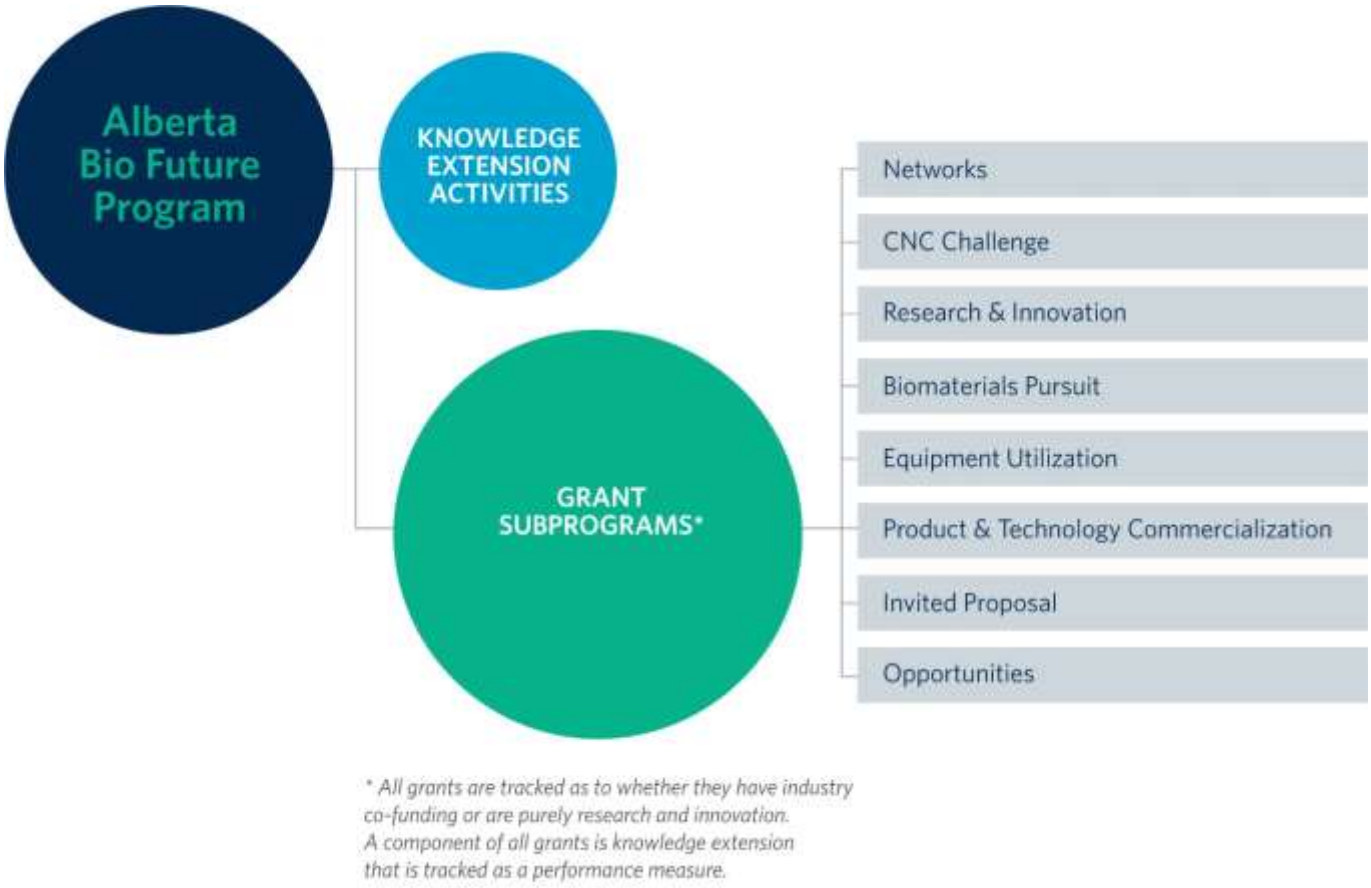
Knowledge transfer, engagement and networks are facilitated by the ABF program team through active partnerships, participation in technical conferences (as presenters, booth sponsors and through networking). All these activities are aimed at delivering the strategic objectives of the ABF program and participation in strategic research networks such as the NSERC Industrial Research Chair in the Industrialization of Building Construction, and the NSERC/Cenovus/Alberta Innovates Associate Industrial Research Chair in Energy and Environmental Systems Engineering. See Section 6 for more details about ABF knowledge extension activities.

In keeping with the program objective of pursuing and supporting efforts that will ultimately resonate with industry, the program team is looking for a clear line of sight to industry. Projects that have an industry cash contribution are labeled as aligned under “industry co-fund.” Projects – often early applied work – without an industry cash contribution but maybe industry and other in-kind contributions, are labeled as aligned under “research and innovation.”

Industry leverage strengthens a project and can provide more resources for a more successful result. By contributing their own funds and investing in-kind resources, industry signals not only strong interest and commitment, but also indication they see the real possibility of commercialization success. The degree of industry co-fund is indicated in aggregate in each subprogram description in the following sections.

3.1 Alberta Bio Future Subprograms

(Adapted from Alberta Bio Future Program Formative Evaluation, August 2017.)



3.2 Market Intelligence and Foresighting

The ABF program team actively seeks to expand its understanding of both the supply and demand sides of bioindustrial opportunities. Engaging on the demand side with end-use companies, be they multinationals or small and medium enterprises, helps the team stay current about industry needs, challenges and opportunities companies would consider. Engaging on the supply side with researchers, technology developers and those creating new products provides the team with knowledge about possible solutions for challenges faced by end-use companies.

Through presentations, meetings and seminars at domestic and international venues over the last few years, the team has generated much excitement about bioindustrial opportunities, particularly in the area of CNC. Some of those interactions have led directly to numerous connections made between specific researchers and supply-side or end-use companies interested in using the researcher's knowledge, research or intellectual property for potential

commercial development. Those types of discussions are ongoing, and in many cases have led to the development of non-disclosure agreements to allow the confidential exchange of information, collaborative research projects or even early-stage commercial development. The momentum around CNC application development is growing at an ever-increasing pace, and it continues to look like a very strong diversification opportunity for Alberta's pulp producers. Strategic investments and patience in this area by the Government of Alberta and Alberta Innovates are starting to pay off.

The ABF program team is also active in the market development of other biomaterial areas of interest to Alberta. The team is engaged with companies interested in incorporating lignin and cellulose nanofibrils (CNF), a variation of CNC, into their end products. However, these discussions are not quite as advanced as the ones involving CNC, simply due to their earlier-stage profile.

Other discussions in progress are exploring opportunities arising from diversion of waste and byproduct streams from forest products and pulp mills into higher value-added products, and reducing landfill pressures. The ABF team is examining market demand information, production costs and economics, and technical opportunities available for each type of waste material. This information is developing at a rapid pace, as are the options available. The team has built connections across the product development landscape, from academic researchers to feedstock producers to end-use companies. This gives the team excellent capacity to enable and facilitate targeted and productive conversations aimed at leveraging the availability of waste materials into new biomaterials with high-value applications.

3.3 Building Company and Research Connections

Projects funded by ABF all populate the innovation pipeline, but at varying stages of innovation development. Their common bioindustrial thread resonates strongly with end users regardless of how much time, money or effort is needed to bring the project to fruition. Through ABF's work across the innovation supply chain – from fundamental researchers to bioindustrial producers to end users – the program team acts as a connecting force between these often-disparate groups.

This connection improves the chances of successful implementation of the project's new science discovery or technology. The program team works hard to help researchers ground their investigations with doses of industry reality, and to inform end users of emerging opportunities for diversification. With strategically targeted funding, rigorous review of project proposals and constant interaction with both supply-side and end-use companies, tremendous opportunities are being identified, pursued and developed.

A good example of the connection process across the innovation continuum is the cross-sector opportunity identified between agricultural-based polyurethanes with forestry-based cellulose nanocrystals. In ABF project BFR-16-027, Dr. Jonathan Curtis's team at the University of Alberta

had developed formulations for bio-based polyurethanes from non-food-grade canola, for use in a variety of plastic materials. The expertise from this research led to advancements in another ABF project (BFC-16-013) in the CNC Challenge 2.0 subprogram. The team has successfully developed CNC/polyurethane composites, leveraging CNC's hardness characteristics to produce a much stronger, abrasion-resistant surface coating. Through its market development efforts, the ABF program team previously had established a relationship with a large paint manufacturer. The manufacturer had significant interest in polyurethane-based paints and a desire to incorporate greener ingredients in its formulations, while maintaining strong performance. With these contacts in place, the ABF team introduced Dr. Curtis's group to this manufacturer. Both are now working together to investigate whether the CNC-based composite paint formulated in Alberta can be scaled up to produce a commercially viable product.

The ABF program fills a significant niche in the funding ecosystem that supports Alberta's emerging bioeconomy.

Source:
"Alberta Bio Future Program Formative Evaluation," PowerPoint presentation. August 2017

Another example is the ABF team's work with the Alberta Forest Products Innovation Consortium, a collective of like-minded forest companies interested in collaborating on issues of common interest. Dr. Paolo Mussone of NAIT proposed to develop a catalyst for the energy sector using the ash byproduct from kraft pulp mills. The consortium members agreed to contribute industry co-funding to his ABF proposal submission, which was successfully funded under project BFR-16-071. Interestingly, the analysis done by Dr. Mussone to characterize the various wood-based ashes produced around Alberta was circulated by the ABF program team to some end-use companies that currently use coal-based ash. That connection has led to a number of different application development efforts, opening up previously unseen opportunities for use of a material that is typically landfilled.

In another connection example, West Fraser has invested in a lignin extraction facility at their Hinton kraft pulp mill, with a portion of the funding coming from the ABF program. Much research has suggested a significant opportunity for the use of lignin in adhesives, particularly those used in engineered wood products such as plywood, oriented strand board and cross-laminated timbers. Through an introduction by the ABF program team, West Fraser is now working closely with Hexion Canada under project BFP-16-025 funded under the ABF Product and Technology Commercialization subprogram. Researchers in this project are developing bio-based phenol formaldehyde resins, bringing together two industry leaders from their respective fields for the common purpose of developing a viable market for lignin.

Stemming from this research on lignin, the University of Alberta's Dr. Ying-Hei Chui, NSERC Industrial Research Chair in Engineered Wood and Building Systems, is now engaged with both companies, discussing how their efforts can be aligned with his research interests in cross-laminated timber and massive timber panels.

The follow-on impact of ABF's initial investment in the lignin extraction facility illustrates well the benefit of the ABF program team having deep and varied networks of research and industry experts.

As projects advance and show promise, the ABF program team is able to help researchers envision the next step for their project. Through market intelligence garnered during engagements with end users, the team can help make connections for the researchers. Conversely, with the ABF program team's knowledge of where researchers are making progress, the team is able to initiate discussions with targeted end-use companies and present them with early-stage opportunities and ideas for applied research activities.

Discussions, meetings, networking, conferences and other market intelligence activities help build relationships between Alberta Innovates, researchers and companies.

Source: Alberta Innovates

3.4 Selected Alberta Bio Future Industry Partners

The ABF program team has relationships with many companies working in the bioindustrial sector, including the following:

3.5 Mid-Term Review – Findings and Implications

Alberta Economic Development and Trade, ABF's program partner, initiated a mid-term, third-party review of the program. This five-month review sought to confirm appropriate management by Alberta Innovates, achievement of results and ongoing relevance of the program.

To simplify the process during the review, the ABF program team decided to freeze funding and initiation of new projects. However, this decision caused a delay in completion of some multi-phase projects.

Once the review was complete in November 2017, the ABF program team made a few small course corrections to improve delivery. In brief, the review found that the ABF program was well managed, showing good results and should be considered for renewal when the current term expires. Some review recommendations related to program delivery to further increase the quality of selected projects and improve effectiveness of support. The ABF program team took these constructive recommendations to heart. It redesigned the subprograms for improved alignment with program objectives and a more targeted focus. The team ended the Equipment Utilization subprogram, ended the Invited Proposal subprogram and replaced it with the Opportunities subprogram. It initiated the Biomaterials Pursuit subprogram and expanded the Challenge 3.0 subprogram to develop biomaterials from more types of biomass feedstock.

These changes will offer stakeholders a clearer view of where they should engage ABF and where that path might lead as their projects, technologies and products develop and evolve. The changes also enable the program team to better engage with potential industry partners and end-users, bringing their bioindustrial interests into ABF to strengthen the innovation supply chain and build research capacity in Alberta.

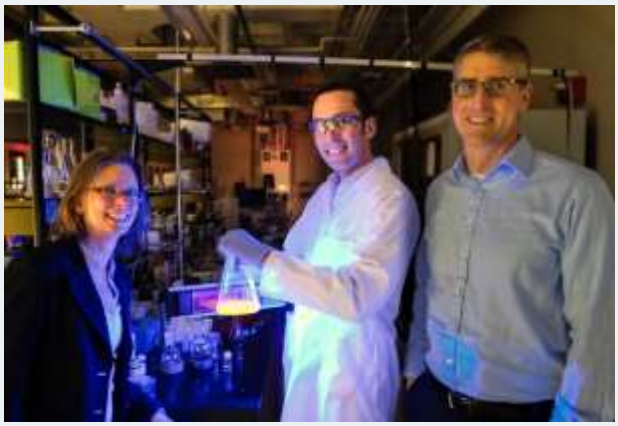
The ABF program team has built extensive networks and contacts during this journey. These program changes help to further leverage those relationships, to make delivery of ABF even more relevant and successful in expanding and diversifying Alberta's economy.

---

4. Highlights

The Alberta Bio Future program has supported 78 projects over the period April 1, 2015, to March 31, 2017. The projects are at varying stages of development along the innovation continuum: basic research, applied research and pre-commercialization. What they all have in common is potential to advance Alberta's bioeconomy. The following stories highlight a few of these projects.

Light-Activated Cleaner



Dr. Belinda Heyne with her team, Dr. David Press and Dr. Todd Sutherland, are developing a light-activated cleaner.

Source: Dr. Belinda Heyne

Antibiotic-resistant infections are on the rise in hospitals and food packing plants must frequently recall tainted products. A group of researchers at the University of Calgary is developing a new way to curb the spread of bacteria causing these problems with a product derived from wood called cellulose nanocrystals (CNC).

