

# R&D Activities & Initiatives for Biorefinery Development in Canada



IEA Bioenergy

Task 42 Biorefining

IEA Task 42 – Progress Meeting – April 19 and 20<sup>th</sup>, 2016

Eric Soucy

Natural Resources Canada - CanmetENERGY



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# Recent Canadian Biorefinery Initiatives

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RECOGNIZING THE FOREST FIBRE'S VALUE



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FROM INCREASING FIBRE YIELD TO MAXIMISING ENERGY EFFICIENCY, WE FOCUS ON MAKING THE BEST SOLUTIONS POSSIBLE.



**KADANT**



# Recent Canadian Biorefinery Initiatives (cont'd)

## Schlumberger invests in CelluForce



March 26, 2015

Written by CNW/Domtar Corporation



March 26, 2015 - Domtar Corporation recently announced an investment by Schlumberger in CelluForce, a joint venture between Domtar and FPInnovations that manufactures wood-derived nanocrystalline cellulose (NCC).

The investment is a collaboration to explore the use of NCC to enhance the productivity of oil and gas wells.

Schlumberger is the world's leading supplier of technology, integrated project management and information solutions to the oil and gas industry.

NCC is manufactured using a patented process in Domtar's pulp mill in Windsor, Que. NCC (also referred to as Cellulose Nanocrystals, or CNC) is the primary component that provides structural strength to trees. NCC is a renewable, biodegradable, nontoxic material.

Details of Schlumberger's investment in CelluForce remain confidential.

This investment follows a \$4-million grant announced by CelluForce in February 2015 from the government of Canada's sustainable development technology program (Sustainable Development Technology Canada, or SDTC) for similar research and development work.

"Innovation is one of our core values at Domtar, so we are pleased to have the opportunity to collaborate with Schlumberger, a recognized technology innovator in hydrocarbon recovery and production," said Patrick Loulou, Domtar's senior vice-president for corporate development and a member of CelluForce's board of directors.

"The Schlumberger investment, coupled with the recent grant from SDTC, creates positive momentum in realizing the benefits of using NCC to improve the efficiency of oil and gas production," said Richard Berry, chief technology officer at CelluForce.

## Mitsui & Co. invests additional \$25M in BioAmber



February 11, 2016

Written by Andrew Snook



BioAmber's bio-based succinic acid plant in Sarnia, Ont.

Photo by Andrew Macklin

Mitsui will also have an increased role in the commercialization of the bio-succinic acid produced at the Sarnia plant and will provide dedicated resources to work alongside BioAmber's commercial team.

February 11, 2016 - BioAmber Inc. has received an additional \$25-million investment from Mitsui & Co. Ltd., its partner in its bio-based succinic acid plant in Sarnia, Ont.

The additional \$25 million investment is in exchange for an additional 10 per cent of the equity in the joint venture project, increasing Mitsui's stake from 30 per cent to 40 per cent, according to a recent press release from BioAmber.

"Mitsui's increased commitment to the Sarnia plant is a strong endorsement of its value and potential," said Jean-Francois Huc, CEO of BioAmber. "We have in Mitsui, a financially robust, global partner that is



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# Recent Canadian Biorefinery Initiatives (cont'd)

## West Fraser begins lignin production

April 06, 2016

Written by Andrew Macklin



April 6, 2016 – West Fraser has begun lignin production at its pulp mill in Hinton, Alberta.

The state-of-the-art facility, which recovers lignin from the pulping operation using a novel technology, and transform this wood byproduct into useful, environmentally friendly bioproduct, began production in March.

"Innovation can open new markets and commercial opportunities for our forest industry, which plays a crucial role in further diversifying our economy and strengthening our rural communities and the province as a whole," said Oneil Carrier, Alberta Minister of Agriculture and Forestry.

West Fraser will develop the use of lignin as a natural adhesive in its engineered wood products – as a renewable substitute for certain synthetic resin components currently derived from fossil fuels. Examples of other potential applications include green chemicals (bio alternatives to petroleum-based chemicals), thermoplastic composites (advanced mouldable materials), and packaging.

The startup of a lignin recovery plant is a major innovation in the forest industry and represents a significant milestone in the growth of the Alberta bioeconomy, said Steve Price, CEO of Alberta Innovates Bio Solutions.

## New Sarnia sugar plant promises new jobs, future growth

March 01, 2016

Written by Taylor Fredericks



Photos courtesy of Murray McLaughlin

March 1, 2016 - There are exciting times ahead for farmers in the Sarnia, Ont. area following the announcement of a new biomass plant that will convert agricultural byproducts into sugars used in the production of environmentally-friendly chemicals and plastics.

Comet Biorefining, a London-based provider of cellulosic glucose biofuel technology, has agreed to build the plant at Transalta's Bluewater Energy Park, adding to an already-robust cluster of bio-industrial projects in the area. Set to open in 2018, the plant is expected to produce 27 million kilograms of dextrose sugar syrup annually using corn stover and straw from local farms, which should prove a huge boon to the local economy, both for farmers and jobseekers.