One of CNC's many unique characteristics is its reaction to light. Drs. Belinda Heyne and Todd Sutherland have developed a novel formulation with CNC that kills bacteria by turning on a room's light. "We have reinvented how to clean," said Heyne. "It's clean. It's green. It's safe."

This project is a good example of how an idea moves through the innovation continuum with support from Alberta Innovates. Heyne and Sutherland received a seed grant from the Alberta Innovates CNC Challenge to prove the concept. In 2015, they received a much larger grant from the ABF Research and Innovation subprogram in Project BFR-16-017 to develop a prototype. In 2018, they received a grant from the ABF Biomaterials Pursuit subprogram in Project BFM-18-001 to develop a market-ready product by 2020. Industry is very interested.

"We couldn't have gotten this far without Alberta Innovates' support," said Heyne. "It's not just the money. It's also their care that you succeed. I've never experienced that level of interest and help from any other funder."

West Fraser – Hinton Pulp Lignin Recovery Plant

The West Fraser Hinton Pulp Lignin Recovery Plant (left) is Canada's first commercial-scale kraft lignin production facility and the only plant in the world using this LignoForce System™ technology to produce lignin powder (right).

Source: Hinton Pulp, a division of West Fraser

The most innovative opportunity available to the pulp industry in Canada is expansion as a biorefinery, turning wood fibre into chemicals or energy products. West Fraser's Hinton Pulp mill has commissioned a new facility that produces lignin, a versatile material that comes from trees. Lignin, a byproduct of the pulping process, is currently burned as a fuel source for mills. West Fraser's lignin has been used successfully in some commercial applications. Organizations developing new products use samples of lignin from Hinton Pulp mill to research interesting commercial applications.

Alberta Innovates supported construction of the lignin recovery plant in Hinton through the Alberta Bio Future program under Project AMC-14-001. "Alberta Innovates has been very supportive and with great leadership," said Dave Pors, Energy Manager, Hinton Pulp, a division of West Fraser. "I think it is innovative to have us repay half our grant to add funding to the Alberta Innovates follow-on Lignin Challenge funding program that supports development of more opportunities for lignin."

Changing consumption patterns for pulp products means the lignin recovery plant offers an opportunity to produce a higher-value product from the mill's manufacturing processes, adding a new revenue stream. It is also part of a market shift to discover new business opportunities from greener, lignin-based products. Commissioned in 2016, the Hinton plant can produce up to 30 tonnes per day of lignin. The potential market for lignin-based commercial products is high. More than 200 organizations in Edmonton, Europe, China, Japan and South America have already received samples of lignin ranging in size from one kilogram to more than one cubic metre. Researchers are finding ways to develop lignin as a binder in briquettes, soil stabilization formulations, polyols for polyurethane and foams, foam insulation, coatings, roofing products, dust suppression, sludge stabilization, dispersants, and most importantly for West Fraser, as a replacement resin in engineered wood products such as plywood and oriented strand board. West Fraser estimates that every tonne of lignin substituted in conventional phenol formaldehyde resins prevents one tonne of carbon dioxide emissions from entering the atmosphere.

Biorefining Conversions Network

Researchers at the FORGE pilot plant in Edmonton have developed a way to turn waste fat into renewable drop-in fuels.

Source: FORGE Hydrocarbons Corp.

The world now knows that Alberta is at the heart of new secondary manufacturing and processing opportunities from biomass. The Biorefining Conversions Network (BCN) brought that message to thousands of people in the domestic and international bioindustrial communities through its research, global partnerships and knowledge extension activities.

Based at the University of Alberta, the BCN became Alberta's "go-to" bioindustrial hub from 2009 to 2016 under two phases: BCN 1.0 and BCN 2.0. It was funded initially by the Government of Alberta and later by Alberta Innovates, with funding from the Alberta Bio Future program in its final year under Project BIO-12-007.

"The Biorefining Conversions Network was the right program at the right time," said its executive director, Dr. David Bressler. "It was very insightful for the Government of Alberta to set up the network and try a new approach to industry partnerships."

The goal was to partner with industry and develop ways for Alberta to go beyond the primary processing of traditional commodity products like grain or lumber. The aim was to develop technologies and create capacity that could create secondary manufacturing opportunities from waste biomass for new, high-value, green products such as biofuels, platform chemicals, industrial solvents and bioplastics.

Over seven years and with leadership, its scientists in engineering, agriculture, forestry, chemistry, biochemistry and biological sciences conducted the latest in bioindustrial research across 27 projects, and another 10 affiliated projects not funded by BCN. In 2013, the FORGE Hydrocarbons Corporation spun out of the network, based on the research of Dr. David Bressler. FORGE is building a commercial plant that will produce renewable, drop-in diesel fuel from waste fats like restaurant grease and beef tallow.

continued on next page

Biorefining Conversions Network

continued from previous page

"The benefit to Alberta has been 20-fold," said Dr. Bressler. Government's initial investment of $500,000, which FORGE matched, created more than $10 million in follow-on investments in Alberta, along with the training of many highly qualified people."

A number of other network projects continue to grow into larger initiatives. Dr. Jonathan Curtis's work on non-food-grade canola led to creation of the commercial product BioFoam™, an environmentally friendly spray foam building insulation. Dr. David Stuart's work in synthetic biology led to the North American patent for creation of synthetic emulsifiers, emollients and surfactants for use in the cosmetic and pharmaceutical industries. They are traditionally derived from Southeast Asian palm oil. The work of Drs. Dominic Sauvageau and Lisa Stein is garnering interest from industry. They are investigating use of the potent greenhouse gases methane and methanol to create biopolymers, a stepping stone to bioplastics.

BCN became a busy business development office where companies could be matched with the right academic researchers. And academics could learn how to work with industry clients, create partnerships and, most importantly, learn how to talk the language of business. BCN provided seed funding, effectively lowering a company's research risk. Then the network found leveraging that doubled and tripled this funding. More than 29 industry partners collaborated with BCN 2.0. The network was one of the first organizations to connect forestry companies with each together and with academics to explore the challenges industry faced.

BCN served as a unifying hub in the biomass space and created pan-Alberta research teams to find solutions for industry. "It linked the creative brains across many of Alberta post-secondary institutions. As a result, there's a whole community of people that now know and trust each other," Dr. Bressler said.

More than 95 graduate students were trained in the latest understanding in biorefining technologies. "This will probably be the biggest benefit of BCN to the innovation ecosystem," said Dr. Bressler. As they follow careers that take them to all corners of the world and back to Alberta, "we will continue to benefit over the next decade from the diffusion of bright academics trained by BCN."

BCN was also skilled in spreading knowledge and building awareness of Alberta's bioindustrial strengths on the national and international stage. During BCN 2.0, the core network team engaged in more than 100 opportunities to speak, staff tradeshow booths and participate in research and investor review panels in Canada, U.S., Germany, France, Australia and South America. BCN hosted many workshops and conferences, including annual retreats, that connected the best from traditionally separate sectors in cross-talk, networking, education and partnering opportunities. "Alberta Innovates was open to BCN using a new working model that brought diverse groups together," said Dr. Bressler.

The Biorefining Conversions Network has given Alberta a competitive advantage in generating new opportunities for business that can diversify the economy. The network has expanded Alberta's bioeconomy and created new pathways for growing the province's agricultural and forest industries.

Concrete Hemp Fibre Reinforcement

Engineers can now specify a new additive for concrete when designing swimming pools, skateboard parks and even Olympic bobsled runs. Concrete used for these types of projects with non-conventional shapes must be sprayed in place, called shotcrete, and it often cracks.

Construction projects with non-conventional shapes, like skateboard parks, can now use industrial hemp fibres for reinforcement

Source: Canadian Greenfield Technologies Corp.

Typically, plastic or glass fibres are used for reinforcement. Calgary-based company, Canadian Greenfield Technologies Corp. (CGT), has developed an alternative fibre choice that produces stronger concrete and is resistant to cracking. This reduces the need for costly repairs and production of replacement concrete, which results in emission of high volumes of greenhouse gases.

The company's proprietary concrete fibre reinforcement product, NForce-Fiber®, mixes into concrete easily without clumping or need for other additives. It is derived from industrial hemp grown in southern Alberta on farms near Lethbridge and Mossleigh. The company developed its manufacturing process with funding support from Alberta Innovates through its Alberta Bio Future program in Project BFP-16-002. "Getting the grant was difficult, as it should be for a competitive funding process," said Dr. Stephen Christensen, Vice President & General Manager, Canadian Greenfield Technologies Corp. "Afterward though, Alberta Innovates was very supportive and the obligation for record-keeping was reasonable."

The pilot plant upgrades went online in spring 2018 with 11 staff and quickly increased the orders filled, including to China. An international team of engineering and construction experts had specified NForce-Fiber® for the concrete construction of the Xiaohaituo bobsleigh and luge track for the 2022 Winter Olympics, to be held near Beijing. CGT won this contract after third-party testing confirmed no other product in the world could match its quality for such a high-performance application.

The pilot plant is producing another unique product from industrial hemp, NForce-Pro™ for use in decorative concrete. This high-end product is becoming a popular alternative to granite and marble for countertops and backsplashes in kitchens and bathrooms. Concrete countertops with NForce-Pro™ fibre are stronger, thinner and lighter than conventional concrete products made with glass or plastic fibres.

CGT also produces a variety of other hemp products, including cat litter, food preservation pads, potting mix, soil amendment, mulch and nutritional exfoliant.

"With the successes we have seen and our products selling on Amazon like crazy, a larger commercial plant is definitely in our future in the next year or two," said Dr. Christensen.

Lignin-Based Resins

Engineered wood products are currently 97 per cent bio-based, but soon they could be up to 99 per cent. The adhesives gluing together wood strands in oriented strand board (OSB) and the wood veneers in plywood are typically made from petrochemical hydrocarbons. Researchers at Hexion Canada's forest products R&D lab in Edmonton are developing ways to create new bio-based adhesives that incorporate lignin, a sticky compound in trees and a byproduct of the kraft pulping process.

October 2017 Hexion open house in Edmonton with John Slayter (Hexion), Dale Plante (Hexion), Honourable David Eggen (Minister of Alberta Education), Steve Price (Alberta Innovates)

Source: Hexion Canada Inc.

In fall 2017, Hexion completed expansion of its lab, the Plante Research and Development Centre, with addition of a pilot-scale, steam-preheated press. No other facility in the world has this capability to simulate modern commercial steam preheated OSB presses. This equipment is critical in proving the commercial viability of bio-modified resin performance. Alberta Innovates supported the expansion with funding from its Alberta Bio Future program in Project BFP-16-025. "Alberta Innovates has been instrumental in putting Hexion in contact with and encouraging collaboration with others in Alberta's bioeconomy," said Jay Taylor of Hexion Canada Inc. "Alberta Bio Future funding of this project demonstrates Alberta's continued investment in the forest products sector."

Based in Ohio, Hexion is a global leader in thermoset resin manufacturing for a multitude of sectors with more than 60 industrial facilities around the world. It considers Edmonton an important growth region for Hexion's global forest products business because of the city's proximity to key customers. Edmonton also has good logistics for getting products and ingredients to and from the U.S. Alberta has 10 panelboard and engineered wood product mills, and four kraft pulp mills.

"Commercialization of lignin-modified resins will directly and indirectly support business growth and employment opportunities, attract and retain highly qualified and skilled personnel to Alberta, reduce greenhouse gas emissions, and demonstrate to trading partners that Alberta forest products made from green, sustainable, lignin-based adhesives are second to none," Taylor said.

The bioindustrial sector in Alberta holds great potential for growth. Innovative products and technologies that utilize sustainable, renewable resources are helping to diversity the province's economy beyond oil and gas.

Composite Laminated Panels

Building designers are interested in construction materials with a lower environmental impact than conventional steel and concrete materials. Researchers at the University of Alberta are developing a new engineered wood product that meets this need, storing and not emitting carbon dioxide. It also offers a high degree of prefabrication and design flexibility, desired attributes in remote communities.

University of Alberta researchers are developing a new engineered wood product, composite laminated panel. It is stronger than any other wood product and alternates layers of structural composite with dimensional lumber.

Source: Dr. Ying-Hei Chui

British Columbia has the world's tallest wood building, with 18 storeys, completed in 2016. Dr. Ying-Hei Chui, of the University of Alberta, is developing a product, composite laminated panel (CLP), that will take wood buildings even higher.

Alberta Innovates has funded two of Dr. Chui's projects, including one through the ABF program under Project BIO-16-014. "Alberta Innovates is to be commended for its foresight," said Dr. Chui. "Unlike other provincial funders I've experienced, it funds projects on research merit and potential to have downstream benefit for the province. I was at the University of New Brunswick for my first project and now for my second, I'm at the University of Alberta."

Two Alberta mills have supplied the materials for Chui's project: Norbord and Tolko. Dr. Chui is working to get the CLP product accepted into building codes. It's already part of the product standard.

ALBERTA INNOVATES

5. Grant Subprogram Details

5.1 Networks Subprogram

Networks signify the presence of sufficient critical mass in an area of research to warrant establishment of a co-ordinated hub of innovation. In a network, researchers work together on a common theme from a co-ordinated base in academia. Networks are able to gather the best research, development and entrepreneurial talent, and focus on targeted and strategic areas of importance. Networks can serve to bridge the gap between academia and industry, helping industry to de-risk the challenge of developing new innovations for the marketplace.

Alberta Bio Future has not established a separate call to networks for proposals. However, networks are welcome to apply to any ABF subprogram, including the Opportunities subprogram. If selected for funding, ABF participates as a network member. A separate category has been set up to track funding to networks (referred to as the Networks subprogram), since budgets are usually much larger than for individual projects and span a longer time period.

Four networks were active in 2017-18, with total project costs of more than $11 million. These are summarized in the table below. Performance measures and financial information are available in the appendices. ABF expenditures for networks include more than project funding, they also include salaries for core network staff.

Projects

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
ABI-17-002 *Industry Co-funded* *Networks* ---- **Amit Kumar** University of Alberta ---- **$2,100,000**	**NSERC/Cenovus/Alberta Innovates Associate Industrial Research Chair in Energy and Environmental Systems Engineering**	*This Industrial Research Chair (IRC) program is aimed at developing Canada's fundamental research capacity in the technologies of energy production, conversion and use at the systems level, along with associated environmental impacts, through development of fundamental science-based models. The program will train researchers who would contribute to Canadian workforce and contribute to Canada's effort to reduce greenhouse gas emissions. This is a continuation of Project BIO-12-001, and is now in second phase. Renewed IRC started Sept. 2017 after an NSERC review was conducted March to June 2017. Two new partners joined in Phase 2: Environment and Climate Change Canada (ECCC) and Natural Resources Canada*

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
		(NRCan). The objective is to identify pathways to low-carbon energy production and use, considering costs, environmental impacts and resource availability.
BIO-12-007* *Industry Co-funded* *Networks* --- **Bressler, David** University of Alberta --- **$3,905,000**	**Biorefining Conversions Network Program**	*Objective of BCN is to create a co-ordinated critical mass in bioindustry R&D, to catalyze development of new technologies for Alberta's bioindustrial economy.*
BIO-12-011 *Industry Co-funded* *Networks* --- **Kumar, Amit** University of Alberta --- **$1,890,000**	**NSERC / Cenovus / Alberta Innovates Associate Industrial Research Chair in Energy and Environmental Systems' Engineering**	*Leveraged funding to establish an Industrial Research Chair (IRC) position is aimed at assessing technologies for energy production, conversion and use, along with associated environmental impact assessments through fundamental science-based models. Project was renewed in ABI-17-002. Original IRC was completed Aug. 31, 2017. The objective is to identify pathways to low-carbon energy production and use, considering costs, environmental impacts and resource availability.*
BIO-16-010 *Industry Co-funded* *Networks* --- **Mohamed Al-Hussein** University of Alberta --- **$3,930,000**	**NSERC Industrial Research Chair in the Industrialization of Building Construction**	*This Industrial Research Chair position was renewed for a second term, to improve existing approaches to modular construction, manufacturing techniques, minimize construction waste and increase productivity.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BIO-16-014 *Industry Co-funded* *Networks* ---- **Haitao Yu** Landmark Group **$3,382,849**	**Massive timber panel system behaviour study and its application in buildings**	*The aim is to develop technical information to enable increased use of engineered wood products in wall and floor systems. This is in collaboration with the NSERC Industrial Research Chair in the Industrialization of Building Construction, described above.*

Not active in 2017-18 but the project is of strategic importance to the ABF program

5.2 Cellulose Nanocrystal (CNC) Challenge

Prior to launch of the ABF program, the former Alberta Innovates Technology Futures (AITF) initiated a program in 2014 called CNC Challenge 1.0. The program was aimed at identifying and supporting proof of concept-level projects involving the potential use of CNC in novel applications. Based on this very successful program, ABF launched a second iteration in February 2016, the CNC Challenge 2.0, in partnership with Alberta Innovates Technology Futures. In 2016-17, 11 successful proponents each received $25,000 from ABF for their one-year projects. They also received up to one kilogram of CNC and access to technical assistance from AITF's CNC experts. Their total project costs were more than $400,000, including the ABF funding.

Not only did this subprogram help populate the CNC application development pipeline with potential products, but, just as significantly, also helped develop cellulose nanocrystal capacity in research organizations and companies across Western Canada. The array of application areas developed under this subprogram was broad and exciting, ranging from chemicals and composites, to health and medical, to energy storage and energy extraction. CNC is a biocompatible material; thus, medical and health uses are of great interest to researchers and of potential commercial value to CNC producers and end-users. Alberta is quickly being recognized as a world leader in this area, due in part to the support provided through the CNC Challenge subprograms and the pilot plant located at InnoTech Alberta (formerly called Alberta Innovates Technology Futures).

Cellulose Nanocrystals (CNC)

CNCs are nanoscale fibre particles derived from wood cellulose that have desirable properties such as high tensile strength, axial stiffness, heat stability, and low density, making it highly applicable as reinforcement material in composites used in automotive, paint, food packaging and pharmaceutical industries.

Source: Bressler, David. "2016 BCN 2.0 Project Outcomes Update," p. 52.

During 2017-18, all 11 projects in the CNC challenge subprogram closed and are summarized below. Performance measures and financial information are available in the appendices.

ALBERTA INNOVATES

Projects

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFC-16-002 *Research and Innovation* ---- **Thomas Baumgartner** University of Calgary ---- **$25,000**	**Development of value-added CNC for application as electronic component in sustainable batteries**	*Aimed at developing sustainable redox flow batteries with a CNC-based scaffold. Demonstrated viability of the concept but requires more work to ultimately establish whether CNC offer competitive advantage to existing materials. Resulted in a peer-reviewed publication.*
BFC-16-003 *Research and Innovation* ---- **Simon Park** University of Calgary ---- **$75,000**	**Development of CNC nanocomposites for aluminum-air batteries**	*Researchers investigated aluminum-air batteries, which can potentially replace conventional Li-Ion batteries. They have discovered that CNC-reinforced copper electrodes can decrease electrical resistance, even in extreme heat. The ability to withstand elevated temperatures for long durations and external strains make the nanocomposite electrodes attractive for many applications including electrodes, electrical devices and sensors.*
BFC-16-006 *Research and Innovation* ---- **Cagri Ayranci** University of Alberta ---- **$25,000**	**Realizing potential benefits of CNC for the rapidly developing additive manufacturing market**	*Aims to incorporate CNC into acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA) composite systems and promote the use of CNC to companies that produce these filaments at industrial scale. Final report due June 2018.*
BFC-16-012 *Research and Innovation* ---- **Helen Burt** University of British Columbia ---- **$25,000**	**Removal of trace pharmaceuticals and endocrine-disrupting chemicals from water using filtering systems based on modified CNC**	*Promising results in demonstrating the feasibility of modified CNC for ionically binding and removing very small quantities of non-steroidal, anti-inflammatory medications. Work proceeding under other funding to move to prototype scale.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFC-16-013 *Research and Innovation* ---- **Jonathan Curtis** University of Alberta ---- **$25,000**	**Does CNC incorporation enhance the properties of UV-cured polyurethane coatings?**	*Use of CNC in polyurethane coatings, leveraging potentially superior mechanical properties in an ultraviolet curable resin. Observed reduction in oxygen diffusion and improved our understanding of the low dosage rates available for nano-reinforcement.*
BFC-16-014 *Research and Innovation* ---- **Kenneth Bosnick** National Research Council of Canada (NINT) ---- **$50,000**	**CNC polymer nanocomposites for high-barrier applications**	*Successfully demonstrated the incorporation of CNC in polymer nanocomposites for food packaging and possible anti-corrosion applications.*
BFC-16-018 *Research and Innovation* ---- **Amir Sanati-Nezhad** University of Calgary ---- **$25,000**	**Novel CNC hydrogel for 3D bioprinting of organs on chip**	*Successful synthesis of hydrogel, with appropriate pore structure and bioprinting ability. Optimized formulation for the creation of desirable liver cell replication. Resulted in one peer-reviewed publication.*
BFC-16-020 *Research and Innovation* ---- **Ian D. Gates** University of Calgary ---- **$25,000**	**CNC for steam foam applications in steam assisted gravity drainage (SAGD)**	*Use of CNC suspensions to displace oil from underground reservoirs to improve recovery volumes and reduce production costs.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFC-16-024 *Industry Co-funded* ---- **Rongbing Du** National Research Council of Canada (NINT) ---- **$25,000**	**Development of thermally degradable epoxy adhesives containing CNC**	*Leveraged CNC's stiffness and toughness, while exploiting its thermal instability to create epoxies that can easily be removed in applications where de-bonding is required. Collaborative effort between University of Alberta, the National Research Council's Nanotechnology Research Centre and the National Sciences and Engineering Research Council (NSERC).*
BFC-16-025 *Research and Innovation* ---- **Zaher Hashisho** University of Alberta ---- **$76,300**	**Novel electrospun nanofiber adsorbent for air pollution control and air sampling applications**	*These adsorbents were shown to provide superior mass and heat transfer compared to traditional adsorbents. Further work needed to optimize the porosity and surface area.*
BFC-16-026 *Research and Innovation* ---- **Afsaneh Lavasanifar** University of Alberta ---- **$27,000**	**CNC in bioadhesive hydrogels for wound closure and local drug delivery**	*Demonstrated the use of CNC hydrogels for bioadhesive drug delivery on cancer wounds. Shows promising application in a variety of pharmaceutical applications.*

Building upon the success of CNC Challenges 1.0 and 2.0, a third iteration of CNC Challenge was launched in December 2017. A total of 37 proposals were received and reviewed, with 17 projects selected to each receive $25,000 in funding. These projects will start in the 2018-19 fiscal year and be included in next year's ABF annual report.

Of note is the addition of an industrial partner to CNC Challenge 3.0, Alberta Pacific Forest Industries (Al-Pac), which operates a kraft pulp mill in Boyle, Alberta. Al-Pac has been working actively with Alberta Innovates since 2009 to investigate and develop the viability of commercial-scale CNC production at its pulp mill. The company aims to diversify its product offerings with high-value products.

Al-Pac's contribution of cash and in-kind provision of CNC expands the number of projects to be supported and provides an industrial lens to the assessment of the economic viability of many of these potential applications. It is a significant step forward in the journey toward CNC commercialization in Alberta.

With the CNC Challenge subprogram being successful, a Lignin Challenge 1.0 subprogram was launched in late February 2018. The single-stage (letter of intent) call received 20 proposals for review. It used the same approach and criteria as the CNC Challenge. West Fraser established a lignin extraction facility at its Hinton kraft pulp mill with support through the former Invited Proposal subprogram. Now, through a partnership between Alberta Innovates and West Fraser, this lignin facility will provide the successful subprogram proponents with up to one kilogram of lignin for their early-stage research. Successful candidates also each received $25,000 for projects that started in early 2018-19 and have one year to finish. This new Challenge subprogram is helping to open new markets by populating the lignin application pipeline with potential new uses for lignin.

ABF is currently considering the creation of Challenge-level initiatives for other biomass materials of relevance to Alberta, such as cellulose nanofibrils or hemp. The program team is investigating interest and demand and will proceed with new funding calls if sufficient funding is available.

InnoTech Alberta's CNC pilot plant produces one-kilogram samples of CNC for researchers to use in developing new high-value biomaterial products.

Source: Alberta Innovates

5.3 Research & Innovation Subprogram

The Research and Innovation subprogram opened to applications in September 2015, Year 2 of the ABF program. The focus of this subprogram was to develop bioindustrial products and technologies at any stage of the innovation continuum that would add value to Alberta's biomass. Co-funding from industry was encouraged, but not mandatory.

In 2017-18, 16 projects were active, ranging in length of up to four years. Over the lifetime of the projects, they were allocated more than $4 million in funding from ABF, in addition to another $2M from proponents, for a total project worth of $6M.

In 2017-18, three projects closed and the remaining 13 projects in the Research and Innovation subprogram were still active. They are all summarized in the table below. Performance measures and financial information for this subprogram are available in the appendices.

Projects

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFR-16-002 *Research and Innovation* ---- **Roger Cheng** University of Alberta ---- **$105,023**	**Development and evaluation of 5-layer lumber-SCL massive timber panel products**	*Improving the performance characteristics of cross-laminated timber and structural composite lumber in an effort to offer a viable replacement to more expensive and energy intensive materials.*
BFR-16-005 *Research and Innovation* ---- **Rokib Hassan** BarrierTEK Inc. **$411,825**	**Development of a liquid-applied moisture vapor permeable air barrier and fire-retardant nano-composite emulsion**	*Creation of a nano-composite emulsion that offers moisture vapour barrier permeability and water resistance performance, easy application and strong surface adhesion for use over house barrier wraps. Testing has been completed on panel material and proponent is currently investigating next steps in evaluation and certification process.*

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
BFR-16-006 *Research and Innovation* --- **Yang Liu** University of Alberta --- **$240,000**	**Optimization of CNC hydrogel for inhibition of biofilm formation on medical devices**	*Development of a CNC-based coating which prevents the adhesion of bacteria and biofilms on the surface of medical devices. If successful, this treatment could drastically reduce the occurrence of infections, improving patient outcomes and reducing the cost and burden on the healthcare system. Patent has been granted and researchers are engaged in licensing discussions with a several companies. Work continues.*
BFR-16-015 *Research and Innovation* --- **Yaman Boluk** University of Alberta --- **$300,000**	**Development of modified CNF for controlled atmosphere food packaging films**	*Development of intelligent food packaging to extend the life of packaged produce through the control of oxygen, carbon dioxide and moisture. Work continues.*
BFR-16-017 *Research and Innovation* --- **Belinda Heyne** University of Calgary --- **$403,750**	**CNC-based antimicrobial coatings for biofilm prevention**	*Considerable progress has been made in developing a light sensitive CNC-dye that creates singlet oxygen. This singlet oxygen becomes an extremely effective biocide to control biofilms. Technical work continues, and we are helping these researchers engage with various potential industrial end-users.*
BFR-16-027 *Research and Innovation* --- **Jonathan Curtis** University of Alberta --- **$676,925**	**Development of bio-based resins for industrial use in fibre mat-based composite biomaterials**	*Creation of a plant oil-based epoxy resin for use in the manufacture of natural fibre composite mats (e.g. automotive panels). Now working with a commercial partner to scale up production.*

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
BFR-16-028 *Research and Innovation* --- **Jeffrey Stryker** University of Alberta --- **$712,400**	**Catalytic deoxygenative depolymerization of lignin under mild conditions. Production of "petrochemicals" from waste biomass**	*Investigating the creation of bio-chemicals from kraft pulp mill waste materials. Continuing to optimize the catalysts involved, with good progress being made.*
BFR-16-032 *Research and Innovation* --- **Cagri Ayranci** University of Alberta --- **$417,375**	**Engineering lignin as a precursor for carbon fiber using novel biodegradation and purification techniques**	*Investigating the use of lignin as a feedstock in the production of high value carbon fibre. Critical for its use is the removal of impurities, as those greatly impact quality. Initial electrospinning has shown good potential for success.*
BFR-16-033 *Research and Innovation* --- **Mohammad Reza Vakili** University of Alberta --- **$232,188**	**Fabrication of CNC-based bio-nanocomposite for bone tissue repair**	*Generation of biocompatible composites to mimic and assist the structure and function of natural bone healing. Work continues under this project, with progress being made in the formulation of composites and their adhesion to bone cells.*
BFR-16-046 *Research and Innovation* --- **Xihua Wang** University of Alberta --- **$249,900**	**CNC materials for novel applications in electronics and optoelectronics**	*Replacement of synthetic polymers with CNC-based composites to leverage their renewable, bio-based properties. Has resulted in two peer-reviewed publications and a provision patent, with another two publications at submission stage.*