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# Recent Canadian Biorefinery Initiatives (cont'd)

## FPInnovations, Kruger dedicate cellulosic filament plant

June 17, 2014



June 17, 2014, Trois-Rivières, Que. - FPInnovations and Kruger Inc. today dedicated the world's first cellulose filament (CF) demonstration plant at Kruger's Trois-Rivières Mill.

The five ton/day plant will provide enough CF tonnage to permit commercialization and application development. CF is a new material extracted from wood pulp fibres that is revolutionary because of its unique properties. CF has major potential for Canada's forest sector because of its wide range of applications from existing paper products to new products. The nature of CF allows it to be combined with many materials to develop a wide range of high-value products currently sought after by many Canadian and international industry sectors and is expected to contribute significantly to the Forest Products Association of Canada (FPAC)'s Vision 2020 ambitious economic objectives.

"This demonstration plant is a great example of how collaboration and strategic investment in research and development can lead to the development of innovative new products that will transform the pulp and paper industry while supporting traditional markets," said FPInnovations' president and CEO Pierre Lapointe. "The inauguration of this facility places Canada in the pole position of global competition to develop the next generation of cellulose-based materials."

## Edmonton biorefinery to create renewable transportation fuels



March 10, 2016

Written by Alberta Innovates - Bio Solutions



March 10, 2016 - An Edmonton company is reaching the final stage of its project to build a biorefinery that will convert non-food canola oil and waste fats into next-generation, renewable transportation fuels that can replace or blend with conventional fuels.

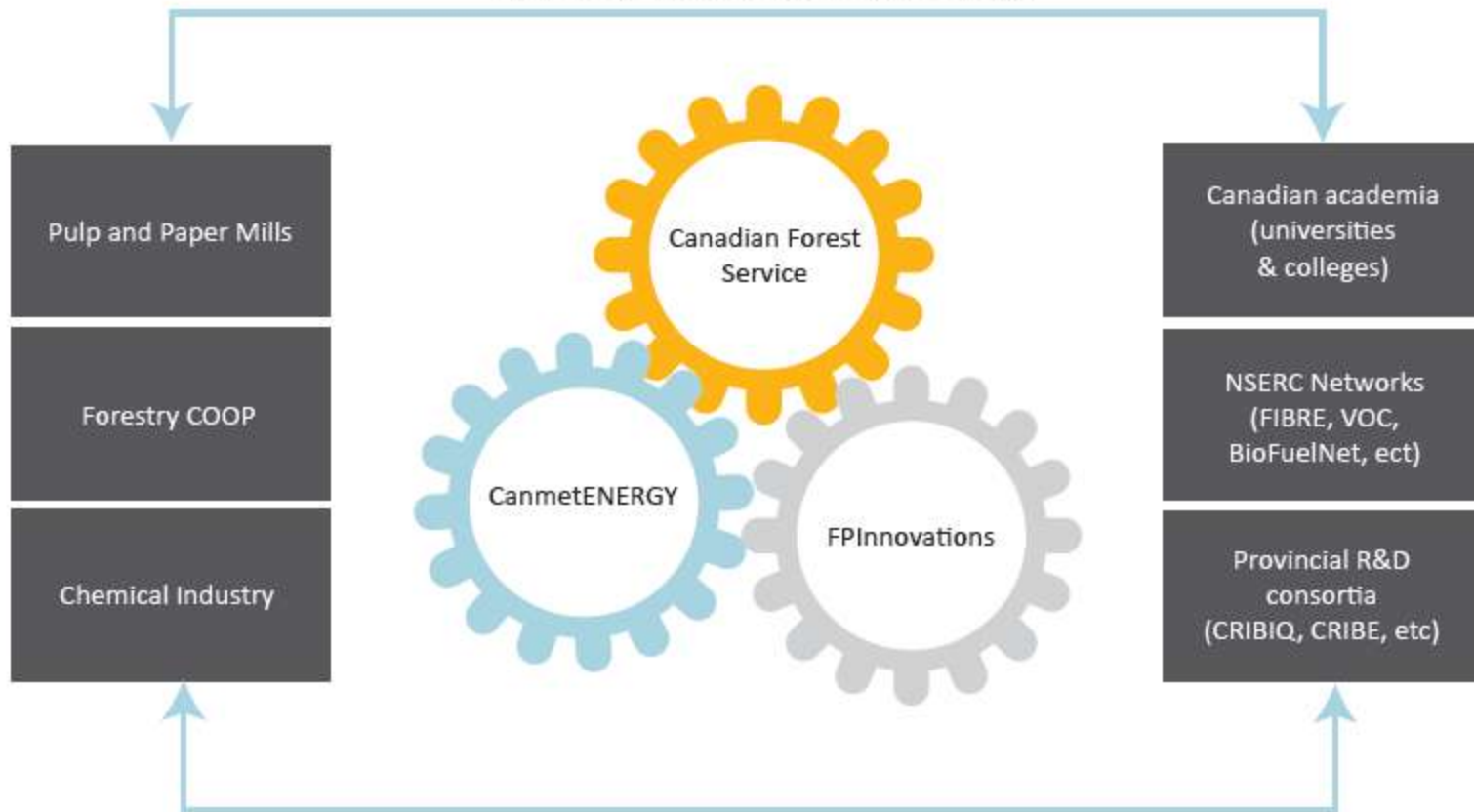
The company, [SBI BioEnergy \(SBI\)](#), has been working on scaling up its novel "catalytic" processing technology for the past three years, thanks to \$1.4 million in funding from [Alberta Innovates Bio Solutions \(AI Bio\)](#). The process creates no emissions, generates no waste and costs less than other alternative fuel technologies.