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
BFR-16-058 *Research and Innovation* --- **Dominic Sauvageau** University of Alberta --- **$468,650**	**Co-conversion of C1 wastes from Alberta energy and pulp and paper sectors by methylotrophic bacteria**	*Creating processing strategies, based on the behaviour of these organisms, for the recovery and production of valuable products from methane and methanol used as co-substrates.*
BFR-16-060 *Industry Co-funded* --- **David Bressler** University of Alberta --- **$748,400**	**Design and application of a high-pressure microwave drop-in biofuel reactor system**	*Improving upon existing biofuel production technology, with the inclusion of microwave heating. Custom-designed microwave equipment is fully operational and work is progressing.*
BFR-16-071 *Industry Co-funded* --- **Paolo Mussone** NAIT --- **$163,060**	**Utilization of boiler fly ash from Alberta pulp and paper mills for the removal of hydrogen sulfide from industrial gas streams**	*Characterize and evaluate various wood-based ashes for use in gas processing filtration. Technical assessment is complete, now finalizing engineering estimates on costs of recovering ash at participating mills.*
BFR-16-072 *Research and Innovation* --- **Paolo Mussone** NAIT --- **$172,450**	**Catalytic distillation for the production of di-methyl ether from Alberta biomass**	*Producing a low-carbon footprint, renewable fuel through a single unit operation, benefitting from significant cost reductions.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFR-16-074 *Research and Innovation* ---- **Thomas Thundat** University of Alberta ---- **$153,500**	**Converting cellulose nanocrystals into high-value 1-dimentional nanocarbons for energy storage**	*Aimed at developing a procedure converting nanocellulose into low-cost carbon nanofibers to potential replace the carbon nanotubes for various energy storage applications.*
BFR-16-078 *Research and Innovation* ---- **David Stuart** University of Alberta ---- **$442,794**	**Engineered microbial cells for the biosynthesis of industrial oleochemicals**	*Use of microbial cells in the conversion of agricultural and forestry waste into compounds that could replace commonly used chemicals. The study has resulted in one peer-reviewed publication, with a second publication being prepared and a review of patents is underway. Application for second stage funding of this work is currently being sought from AAFC AgriScience Program funds.*

5.4 Biomaterials Pursuit Subprogram

This subprogram was created to further promising results seen through early-stage investments, such as those in the subprograms for CNC Challenge, Research and Innovation, and the internally funded InnoTech Alberta lignin projects. As described previously, many of the ABF investments are aimed at populating an application development pipeline, from fundamental research through to pre-commercialization activities. The new Biomaterials Pursuit subprogram has been designed to provide enhanced levels of funding to projects that warrant further support for scale-up. Funding of up to $300,000 per project is available for periods of up 2.5 years, with project concluding by Dec. 31, 2020. The expectation at this stage of funding is for proponents to engage with industrial partners to demonstrate the commercial potential in their work.

This subprogram is open to a wide audience of biomaterial projects relevant to Alberta, such as proposals to utilize CNC, cellulose nanofibrils (CNF), lignin and hemp. Its first call for proposals, launched in December 2017, received 45 letters of intent.

The projects active in 2017-18 are summarized in the table below. As they have just started, performance measures are not available but financial information is included in the appendix.

Projects

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFM-18-001 *Industry co-funded* ---- **Belinda Heyne** University of Calgary ---- **$373,650**	**Light-activated cellulose nanocrystals for a clean environment**	*Using light-activated CNC to eliminate antibiotic-resistant microbes. Continuation of project initially funded under CNC Challenge 2.0.*
BFM-18-002 *Industry co-funded* ---- **Cagri Ayranci** University of Alberta ---- **$376,800**	**Towards assembling nature back together: additive manufacturing of large-scale CNC-reinforced lignin components for green composites**	*Preliminary investigation of manufacturing, characterizing and modeling of CNC-lignin composites for 3D, additive manufacturing. Extension of projects supported under CNC Challenge 2.0 and the ABF Research & Innovation subprograms.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFM-18-003 *Industry co-funded* ---- **Zhi Li** University of Alberta ---- **$463,750**	**Application of cellulose nanocrystals in flexible and wearable energy storage devices**	*CNF and CNC in batteries for use in clothing and wearable accessories. Continuation of project funded under the ABF Research & Innovation subprogram.*

5.5 Equipment Utilization Subprogram

Alberta has invested significant effort and resources to establish bioindustrial infrastructure and expertise at public institutions. These resources are tremendous assets and are accessible to those interested in developing processes, technologies and products from Alberta's biomass resources. The Equipment Utilization subprogram aimed to encourage increased usage of these assets by pre-commercial and commercial proponents to facilitate development of their projects. This subprogram was open to continuous intake of applications from companies starting March 12, 2015, in Year 1 of the ABF program.

Although it was widely seen as an area of significant interest and need, and despite efforts to attract more activity, it did not generate the expected level of interest. Only five projects were approved, ranging in length of up to two years. One project dropped out. Together, the four remaining projects received almost $260,000 in funding from ABF over the term of projects, while proponents contributed $540,000, for a total of $800,000. The proponents, all of them companies, were required to provide 25 per cent of the equipment's usage costs.

As a result of the mid-term review and consideration by the ABF program team, this subprogram was discontinued in 2017-18. Remaining funds were repurposed into other subprograms.

One project closed in the Equipment Utilization subprogram in 2016-17 and the other three were still active in 2017-18. All projects are summarized in the table below. Performance measures and financial information for this subprogram are available in the appendices.

Projects

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFE-15-002 *Industry Co-funded* ---- **Geoff Clarke** Alberta-Pacific Forest Industries Inc. ---- **$100,000**	**Reducing CNC production cost by reusing the spent sulfuric acid in bleach plant**	*Technical feasibility assessment of using acid used in the production of CNC in subsequent pulp mill processes to improve economics. Demonstrated a 39% reduction of CNC production costs. Project completed, and the results are directly informing further work at InnoTech's CNC pilot plant, in their work with Alberta-Pacific.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFE-15-003 *Industry Co-funded* ---- **Dan Madlung** BioComposites Group ---- **$168,000**	**Research and development of hemp fibre-based mat products**	*Investigation of structural and non-structural hemp-based fibre mats, potentially replacing glass fibres, while providing high tensile strength and stiffness.*
BFE-16-007 *Industry Co-funded* ---- **Leonard Leskiw** Soil Savvy Inc. ---- **$120,797**	**Development of nutrient enriched granular biochar for applications in reclamation of industrially disturbed lands**	*Funding assisted in the production of specific biochar soil amendments derived from barley grain. The biochar was subsequently analyzed and field tested in experiments with a variety of tree seedling species to measure growth performance.*
BFE-16-017 *Industry Co-funded* ---- **David Harman** Northland Forest Products Ltd. ---- **$433,000**	**Biochar production from forestry residues at Northland Forest Products Ltd.**	*Demonstration scale biochar production from forest products' residuals, to allow technical feasibility testing and market development. Project delayed due to the 2016 fire in Fort McMurray. Final report expected in May 2018.*

5.6 Product and Technology Commercialization Subprogram

Carrying bioindustrial material technology and product development beyond basic research and laboratory requires dedicated effort and research. The product and technology commercialization ABF subprogram is directly aimed at providing that support to high-quality projects in the later development stage of the innovation continuum. This offers them the ability to scale up their concepts toward commercialization, providing they have projects that:

- Have a direct application to the bioindustrial sector. (Note: in this program, bioindustrial products exclude food, feed or pharma products.)
- Develop bioindustrial products and bioindustrial technologies that use renewable, sustainable biomass, with a focus on agriculture and forestry biomass, produced or available in Alberta.
- Will be commercialized within three years by an Alberta-based company.
- Include pre-commercial or commercial development:
    - Pilot or scale-up work, prototype development.
    - Research, but only as an activity required to directly support commercialization, i.e., market research, research to gain certification or implement codes or standards, etc.

In 2017-18, four projects were active, ranging in length of up to three years. Over the lifetime of the projects, they were allocated more than $2.3 million in funding from ABF with total project costs of more than $6 million.

In 2017-18, two projects closed and the other two in the Product and Technology Commercialization subprogram remained active from previous years.

All four projects active in 2017-18 are summarized in the table below. Performance measures and financial information for this subprogram are available in the appendices.

ALBERTA INNOVATES

Projects

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFP-16-002 *Industry Co-funded* ---- **Stephen Christensen** Canadian Greenfield Technologies ---- **$1,059,800**	**Pilot facility for the production of natural / industrial reinforcing fibre**	*Successfully developed pilot-scale production of hemp-based concrete reinforcement, demonstrating improvements in shrinkage cracking performance, thereby increasing concrete life expectancy and reduction of greenhouse gas (GHG) emissions. Third-party validation and profiling in industry trade publication.*
BFP-16-025 *Industry Co-funded* ---- **James Taylor** Hexion Canada ---- **$2,980,426**	**Novel steam preheating pilot unit to develop bio-based phenol formaldehyde resin technology for oriented strand board**	*Substituting or partially replacing synthetic resins with naturally derived materials, with focus on establishing pilot-scale steam preheating capacity and developing improved bio-based phenol formaldehyde resins. Mill trials beginning shortly.*
BFP-16-026 *Industry Co-funded* ---- **Geoff Clarke** Alberta Pacific Forest Industries Inc. ---- **$690,000**	**Novel process enhancements for advancing CNC production for high-end applications and improved economics**	*Building upon previous investments in CNC pilot plant operations, this project investigated and developed process improvements in feedstock pre-treatment, sulfuric acid recovery, purification and drying. All aimed at improving process economics, yield and product quality.*
BFP-16-029 *Industry Co-funded* ---- **Michael Kennedy** OleoFoam Inc. ---- **$1,287,647**	**Commercialization of bio-polyol and bio-based spray foam**	*Advance the production of canola-based rigid polyurethane foams to testing and application for certification under the Canadian Construction Materials Council.*

5.7 Invited Proposal Subprogram

The Invited Proposal subprogram was aimed at offering opportunity for projects that didn't align with existing funding subprograms, but which might warrant consideration due to unique and/or exceptional opportunities that would be missed if they were not considered for funding in a timely manner. This subprogram was a continuous open call for proposals, and if selected, proponents were invited to submit full proposals for a thorough review. Criteria was quite broad to enable submissions from audiences not previously considered. Also considered were projects with timing that may not have aligned to existing or planned calls but had topics of strategic alignment with the ABF program.

In 2017-18, 16 projects were active under the Invited Proposal subprogram, with projects lengths of up to five years. Over the lifetime of the projects, they were allocated almost $4 million in funding from ABF with total project costs of more than $11 million.

During 2017-18, six projects closed, two were launched and another eight remained active from previous years under the Invited Proposal subprogram. They are all summarized below with performance measures and financial information provided in the appendices.

Projects

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
2014F102R *Research and Innovation* --- **Aman Ullah** University of Alberta --- **$391,540**	**Monomers and biopolymers from renewable plant oil for various industrial applications**	*Identify new opportunities for tailoring plant oils into niche market applications.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
ABI-14-002 *Research and Innovation* ---- **Andriy Kovalenko** University of Alberta ---- **$1,009,800**	**Fabrication of a 4.5V supercapacitor stack prototype with electrode-grade nanoporous carbon from biochar using CNC-based inkjet printing**	*Two locally produced biochars will be used as a feedstock to develop nanoengineered carbon for supercapacitor (SC) applications. On physical activation and supercritical thermal treatment, carbon will be used in printable ink formulation to make SC electrodes on nanocellulose paper. Molecular theory of solvation will be used to rationally design carbon material and electrolyte composition. Using Origami assembly method, SC components will be integrated in a 0.9V cell and a 4.5V stack prototype.*
ABI-14-004 *Industry Co-funded* ---- **Amit Kumar** University of Alberta ---- **$320,000**	**Algae-based biomass for production of fuels and chemicals**	*Evaluation of algae-based hydrogen and diluent production, including an energy and emission assessment.*
ABI-15-001 *Industry Co-funded* ---- **Bernhard Seifried** Ceapro Inc. ---- **$1,750,000**	**Implementing pressurized gas expanded technology at a commercial and demonstration scale to generate novel bio-based products with improved purity and functionality**	*Support construction of demonstration scale facility to produce highly porous and purified bionanomaterial and bioactive ingredients.*
ABI-15-002* *Research and Innovation* ---- **James Rude** University of Alberta ---- **$154,000**	**Economy-wide impacts of second generation biofuels: a general equilibrium approach**	*Investigated the economic implications of Canadian second-generation biofuel production given alternative forms of government support, alternative regulatory regimes, and different competitive environments. Although completed just before the beginning of this annual report's coverage, the results of this work have become fundamental in our understanding and support for future proposals.*

PROJECT NUMBER *Alignment* ---- Project Investigator Organization ---- Total Project Funding	Project Name	Project Summary
ABI-15-003* *Research and Innovation* ---- **Martin Luckert** University of Alberta ---- **$161,120**	**Economic availability of cellulosic ethanol feedstocks from private land: a land-use change model**	*Investigate the economic conditions under which private agriculture land owners would be willing to grow woody biomass crops for energy products and other alternatives to traditional agricultural products. Again, this report provides critical information for us to target and select future investments.*
ABI-16-002 *Industry Co-funded* ---- **Yaman Boluk** University of Alberta ---- **$240,000**	**Effects of aqueous suspension properties on the atomization and dispersibility of spray-dried cellulose nanocrystallite granules**	*Studying the impact of electrolytes, surfactants and polymers in droplet formation and granule size. Leverages funding from a national funding competition, NSERC and Alberta Innovates.*
ABI-16-003 *Industry Co-funded* ---- **Karthik Shankar** University of Alberta ---- **$80,000**	**Advanced resonator- and imaging-based characterization of morphology and aggregation in cellulose nanocrystals and nanofibrils**	*Assess physical behaviour of nanocelluloses to improve understanding and facilitate application development. Leverages funding from a national funding competition, NSERC and Alberta Innovates.*
ABI-16-004* *Industry Co-funded* ---- **John Peters** Silvacom ---- **$112,500**	**Biomass mapping / community investment attraction project**	*Acquisition of detailed biomass inventory data and development of reports and maps for five Alberta communities, to inform opportunities for bioindustrial development.*
ABI-16-006 *Industry Co-funded* ---- **Michael Kennedy** Green Analytics ---- **$406,000**	**Strategic development of a sustainable supply chain for industrial biomass co-firing in Alberta**	*Assessment of biomass feedstock supplies proximate to coal-fired electrical generating facilities, to inform the potential economics and logistics of co-firing with biomass.*

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
ABI-16-007 *Industry Co-funded* --- **William Bardosh** TerraVerdae Bioworks Inc --- **$595,000**	**Optimization of PHB biopolymer production and products**	*Based on TerraVerdae's bio-based methanol fermentation process to produce PHB polymers, this project focused on improving yields and developing prototypes of polymer composites.*
ABI-16-008 *Research and Innovation* --- **Aman Ullah** University of Alberta --- **$488,280**	**Scale-up trials for highly efficient and rapid plant oil conversion technology**	*Scale-up of lipid conversion technology to assess commercialization applicability.*
ABI-16-009 *Research and Innovation* --- **Jonathan Curtis** University of Alberta --- **$432,000**	**Flame retardant polyols from oilseed crops**	*Develop phosphate / lipid-based additives to impart flame retardancy to bio-based foams and other polyurethanes.*
ABI-16-010 *Industry Co-funded* --- **Tamrat Tekle** Natural Fibre Technologies Inc. --- **$630,500**	**Commercial bast fibre separation plant**	*Build a commercial fibre processing, cleaning and particulate fractionation operation.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
ABI-16-011 *Industry Co-funded* ---- **Edson Ng** G4 Insights Inc. ---- **$1,130,000**	**G4 Alberta renewable natural gas demonstration project**	*Support the construction of continuous-process equipment for production of renewable natural gas from biomass feedstocks, including injecting the gas into the Alberta natural gas grid for six months.*
ABI-17-001 *Industry Co-funded* ---- **Amit Kumar** University of Alberta ---- **$2,527,000**	**Biobattery – decentralized production of fuel from forest and agricultural waste**	*The project aims to develop a decentralized, waste-to-value-added facility using technology developed by Fraunhofer. It will also demonstrate the feasibility of biobattery technology in Alberta, from wood chips and straw, with potential for small and remote communities, for the production of biofuels and biochemicals. Alberta Bio Future funding was used to leverage funding from Alberta Economic Development and Trade, WestJet, University of Alberta and the Fraunhofer Institute of Germany.*
ABI-17-003 *Industry Co-funded* ---- ALL Weather Windows Ltd.---- **$125,000**	**Development of cellulose nanocrystal-based novel smart window**	*Researchers are developing CNC- and CNF-coated smart windows that are energy-efficient, can automatically dim glass to block harmful UV light and provide better privacy than curtains. Related to Project ABI-16-001.*
AMC-14-001* *Industry Co-funded* ---- **Brian Grantham** West Fraser Hinton Pulp Mills Ld. ---- **$22,000,000**	**Lignin research recovery plant**	*Partial capital contribution, funded through the Advanced Materials and Chemical program. Capital facility is now commissioned and operating, with process optimizations being made to improve yield and quality. Funding is in the form of a repayable grant, wherein West Fraser will contribute to lignin research efforts in Alberta.*
BIO-13-007* *Industry Co-funded* ---- **Inder Singh**	**Scale-up and demonstration of advanced high-efficiency catalytic process for fuel**	*Development of SBI's 10-million-litre, commercial renewable fuel production facility in Edmonton, utilizing agricultural feedstocks to offset the import of renewable fuels.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
SBI Fine Chemicals ---- **$2,070,000**	**production from Alberta farm products**	
BIO-14-015* *Research and Innovation* ---- **John Peters** Silvacom ---- **$6,489,600**	**BRIMS Phase 3**	*Continuation of investments to develop a biomass resource inventory system to allow for the development of, and investment in, bioindustrial projects in Alberta, through spatial knowledge of where the biomass can be sourced.*
BIO-16-005 *Industry Co-funded* ---- **Vivek Bindiganavile** University of Alberta ---- **$483,000**	**Development and characterization of nano-engineered cement-based composites for sustainable construction**	*Utilizing production equipment located at InnoTech Alberta, this project looks to improve the performance of cement-based systems through the incorporation of nanocelluloses.*
BIO-16-007 *Research and Innovation* ---- **Inder Singh** SBI Bioenergy ---- **$300,000**	**Development of biofuels research contribution fund for future research investment - SBI's 10-million-litre renewable fuel demonstration initiative**	*Edmonton-based company, SBI Bioenergy, is researching new feedstocks for its commercial renewable fuel production plant, including the manufacture of new products like bioplastics and renewable solvents.*

Not active in 2017-18 but the project is of strategic importance to the ABF program.

5.8 Opportunities Subprogram

Based on recommendations from the mid-term review, the Opportunities subprogram replaces the Invited Proposal subprogram. It provides an avenue for proponents to submit project proposals to ABF that do not fit into the other subprogram offerings either for reason of scope, theme or timing. Nonetheless, they might warrant consideration due to unique and/or exceptional opportunities that would be missed if they were not considered for funding in a timely manner. This subprogram will continually accept letters of intent until March 31, 2019, and all projects must be completed by 2020. A full proposal is requested if the project meets the main subprogram criteria of presenting a unique and exceptional opportunity.

Since its launch in November 2017 to March 31, 2018, this subprogram has received 17 proposals. Of those, three were funded during 2017-18. Over the lifetime of the projects, the three projects were allocated almost $700,000 in funding from ABF, plus $900,000 from proponents, for a total of $1.6M.

The projects active in 2017-18 are summarized below. As they have just started, performance measures are not available but financial information is presented in the appendices.

Projects

PROJECT NUMBER *Alignment* --- **Project Investigator** Organization --- **Total Project Funding**	**Project Name**	**Project Summary**
BFI-18-001 *Industry co-funded* --- **Geoff Clarke** Alberta Pacific Forest Industries Inc. --- **$720,000**	**CNC refinement, drying and blending for high-value applications**	*Improving economics of CNC process and quality, aimed at opening new application markets.*
BFI-18-002 *Industry co-funded* --- **Erik Larsen** EC Labs --- **$635,831**	**Scale-up and production of natural personal care products**	*Support for interim manufacturing capacity while the company's own Health Canada registered facility is being developed. EC Labs has created 40 new and innovative natural personal care product formulations using Alberta biomass.*

PROJECT NUMBER *Alignment* ---- **Project Investigator** Organization ---- **Total Project Funding**	**Project Name**	**Project Summary**
BFI-18-003 *Industry co-funded* ---- **Brian Grantham** West Fraser Mills (Hinton) ---- **$260,000**	**Process validation for anaerobic digestion of foul condensates at a kraft pulp mill**	*Investigating an approach to processing waste materials new to kraft pulp mills in North America.*

6. Knowledge Extension Details

The development of an idea through all stages of the innovation continuum is often a lengthy process that can take up to a decade or in some cases, several decades. For example, development in Alberta of cellulose nanocrystals to its current stage has taken about 10 years. CNC work started with pioneering leadership in Alberta to create a western centre for forest nano material, value-added through CNC development. It culminated in the commissioning of the CNC pilot plant. Importantly, research, development and application leadership was being created simultaneously through the support of the Nanofibre Chair in Forest Products at the University of Alberta. Based on these important investments in the CNC platform, the application and commercialization opportunities are being realized today and in the future.

At all stages of the continuum, highly qualified personnel (HQP) must be available to do the work through on-the-job training, education or knowledge transfer. Knowledge must also be extended to other researchers, supporting organizations, investors and industry to garner support for development of an idea which could mean creation of an entirely new industry.

Embedded in most ABF projects is funding support for creation of high-quality, skilled positions. Individuals in these positions like post-doctoral fellows, PhD candidates, master's students and undergraduate students gain new knowledge through the project. This helps to expand bioindustrial expertise and experience in Alberta, cementing Alberta's future as a global player in bioindustrial development.

Extension of knowledge can occur in many ways: presentations, meetings, seminars, conferences at domestic and international venues, and more. These interactions build engagement, generate awareness and excitement, and help to spread knowledge to a broader audience. They also lead to new connections who may contribute to advancing the idea.

The performance measures table in the appendices presents a summary of the outcome of ABF projects in terms of HQP development and occurrences of knowledge management.

In addition to the ABF projects, the program team also engages in numerous knowledge extension activities. Through their collaborations and interactions with partners, proponents, researchers, industry, investors and other innovation support organizations, they bring knowledge about Alberta's bio sector, stimulate increased interest in research and innovation, and coordinate collaboration opportunities. This activity directly supports strategic priority three in the ABF grant agreement with Alberta Innovates: foster clusters that offer high growth potential to broaden Alberta's base.

See below for the program team's main knowledge extension activities in 2017-18.

The History of Cellulose Nanocrystals in Alberta

The dryer unit at InnoTech Alberta's CNC pilot plant removes moisture from the cellulose biomaterial.

Source: Alberta Innovates

Alberta's interest in cellulose nanocrystals (CNC) began about 10 years ago, when this biomaterial was presented as a possible diversification opportunity for the province's pulp mills. CNC can be produced from any cellulosic material, so at that time there were even thoughts it could be an opportunity for agricultural crop diversification for sugar beets or even hemp. As the science developed, Alberta Pacific Forest Industries (Al-Pac) emerged as an interested and engaged industrial partner. Alberta Innovates commissioned a market study by Dr. Bruce Lyne to evaluate just how tangible and realistic the opportunity was for Alberta. The results led to the investments to construct and commission the CNC pilot plant at what is now InnoTech Alberta's Millwood's campus. Momentum built around the CNC. About five years ago, the science around CNC had developed to the point that it was well understood, and what remained was optimization to make the economics work. Alberta Innovates began to invest more heavily in application development and novel research with the aim of creating market demand, albeit recognizing that this demand would be years in the making. Simultaneously, process improvements were being made to streamline the production of CNC and lower production costs to make it a more compelling business case for producers and customers alike. As the development has progressed, Al-Pac has taken a greater role in funding research and conducting market development activities.

Representatives from Alberta have made presentations at a variety of national and international events in an effort to create more research and industrial interest in CNC. This has led to a strong and developing network of partners, collaborators and potential customers involved in developing end-use applications in a variety of sectors, ranging from electronics to industrial coatings to composites to medical devices.

Alberta CNC is now recognized around the world, with samples having been provided throughout North America, Europe, South America and Asia. As those have been assessed by researchers and end-users, demand for more samples of greater volume has emerged. As a number of efforts by Alberta Innovates draw close to commercialization, the Corporation continues to pursue new opportunities for high-value applications for this interesting material. A commercial-scale CNC production facility that was but a far off wish many years ago may soon be a reality, thanks to the efforts of many organizations over the years.

2017-18 Knowledge Extension Activities

Hemp Decortication Plan for Alberta

Researchers at the Alberta Innovates facility in Vegreville, Alta., are testing the best way to grow and harvest industrial hemp in Alberta's northern growing conditions.

Source: Alberta Innovates

Alberta Agriculture and Forestry approached InnoTech to develop a plan for the future of hemp decortication in Alberta. The expert, Corey Keith, was hired to evaluate the existing system and provide recommendations for the best way Alberta could move forward. He conducted interviews, did background research and made several recommendations.

The ABF program team became involved to make sure decisions were thoughtful and informed by the best knowledge available. The ABF team helped InnoTech to identify and commission the right expert, assisted with the evaluation process, and reviewed the report. Although its recommendations were not ultimately adopted, the intelligence gathered will prove useful in the future.

Government of Alberta's Climate Change Innovation and Technology Framework (CCITF)

Launched in December 2017 by the Government of Alberta, the Climate Change Innovation and Technology Framework (CCITF) was developed to achieve the goals of Alberta's Climate Leadership Plan through innovation and technology.

Two members of the ABF project team are co-leading programs with the broader CCITF program team to provide knowledge and expertise in the following framework areas: cleaner oil and gas; methane emissions reduction; low-carbon electricity; waste to value-added; green buildings and energy efficiency.

Natural Resource Canada's Clean Growth Program

The federal Clean Growth Program (CGP), which closed on March 5, 2018, aims to stimulate clean technology research, development and demonstration projects in Canada's energy, mining and forestry sectors.

Some members of the ABF team are collaborating with the broader CGP program team to provide knowledge and expertise about the production and use of advanced materials and bioproducts, especially in Alberta.

BIO World Congress on Industrial Biotechnology

The BIO World Congress on Industrial Biotechnology is a leading international conference for government, industry and academia to share the latest advances in renewable chemicals, synthetic biology, enzymes, food ingredients and biofuels. With more than 1,000 attendees from about 530 industrial biotechnology companies around the world, this annual technical conference offers Alberta opportunity to raise awareness of the province's capacity and achievements, recruit new technology companies to Alberta and build partnerships.

Held annually in different cities across North America, the 2017 event occurred in Montreal from July 23 to 27. Alberta's presence was co-ordinated by BioEconomy Alberta, the collective name for more than 30 professionals from government, academia and innovation support organizations who share efforts in advancing Alberta's bioeconomy. This group is led by Alberta Innovates.

The outgoing World Congress mission team from Alberta consisted of nine individuals, including two from Alberta Innovates. Also in attendance from Alberta were seven companies, including three who received travel bursaries from Alberta Innovates. The four who attended on their own were Ceapro, Steeper Energy, TerraVerdae Bioworks and Enerkem. The three who received bursaries were Roshan Water Solutions, Susteen Technologies Canada and Zen Earth Corp.

Two Albertans were speakers on two BIO World Congress breakout session panels – an InnoTech Alberta researcher and a biomass consultant. Both sessions were well attended and provided the Albertans a chance to advance knowledge about biomaterial development and the use of hemp to make advanced materials. Across the team, this outgoing mission trip resulted in at least 41 significant company introductions and meetings, and another 21 significant meetings with service providers from federal, provincial, university and industry organizations. Additional contacts were made with: 13 new individuals, 14 speakers for potential future events. Several on-site introductions to key contacts were provided to one of the Alberta companies with a travel bursary. Existing partnerships were renewed and maintained, including with Oberon Fuels and Bioindustrial Innovation Canada. A possible new partnership with Queensland, AU was initiated.
Many more than expected attended the annual tri-province prairie networking reception. About 170 national and international guests from across North America, Germany, The Netherlands and Australia met the Alberta mission team and learned of the SPARK 2017 conference.

Costs for the tradeshow booth and networking reception were shared by three provinces: Alberta (BioEconomy Alberta with in-kind support provided by BioAlberta), Saskatchewan (Ag-West Bio) and Manitoba (Life Science Association of Manitoba). The three provinces regularly combine efforts to gain visibility at international conferences under the brand name of Canadian Prairie Biosciences.

Upon return to Alberta, the industry trends, innovations, new opportunities and competitive intelligence gained at the Congress were shared with key clients, Government of Alberta staff and partners.

SPARK 2017

***LEFT:** Alberta Innovates CEO Laura Kilcrease (second from right) participates in plenary panel at SPARK 2017.*
***RIGHT:** Deron Bilous, Minister of Alberta Economic Development and Trade, addresses SPARK gathering.*
Source: Emissions Reduction Alberta

With the theme "Connecting Innovators, Advancing Technology," clean tech conference SPARK 2017 explored ways Alberta could reduce greenhouse gas emissions and accelerate its bioeconomy. The conference was held November 6 to 8, 2017, at the Shaw Conference Centre in Edmonton, co-hosted by the Bio business line of Alberta Innovates and Emissions Reduction Alberta.

It attracted nearly 600 innovators and enablers from academia, government and industry. The main sectors - represented by almost 290 industry attendees - were, from most to least: biofuels production, oil and natural gas extraction, natural gas production, oil production and oil sands mining, livestock and crop management, in situ oil production, renewable electricity generation, chemical manufacturing, electricity generation, forest products, landfills and waste management, commercial and residential building, transportation and utilities.

The conference program brought together speakers and attendees from these diverse sectors to spark cross-talk, networking and connections. Popular breakout sessions included: Bioindustrial development and biological GHG emissions; Technology development to measure and enhance sustainability in biological systems; Biological solutions for transportation products, policy and the future; What's new in biomaterials, biochemicals an bioenergy; What the marketplace wants; Finding the sweet spot for your technology and How to finance your clean tech business.

Featured speakers included Honourable Rachel Notley, Premier of Alberta; Honourable Deron Bilous, Minister of Alberta Economic Development of Trade; Honourable Shannon Phillips, Minister of Alberta Environment and Parks and Minister Responsible for the Climate Change Office; Steve MacDonald, CEO of Emissions Reduction Alberta and Laura Kilcrease, CEO of Alberta Innovates.

The keynote speaker was Thomas Homer-Dixon, author of The Ingenuity Gap and Chair, Global Systems, Balsillie School of International Affairs, University of Waterloo.

SPARK 2017 attracted 34 sponsors and offered a 2.5-day program with 86 speakers and moderators, five plenary sessions, 20 breakout sessions, an innovation showcase featuring 22 organizations, two networking receptions, a pre-conference workshop and a post-conference industry tour. In an evaluation questionnaire about the conference, feedback was very positive, with the majority saying they would attend another SPARK conference.

Co-hosting this conference in the 2017-18 reporting period, has helped to fulfill Alberta Innovates' requirement in the ABF grant agreement from Alberta Economic Development and Trade to co-ordinate regular events that stimulate knowledge exchange and networking in Alberta's bioindustrial space.

GLOBE 2018

Alberta Innovates participated at GLOBE 2018 in Vancouver from March 13-16, 2018, as a member of Team Alberta. The Alberta Pavilion was co-ordinated by Alberta Economic Development and Trade (EDT) and included representatives from EDT, Alberta Environment and Parks, Alberta Climate Change Office and Alberta Agriculture and Forestry. Contributing partners to Team Alberta included, Alberta Innovates, Emissions Reduction Alberta, Calgary Economic Development and Wood Buffalo Environmental Association. Alberta Clean Technology Industry Alliance, BioAlberta, Energy Efficiency Alberta and Innotech Alberta were also collaborators at the event.

In addition, 15 Alberta clean technology companies were part of the Alberta Pavilion. Several of these companies were bioindustrial in focus, including Just BioFiber and BioRefinex. Many of the companies that attended reported new sales leads, and new partner and investor prospects from their participation.

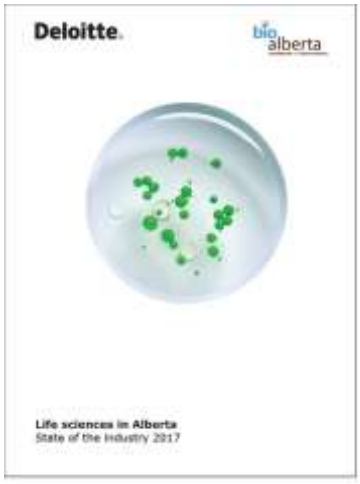
The Honourable Shannon Phillips, Minister of Alberta Environment and Parks and the Climate Change Office, represented the Government of Alberta. She spoke at a panel discussion in the Innovation Expo on March 14 on "Balancing Economic Growth, Diversification and Prosperity while Advancing Emissions Reduction: Alberta's Story." Other Alberta events at the Innovation Expo included:

- *Dr. John Zhou, Alberta Innovates, presented on the Climate Change Innovation and Technology Framework program at a seminar on Emerging Innovations in Cleantech on March 15 in the Disruptor Theatre.*
- *Harold Krenkel, InnoTech Alberta, presented on "Development of the Alberta Carbon Conversion" in the Technology Centre.*

Alberta Innovates supported the development and implementation of a seminar and networking reception, "Alberta Clean Innovation: Partnering for Global Solutions." Minister Phillips provided opening remarks along with an overview of the Climate Leadership Plan. This was followed by a presentation from Jane Humberstone, Director, Emerging Technologies Unit for EDT and Elizabeth Shirt, Executive Director, Policy and Strategy for Emissions Reduction Alberta, and Dr. John Zhou, Vice President, Clean Energy for Alberta Innovates, about the Climate Change Innovation and Technology Framework.

Prairie BioEconomy Guild

Established in 2013 with Alberta Innovates playing a key role, a variety of guest speakers present their insights at the monthly Guild sessions in Edmonton. The sessions offer the opportunity to exchange knowledge and network for business owners, researchers, developers, investors, government staff and other bioindustrial professionals. The Guild sessions aim to build relationships for a foundation of trust that will accelerate development of Alberta's bioeconomy sector.



BioAlberta Life Sciences State of the Industry Survey 2017

Alberta Innovates wanted to better understand the number and focus of companies in the bioindustrial sector in Alberta. BioAlberta has been conducting a survey of Alberta's life sciences companies since 2004. BioAlberta is an industry association, and the "central voice and organizing hub for the life sciences industry in Alberta." It promotes, advocates and proactively facilitates the growth of Alberta's life sciences industry.

Alberta Innovates partnered with BioAlberta to include bioindustrial companies in the surveys conducted in 2015 and 2017. More bioindustrial companies chose to participate in 2017 than in 2015, so a direct comparison of results between the two years is not advisable.

However, some general observations about active companies in the broad bioindustrial sector of Alberta are offered below:

The survey targets companies in a number of areas. Of interest to the Alberta Bio Future program are companies that self-selected as belonging to the three subsectors called industrial biotechnology and bioprocessing, environmental biotechnology, and agricultural biotechnology.

When companies selected more than one subsector, this indicated a diverse portfolio of products.

In the 2015 survey, 16 companies selected the subsectors industrial biotechnology and bioprocessing, and environmental biotechnology. They are known to be focused on the commercialization of biochemicals, biomaterials or bioenergy.

In the 2017 survey, there were 26 companies in these same subsectors, many of which are known to be focused on the commercialization of biochemicals, biomaterials or bioenergy.

Of the companies that responded in 2017, seven had also responded in 2015, while 19 were new respondents. This indicates that BioAlberta was effective in reaching out to new companies in the life sciences space in Alberta.

Subsequent to the survey, BioAlberta developed a Bioindustrial Directory of companies, in which 44 chose to be listed.

Bioindustrial Directory 2017

On April 12, 2017, BioAlberta released its Bioindustrial Directory 2017, a comprehensive directory of companies and service organizations in the province's growing bioindustrial sector. The directory was completed with support from Alberta Innovates. In addition to providing a list of companies, it includes a comprehensive index with categories for feedstock type, process utilized, and core products.

Media Coverage

A summary of media coverage of ABF projects and events is included in Appendix C – Communications Report.

Appendix A – Performance Measures

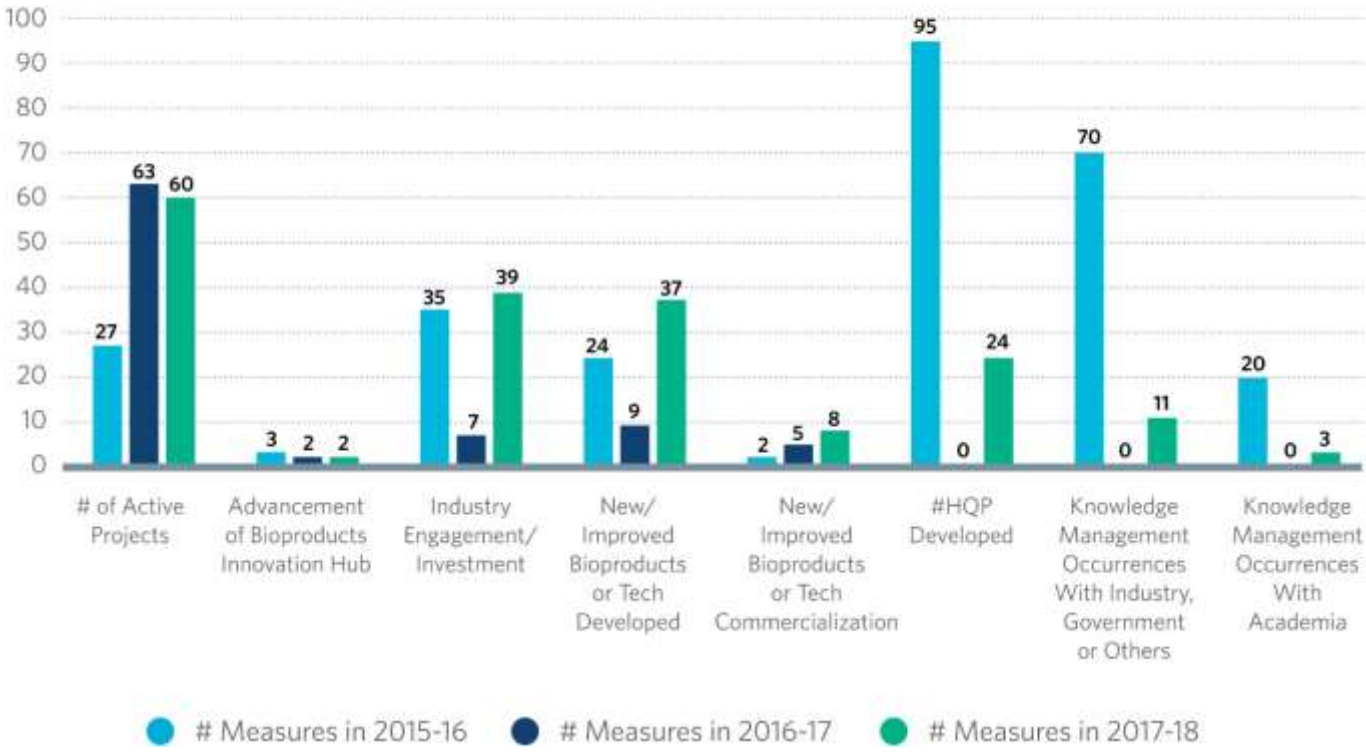
1. Advancement of Bioproducts Innovation Hub[1] - # grand openings, # networks, other indication of growing critical mass.
2. Industry Engagement/Investment[2] - # companies involved.
3. New / Improved Bioproducts or Tech Developed[3] - # technologies developed, # patents, # licences, # successful scale-ups, # proof of concepts, # new concepts, # non-disclosure agreements. *(To avoid double-counting, for each new product/tech only one of these measures was counted in the final total, regardless whether each measure was achieved.)*
4. New/Improved Bioproducts or Tech Commercialized[4]- # products experiencing first-time sales, # spin-off companies, # jobs created.
5. # HQP Developed[5]
6. Knowledge Management Occurrences with Industry, Government or Others[6] - # events hosted, # speaking opportunities, # articles, # news releases, #interviews, # trade shows with booth, # newsletter editions.
7. Knowledge Management Occurrences with Academia[7] - # events hosted, # speaking opportunities, # trade shows with booth, # papers published, # abstracts published.

ALBERTA INNOVATES

Alberta Bio Future Program

SUMMARY OF PERFORMANCE MEASURES

As of March 31, 2018



ALBERTA INNOVATES

Alberta Bio Future Program - Performance Measures for Year 2 - April 1, 2015 to March 31, 2016

Subprogram	Alignment	# Active Projects	Outcomes						
			1. Advancement of Bioproducts Innovation Hub[1]	2. Industry Engagement/ Investment[2]	3. New / Improved Bioproducts or Tech Developed[3]	4. New / Improved Bioproducts or Tech Commercialized[4]	5. # HQP Developed[5]	6. Knowledge Management Occurrences with Industry, Government or Others[6]	7. Knowledge Management Occurrences with Academia[7]
Networks	*Industry co-funded*	2	2	29	16	1	95	70	20
CNC Challenge	*Industry co-funded*								
CNC Challenge	*Research and Innovation*								
Research and Innovation	*Industry co-funded*								
Research and Innovation	*Research and Innovation*								
Biomaterials Pursuit	*Industry co-funded*								
Equipment Utilization	*Industry co-funded*	2							
Product and Technology Commercialization	*Industry co-funded*	4							
Invited Proposal	*Industry co-funded*	12	1	5	3	1			
Invited Proposal	*Research and Innovation*	7		1	5				
Opportunities	*Industry co-funded*								
Total		**27**	**3**	**35**	**24**	**2**	**95**	**70**	**20**

ALBERTA INNOVATES

Alberta Bio Future Program - Performance Measures for Year 3 - April 1, 2016 to March 31, 2017

Subprogram	Alignment	# Active Projects	Outcomes						
			1. Advancement of Bioproducts Innovation Hub[1]	2. Industry Engagement/ Investment[2]	3. New / Improved Bioproducts or Tech Developed[3]	4. New / Improved Bioproducts or Tech Commercialized[4]	5. # HQP Developed[5]	6. Knowledge Management Occurrences with Industry, Government or Others[6]	7. Knowledge Management Occurrences with Academia[7]
Networks	*Industry co-funded*								
CNC Challenge	*Industry co-funded*	1							
CNC Challenge	*Research and Innovation*	10							
Research and Innovation	*Industry co-funded*	2							
Research and Innovation	*Research and Innovation*	14		1					
Biomaterials Pursuit	*Industry co-funded*								
Equipment Utilization	*Industry co-funded*	4		1	1				
Product and Technology Commercialization	*Industry co-funded*	8			1				
Invited Proposal	*Industry co-funded*	13	1	4	3	5			
Invited Proposal	*Research and Innovation*	11	1	1	4				
Opportunities	*Industry co-funded*								
Total		**63**	**2**	**7**	**9**	**5**	**0**	**0**	**0**

ALBERTA INNOVATES

Alberta Bio Future Program - Performance Measures for Year 4 - April 1, 2017 to March 31, 2018

Subprogram	Alignment	# Active Projects	Outcomes						
			1. Advancement of Bioproducts Innovation Hub[1]	2. Industry Engagement/ Investment[2]	3. New / Improved Bioproducts or Tech Developed[3]	4. New / Improved Bioproducts or Tech Commercialized[4]	5. # HQP Developed[5]	6. Knowledge Management Occurrences with Industry, Government or Others[6]	7. Knowledge Management Occurrences with Academia[7]
Networks	*Industry co-funded*	4	1	3	2				2
CNC Challenge	*Industry co-funded*	1		1	1				
CNC Challenge	*Research and Innovation*	10		2	7	1			1
Research and Innovation	*Industry co-funded*	2		2	1				
Research and Innovation	*Research and Innovation*	14		5	13	0	1	5	
Biomaterials Pursuit	*Industry co-funded*	3		3					
Equipment Utilization	*Industry co-funded*	3		3	3				
Product and Technology Commercialization	*Industry co-funded*	4	1	4	2	4	10	1	
Invited Proposal	*Industry co-funded*	11		10	5	2	9	1	
Invited Proposal	*Research and Innovation*	5		3	3	1	4	4	
Opportunities	*Industry co-funded*	3		3					
Total		**60**	**2**	**39**	**37**	**8**	**24**	**11**	**3**

ALBERTA INNOVATES

Appendix B – Project List

TABLE LEGEND:

- **Project alignment** with AI/EDT agreement: Industry Co-Fund, Research and innovation, Networks.
- **Subprograms** within ABF, conducted with an open call for proposals: Product and Technology Commercialization (Prod&Tech Comm), Research and Innovation (R&I), Equipment Utilization (Equip U), CNC Challenge 2.0 (CNC). Subprogram conducted with invited proposal (Invited). Networks (Networks).
- **Committed funds** from ABF=the EDT funds for ABF, from AI (Bio)=AI core funds for ABF, from other contributors including proponent (includes cash and in-kind). Total project cost (includes cash and in-kind)). All committed funds are over the life of the project.

Alberta Bio Future Program

Projects in progress or completed during period April 1, 2017 – March 31, 2018 (funding represents investments over the entire length of project)

Subprogram	Project Number	Alignment	Project Start Date	Project End Date	Project Name	Project Investigator	Organization	Committed Funds ($) From ABF	Committed Funds ($) From AI	Committed Funds ($) From Others	Total Project Cost ($)
Networks and Knowledge Extension	ABI-17-002	*Industry co-funded*	1-Sep-2017	30-Aug-2022	*NSERC/Cenovus/Alberta Innovates Associate Industrial Research Chair in Energy and Environmental Systems Engineering*	Kumar, Amit	University of Alberta		$500,000	$1,600,000	$2,100,000 (in-kind contributions from AI included here)
Networks and Knowledge Extension	BIO-12-011	*Industry co-funded*	1-Sep-2012	30-Aug-2017	*NSERC/Cenovus/Alberta Innovates Associate Industrial Research Chair in Energy and Environmental Systems Engineering*	Kumar, Amit	University of Alberta		$250,000	$1,640,000	$1,890,000
Networks and Knowledge Extension	BIO-16-010	*Industry co-funded*	1-Jul-2016	30-Jun-2021	*NSERC Industrial Research Chair in the Industrialization of Building Construction*	Al-Hussein, Mohamed	University of Alberta		$250,000	$3,680,000	$3,930,000
Networks and Knowledge Extension	BIO-16-014	*Industry co-funded*	1-Sep-2016	31-Aug-2021	*Massive timber panel system behaviour study and its application*	Yu, Haitao	Landmark Group of Companies INC		$500,000	$2,882,849	$3,382,849

	.....				*in buildings – in collaboration with Industrial Research Chair - Dr. Chui*						
CNC Challenge	BFC-16-002	*Research and Innovation*	1-Jul-2016	30-Jun-2017	*Development of value-added CNC for application as electronic component in sustainable batteries*	Baumgartner, Thomas	University of Calgary		$25,000		$25,000
CNC Challenge	BFC-16-003	*Research and Innovation*	1-Sep-2016	31-Aug-2017	*Development of CNC nanocomposites for aluminum -air batteries*	Park, Simon	University of Calgary		$25,000	$50,000	$75,000
CNC Challenge	BFC-16-006	*Research and Innovation*	1-Jul-2016	30-Dec-2017	*Realizing potential benefits of CNC for the rapidly developing additive manufacturing market*	Ayranci, Cagri	University of Alberta		$25,000		$25,000
CNC Challenge	BFC-16-012	*Research and Innovation*	1-Jul-2016	30-Jun-2017	*Removal of trace pharmaceuticals and endocrine-disrupting chemicals from water using filtering systems based on modified CNC*	Burt, Helen	University of British Columbia		$25,000		$25,000
CNC Challenge	BFC-16-013	*Research and Innovation*	1-Jul-2016	30-Jun-2017	*Does CNC incorporation enhance the properties of UV-cured polyurethane coatings?*	Curtis, Jonathan	University of Alberta		$25,000		$25,000
CNC Challenge	BFC-16-014	*Research and Innovation*	1-Jul-2016	30-Jun-2017	*CNC polymer nanocomposites for high-barrier applications*	Bosnick, Kenneth	National Research Council of Canada		$25,000	$25,000	$50,000
CNC Challenge	BFC-16-018	*Research and Innovation*	1-Jul-2016	31-Aug-2017	*Novel CNC hydrogel for 3D bioprinting of organs on chip*	Sanati-Nezhad, Amir	University of Calgary		$25,000		$25,000
CNC Challenge	BFC-16-020	*Research and Innovation*	1-Jul-2016	30-Jun-2017	*CNC for steam foam applications in SAGD*	Gates, Ian D.	University of Calgary		$25,000		$25,000
CNC Challenge	BFC-16-024	*Industry co-funded*	1-Sep-2016	31-Aug-2017	*Development of thermally degradable epoxy adhesives containing CNC*	Du, Rongbing	National Research Council of Canada		$25,000		$25,000

CNC Challenge	BFC-16-025	*Research and Innovation*	1-Sep-2016	31-Dec-2017	*Novel electrospun nanofiber adsorbent for air pollution control and air sampling applications*	Hashisho, Zaher	University of Alberta		$25,000	$51,300	$76,300
CNC Challenge	BFC-16-026	*Research and Innovation*	1-Oct-2016	30-Sep-2017	*Application of CNC in the development of bioadhesive hydrogels for wound closure and local drug delivery*	Lavasanifar, Afsaneh	University of Alberta		$25,000	$2,000	$27,000
Research and Innovation	BFR-16-002	*Research and Innovation*	1-Jun-2016	31-Dec-2017	*Development and evaluation of 5-layer lumber-SCL massive timber panel products*	Cheng, Roger	University of Alberta	$77,710		$27,313	$105,023
Research and Innovation	BFR-16-005	*Research and Innovation*	1-May-2016	30-Apr-2019	*Development of a liquid-applied moisture vapor permeable air barrier and fire retardant nano-composite emulsion*	Hassan, Rokib	BarrierTEK Inc.	$308,869		$102,956	$411,825
Research and Innovation	BFR-16-006	*Research and Innovation*	1-Sep-2016	31-Aug-2018	*Optimization of CNC hydrogel for Inhibition of biofilm formation on medical devices*	Liu, Yang	University of Alberta	$190,000		$50,000	$240,000
Research and Innovation	BFR-16-015	*Research and Innovation*	1-Jun-2016	31-May-2019	*Development of modified cellulose nanofibrils for controlled atmosphere (CA) food packaging films*	Boluk, Yaman	University of Alberta	$213,750		$86,250	$300,000
Research and Innovation	BFR-16-017	*Research and Innovation*	4-Jul-2016	3-Jul-2019	*CNC-based antimicrobial coatings for biofilm prevention*	Heyne, Belinda	University of Calgary	$403,750			$403,750
Research and Innovation	BFR-16-027	*Research and Innovation*	1-May-2016	30-Apr-2019	*Development of bio-based resins for industrial use in fibre mat-based composite biomaterials*	Curtis, Jonathan	University of Alberta	$392,825		$284,100	$676,925
Research and Innovation	BFR-16-028	*Research and Innovation*	1-May-2016	31-Mar-2019	*Catalytic deoxygenative depolymerization of lignin under mild conditions - production of "petrochemicals" from waste biomass*	Stryker, Jeffrey	University of Alberta	$353,400		$359,000	$712,400

Research and Innovation	BFR-16-032	*Research and Innovation*	1-Aug-2016	31-Jul-2019	*Engineering lignin as a precursor for carbon fiber using novel biodegradation and purification techniques*	Ayranci, Cagri	University of Alberta	$306,375		$111,000	$417,375
Research and Innovation	BFR-16-033	*Research and Innovation*	1-Sep-2016	1-Mar-2019	*Fabrication of CNC based bio-nanocomposite for bone tissue repair*	Vakili, Mohammad Reza	University of Alberta	$172,188		$60,000	$232,188
Research and Innovation	BFR-16-046	*Research and Innovation*	1-May-2016	30-Apr-2018	*CNC materials for novel applications in electronics and optoelectronics*	Wang, Xihua	University of Alberta	$167,200		$82,700	$249,900
Research and Innovation	BFR-16-058	*Research and Innovation*	1-May-2016	30-Apr-2020	*Co-conversion of C1 wastes from the Albertan energy and pulp and paper sectors by methylotrophic bacteria*	Sauvageau, Dominic	University of Alberta	$348,650		$120,000	$468,650
Research and Innovation	BFR-16-060	*Industry co-funded*	1-Apr-2016	31-Mar-2020	*Design and application of a high-pressure microwave drop-in biofuel reactor system*	Bressler, David	University of Alberta	$362,900		$385,500	$748,400
Research and Innovation	BFR-16-071	*Industry co-funded*	1-Jun-2016	31-Dec-2017	*Utilization of boiler fly ash from Alberta pulp and paper mills for the removal of hydrogen sulfide from industrial gas streams*	Mussone, Paolo	NAIT	$128,060		$35,000	$163,060
Research and Innovation	BFR-16-072	*Research and Innovation*	1-Sep-2016	31-Aug-2018	*Catalytic distillation for the production of di-methyl ether from Alberta biomass*	Mussone, Paolo	NAIT	$162,450		$10,000	$172,450
Research and Innovation	BFR-16-074	*Research and Innovation*	15-Apr-2016	30-Sep-2017	*Converting cellulose nanocrystals into high-value 1-dementional nanocarbons for energy storage*	Thudat, Thomas G.	University of Alberta	$123,500		$30,000	$153,500
Research and Innovation	BFR-16-078	*Research and Innovation*	1-Jun-2016	31-May-2019	*Engineered microbial cells for the biosynthesis of industrial oleochemicals*	Stuart, David	University of Alberta	$291,573		$151,221	$442,794
Biomaterials Pursuit	BFM-18-001	*Industry co-funded*	1-Mar-2018	31-Mar-2020	*Light-activated cellulose nanocrystals for a clean environment*	Heyne, Belinda	University of Calgary	$223,000		$150,650	$373,650

Biomaterials Pursuit	BFM-18-002	*Industry co-funded*	1-Mar-2018	31-Oct-2020	*Towards assembling nature back together: additive manufacturing of large-scale CNC-reinforced lignin components for green composites*	Ayranci, Cagri	University of Alberta		$300,000	$76,800	$376,800
Biomaterials Pursuit	BFM-18-003	*Industry co-funded*	1-Mar-2018	30-Nov-2020	*The application of cellulose nanocrystals in flexible and wearable energy storage devices*	Li, Zhi	University of Alberta	$290,000		$173,750	$463,750
Equipment Utilization	BFE-15-003	*Industry co-funded*	11-Feb-2016	16-Dec-2018	*Research and development of hemp fibre-based mat products*	Madlung, Dan	BioComposites Group Inc.	$100,000		$68,000	$168,000
Equipment Utilization	BFE-16-007	*Industry co-funded*	1-May-2016	30-Apr-2017	*Development of nutrient-enriched granular biochar for applications in reclamation of industrially disturbed lands*	Leskiw, Leonard	Soil Savvy Inc.	$37,125		$83,672	$120,797
Equipment Utilization	BFE-16-017	*Industry co-funded*	1-Jun-2016	31-Mar-2018	*Biochar production from forestry residues at the Northland Forest Products Ltd. site using the abri-tech carbonizer*	Harman, David	Northland Forest Products Ltd	$72,000		$361,000	$433,000
Product and Technology Commercialization	BFP-16-002	*Industry co-funded*	4-Feb-2016	31-Mar-2018	*Pilot facility for the production of natural / industrial reinforcing fibre*	Christensen, Stephen	Canadian Greenfield Technologies	$580,000		$479,800	$1,059,800
Product and Technology Commercialization	BFP-16-025	*Industry co-funded*	1-Sep-2016	31-Jan-2019	*Novel steam preheating pilot unit to develop bio-based phenol formaldehyde resin technology for oriented strand board manufacture*	Taylor, James	Hexion Canada Inc	$500,000		$2,480,426	$2,980,426
Product and Technology Commercialization	BFP-16-026	*Industry co-funded*	2-Nov-2015	30-Apr-2017	*Novel process enhancements for advancing CNC production for high end applications and improved economics*	Clarke, Geoff	Alberta Pacific Forest Industries	$450,000		$240,000	$690,000
Product and Technology Commercialization	BFP-16-029	*Industry co-funded*	15-Jan-2016	30-Jan-2018	*Commercialization of bio-polyol and bio-based spray foam*	Kennedy, Michael	OleoFoam (also 1782815 Alberta Ltd.)	$800,147		$487,500	$1,287,647

Invited Proposal	2014F102R	*Research and Innovation*	1-Jun-2014	30-Sep-2017	*Monomers and biopolymers from renewable plant oil for various industrial applications*	Ullah, Aman	U of A		$194,400	$197,140	$391,540
Invited Proposal	ABI-14-002	*Research and Innovation*	9-Jun-2014	8-Apr-2019	*Fabrication of a 4.5V supercapacitor stack prototype with electrode-grade nanoporous carbon from biochar using CNC-based inkjet printing*	Kovalenko, Andriy	U of A		$270,000	$739,800	$1,009,800
Invited Proposal	ABI-14-004	*Industry co-funded*	1-Jan-2015	31-Dec-2018	*Algae-based biomass for the production of fuels and chemicals*	Kumar, Amit	U of A		$100,000	$220,000	$320,000
Invited Proposal	ABI-15-001	*Industry co-funded*	1-Apr-2015	16-Apr-2018	*Implementing pressurized gas expanded technology at a commercial and demonstration scale to generate novel bio-based products with improved purity and functionality. ($0.8 M total project, $0.4 K EDT, $0.4K AI Bio)*	Seifried, Bernhard	Ceapro Inc.		$400,000	$1,350,000	$1,750,000 (includes $400,000 from EDT which were administered by AI)
Invited Proposal	ABI-16-002	*Industry co-funded*	1-Sep-2016	31-Aug-2019	*Effects of aqueous suspension properties on the atomization and dispersibility of spray dried cellulose nanocrystal granules*	Boluk, Yaman	University of Alberta		$120,000	$120,000	$240,000
Invited Proposal	ABI-16-003	*Industry co-funded*	1-Aug-2017	31-Jul-2020	*Advanced resonator- and imaging-based characterization of morphology and aggregation in CNCs and CNFs*	Shankar, Karthik	University of Alberta		$50,000	$30,000	$80,000
Invited Proposal	ABI-16-006	*Industry co-funded*	15-Sep-2016	30-Jun-2017	*Strategic development of a sustainable supply chain for industrial biomass co-firing in Alberta*	Kennedy, Michael	Green Analytics Corp		$290,000	$116,000	$406,000
Invited Proposal	ABI-16-007	*Industry co-funded*	12-Sep-2016	30-Jun-2017	*Optimization of PHB biopolymer production and products*	Bardosh, William	Terra Verdae Bioworks Inc.		$250,000	$345,000	$595,000
Invited Proposal	ABI-16-008	*Research and Innovation*	15-Sep-2016	14-Sep-2018	*Scale up trials for highly efficient and rapid plant oil conversion technology*	Ullah, Aman	University of Alberta		$293,580	$194,700	$488,280

Invited Proposal	ABI-16-009	*Research and Innovation*	1-Oct-2016	30-Sep-2018	*Flame retardant polyols from oilseed crops*	Curtis, Jonathan	University of Alberta		$270,000	$162,000	$432,000
Invited Proposal	ABI-16-010	*Industry co-funded*	15-Aug-2016	31-Jul-2017	*Commercial bast fibre separation plant*	Tekle, Tamrat	Natural Fibre Technologies LTD		$230,000	$400,500	$630,500
Invited Proposal	ABI-16-011	*Industry co-funded*	1-Oct-2016	31-Dec-2017	*G4 Alberta RNG demonstration Project*	Ng, Edson	G4 Insights Inc		$180,000	$950,000	$1,130,000
Invited Proposal	ABI-17-001	*Industry co-funded*	1-Feb-2017	30-Jun-2019	*Biobattery – decentralized production of fuel from forest and agricultural waste*	Kumar, Amit	University of Alberta	$300,000		$2,227,000	$2,527,000
Invited Proposal	ABI-17-003	*Industry co-funded*	1-Jul-2017	31-Mar-2018	*Development of cellulose nanocrystals-based novel smart window*		ALL Weather Windows Ltd.	$100,000		$25,000	$125,000
Invited Proposal	BIO-16-005	*Industry co-funded*	1-Jan-2016	31-Dec-2018	*Development and characterization of nano-engineered cement-based composites for sustainable construction*	Bindiganavile, Vivek	University of Alberta		$150,000	$333,000	$483,000
Invited Proposal	BIO-16-007	*Research and Innovation*	15-May-2016	15-Oct-2018	*Development of biofuels research contribution fund for future research investment - SBI's 10 million litre renewable fuel demonstration initiative*	Singh, Inder	SBI Bioenergy Inc.		$300,000		$300,000
Opportunities	BFI-18-001	*Industry co-funded*	18-Jan-2018	31-Mar-2020	*CNC refinement, drying and blending for high-value applications*	Clarke, Geoff	Alberta Pacific Forest Industries Inc.		$520,000	$200,000	$720,000
Opportunities	BFI-18-002	*Industry co-funded*	1-Mar-2018	28-Feb-2020	*Scale up and production of natural personal care products*	Larsen, Erik	EC Labs	$25,201		$610,630	$635,831
Opportunities	BFI-18-003	*Industry co-funded*	28-Mar-2018	28-Feb-2019	*Process validation for anaerobic digestion of foul condensates at a kraft pulp mill*	Grantham, Brian	West Fraser Mills (Hinton)	$120,000		$140,000	$260,000

Appendix C – Communications Report

Communications activities for Alberta Bio Future during 2017-18 mainly centred around the organization and promotion of SPARK 2017, the clean tech conference co-hosted by the bioindustrial team of Alberta Innovates and Emissions Reduction Alberta (ERA) in November 2017. The conference was deemed a success by senior leadership of both AI and ERA, and received positive feedback from attendees and other stakeholders. (See p. 54 for details about SPARK 2017.)

Alberta Innovates also provided communications support for the multi-stakeholder Alberta delegation at World Congress (see p. 53 for World Congress details) before and during this international conference. AI oversaw the redevelopment of the BioEconomy Alberta website (http://www.bioeconomyalberta.com/), and provided communications support for the BioEconomy Alberta team for a portion of the year.

Other activities included the following promotions:

- Co-ordination of AI's participation in a media partnership with Clean Tech Canada for the production of a special report with a spotlight on Alberta's clean tech sector (https://www.canadianmanufacturing.com/operations/new-cleantech-report-puts-alberta-innovation-spotlight-203993/). This included a full-page ad promoting the bioindustrial sector and ABF on p. 12 of the Clean Tech publication.

- One of AI's tactics to raise international awareness was to commission an article about Alberta's bioindustrial strengths, its business climate and GOA support for the bioindustrial sector in a business magazine based in London, U.K., called The New Economy: https://www.theneweconomy.com/technology/alberta-marries-sustainability-with-a-positive-business-atmosphere .

- AI co-ordinated regular articles in issues of Logging and Sawmilling Journal through 2017-18 to raise awareness about AI's bioindustrial-related activities of interest to the forest sector. The magazine is found online at http://forestnet.com/. The AI articles are included in a regular section called "The Edge."

- In addition, communications support was provided for the website launch of four new ABF funding calls during 2017-18 (Opportunities, Biomaterials Pursuit, Lignin Challenge 1.0, CNC Challenge 3.0), plus the migration of all bioindustrial web content from the legacy AI Bio website to the current AI website: https://albertainnovates.ca/funding-alberta-bio-future/.

Media Coverage:

Spark 2017 clean tech conference

- Eleven stories in mainstream media, including CTV Edmonton and Calgary (CTV aired three distinct stories, one aired in Edmonton and Calgary), Calgary Herald, Edmonton Journal, Lethbridge Herald, High River Times, Western Producer.
- Two articles commissioned in the forestry trade magazine Logging and Sawmilling Journal.
- Eighteen online hits – trade websites, online distributions sites.

Biobattery

- One article commissioned in Logging and Sawmilling Journal.
- Three online hits – trade websites, online distributions sites.

BRIMS public launch

- Three stories in mainstream media, including Edmonton Journal, Western Producer, Red Deer Advocate.
- One online hit – trade website.

G4-ATCO renewable natural gas

- One article commissioned in Logging and Sawmilling Journal.
- Two online hits – trade websites.

ALBERTA INNOVATES

Appendix D – Financial Statements

Alberta Bio Future Program

SUMMARY OF FUNDING

As of March 31, 2018

ALBERTA INNOVATES

Alberta Bio Future Program

SUMMARY OF FINANCIAL CONTRIBUTIONS

As of March 31, 2018

ALBERTA INNOVATES

Alberta Bio Future Program (Grant 0715-2014-B03)
EDT Grant Proceeds
For the period ended March 31, 2018
as of 2018-05-22

Account	EDT Actuals 2014/15	EDT Actuals 2015/16	EDT Actuals 2016/17	EDT Actuals 2017/18	EDT Future Commitments 2018/19 Target	EDT Future Commitments 2019/20 Target	EDT Future Commitments 2020/21 Target	TOTAL EDT Funding
Revenues								
Balance as of April 1, 2014	$ 2,000,000							2,000,000
Carryover balance as of March 31 each fiscal		$ 4,580,021	$ 6,036,310	$ 3,471,166	$ 3,633,977	$ 1,589,290	$ 454,950	
Grant payments from IAE/EDT	2,625,000	2,625,000	1,775,000	2,625,000	850,000			10,500,000
Interest (Estimate for future years)	26,269	41,945	44,037	32,085	25,000	25,000	5,000	199,336
Misc Rev (Lignin Funds from West Fraser)					150,000			150,000
	$ 4,651,269	**$ 7,246,966**	**$ 7,855,347**	**$ 6,128,250**	**$ 4,658,977**	**$ 1,614,290**	**$ 459,950**	**$ 12,849,336**
Bio Future Program Expenditures								
Administration and Operations	$ 7,066	$ 22,040	$ 59,170	$ 48,653	$ 75,000	$ 75,000	$ 75,000	361,929
Industry Co-Funded Program		877,500	2,501,267	780,159	496,786	278,190	94,950	5,028,852
Research and Innovation Program		22,500	1,551,389	1,248,241	1,700,988	506,150	0	5,029,268
Networks and Knowledge Extension	64,182	288,616	272,356	417,220	315,000	300,000	290,000	1,947,374
Uncommitted funds as June 1/2018					481,913			481,913
Total AB Bio Future Expenditures	**$ 71,248**	**$ 1,210,656**	**$ 4,384,182**	**$ 2,494,273**	**$ 3,069,687**	**$ 1,159,340**	**$ 459,950**	**$ 12,849,336**
Net Revenue/(Expense)	**$ 4,580,021**	**$ 6,036,310**	**$ 3,471,166**	**$ 3,633,977**	**$ 1,589,290**	**$ 454,950**	**$ 0**	**$ 0**

Leveraged Project Funding from other Contributors (over life of active projects as of March 31, 2018 **$ 10,985,034**

Project Manager's Signature

Steve Price, Executive Director, BioIndustrial Innovation
(Name and Title)

09-Jun-18
Date

Organization's Financial Signing Authority

Joan Unger, Director of Operational Finance
(Name and Title)

09-Jun-18
Date

ALBERTA INNOVATES

Alberta Bio Future Program (Grant 0715-2014-B03)
AI (Bio sector) and Other Revenue
For the period ended March 31, 2018
as of 2018-05-22

Account	AI (Bio) Actuals 2014/15	AI (Bio) Actuals 2015/16	AI (Bio) Actuals 2016/17	AI (Bio) Actuals 2017/18	AI-Bio Future Commitments 2018/19 Target	AI-Bio Future Commitments 2019/20 Target	AI-Bio Future Commitments 2020/21 Target	TOTAL AI-Bio Funding
Revenues								
Alberta Innovates Core Budget	$ 4,886,099	$ 2,389,759	$ 3,684,955	$ 2,599,572	$ 2,332,667	$ 2,028,666	$ 1,907,500	$ 19,829,218
Misc Rev (World Congress - Lignin ESR and West Fraser)	1,027,827	1,522,195	179,848	550,000	75,000	175,000	200,000	$ 3,729,870
	$ 5,913,926	$ 3,911,954	$ 3,864,803	$ 3,149,572	$ 2,407,667	$ 2,203,666	$ 2,107,500	$ 23,559,088
Bio Future Program Expenditures								
Administration and Operations	$ 765,892	$ 859,654	$ 796,760	$ 684,690	$ 860,000	$ 860,000	$ 860,000	$ 5,686,996
Advanced Materials and Chemicals Program	$ 231,143	$ 1,500,000	$ 179,070	$ 300,000				$ 2,210,213
Industry Co-Funded Program	2,147,826	687,500	1,265,000	1,694,701	406,000	212,000	202,500	$ 6,615,527
Research and Innovation Program	1,112,068	852,300	1,578,765	436,807	516,667	106,666	20,000	$ 4,623,273
Networks and Knowledge Extension	1,656,997	12,500	45,208	33,374	25,000	25,000	25,000	$ 1,823,079
Alberta Innovates Future Projections					600,000	1,000,000	1,000,000	$ 2,600,000
Total Alberta Innovates Expenditures	**$ 5,913,926**	**$ 3,911,954**	**$ 3,864,803**	**$ 3,149,572**	**$ 2,407,667**	**$ 2,203,666**	**$ 2,107,500**	**$ 23,559,088**
Net Revenue/(Expense)	**$ -**	**$ -**	**$ 0**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 0**

Leveraged Project Funding from other Contributors (over life of active projects as of March 31, 2018) **$ 43,752,294**

Project Manager's Signature

Steve Price, Executive Director, BioIndustrial Innovation
(Name and Title)

09-Jun-18
Date

Organization's Financial Signing Authority

Joan Unger, Director of Operational Finance
(Name and Title)

09-Jun-18
Date

NOTE 1: Misc. Rev. (World congress, Lignin ESR, and West Fraser) – includes contributions from other organizations for the Bioeconomy AB Team mission to Bio World Congress, $1.0M from then Ministry of ESRD for the West Fraser Lignin Recovery Plant project. Amounts in 2018/19 and 2019/20 are the repayable grant proceeds from West Fraser, to be placed in the Lignin research fund, as per the agreement with West Fraser as well as a contribution from Al Pac for CNC Challenge 3.0.

NOTE 2: Alberta Bio Future Program Expenditures, Advanced Materials and Chemicals Program, shows projects that have followed through to ABF, and the expenditures are project payments and administration costs.

NOTE 3: The Financial Statements reflect all financial disbursements and future year commitments over the life of Alberta Bio Future program and will not align with annual reporting of project costs shown within this document. The Financial Statements include administration and other related costs to the program and not included in project costs reported earlier in the document.

ALBERTA INNOVATES

Writing support provided by Corporate Communications and Planning

Graphic design support provided by id8 design group