In just a few weeks, SBI expects to move into its newly built facility in the Edmonton Research Park, which will house a demonstration refinery capable of producing up to 10 million litres of renewable fuel per year. Commissioning the plant will take several months, but SBI hopes to start producing by year's end. The company's next goal will be to build a full-scale commercial biorefinery that will produce up to 240 million litres/year by 2018.



# R&D Biorefinery Hub Creation

Coordination across a wider range of biorefinery-based R&D and innovation in Canada



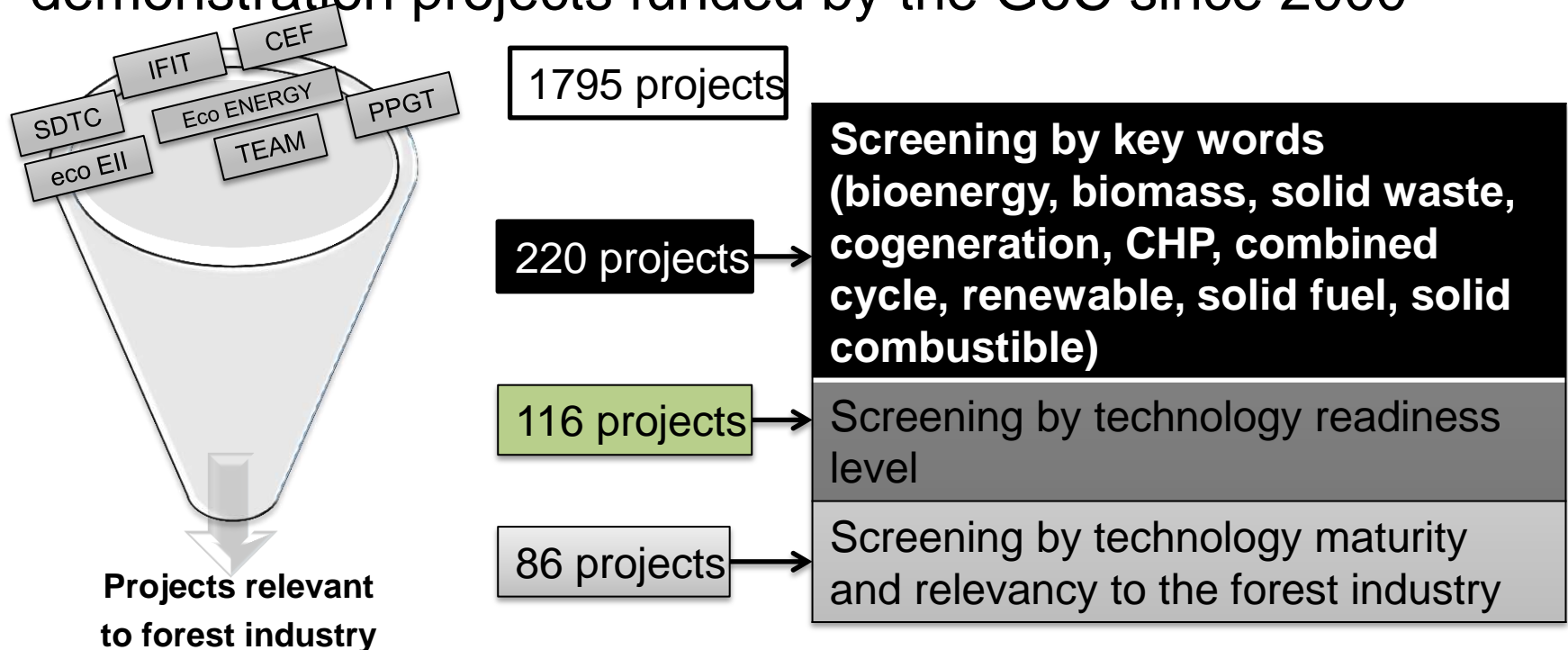
# **Assessment of Integrated Bioenergy Systems in the Canadian Forest Industry**

## **Lessons Learned, Barriers, Cost-Benefits, Standards and Practical Guidelines**



# Approach for Data Collection and Analysis

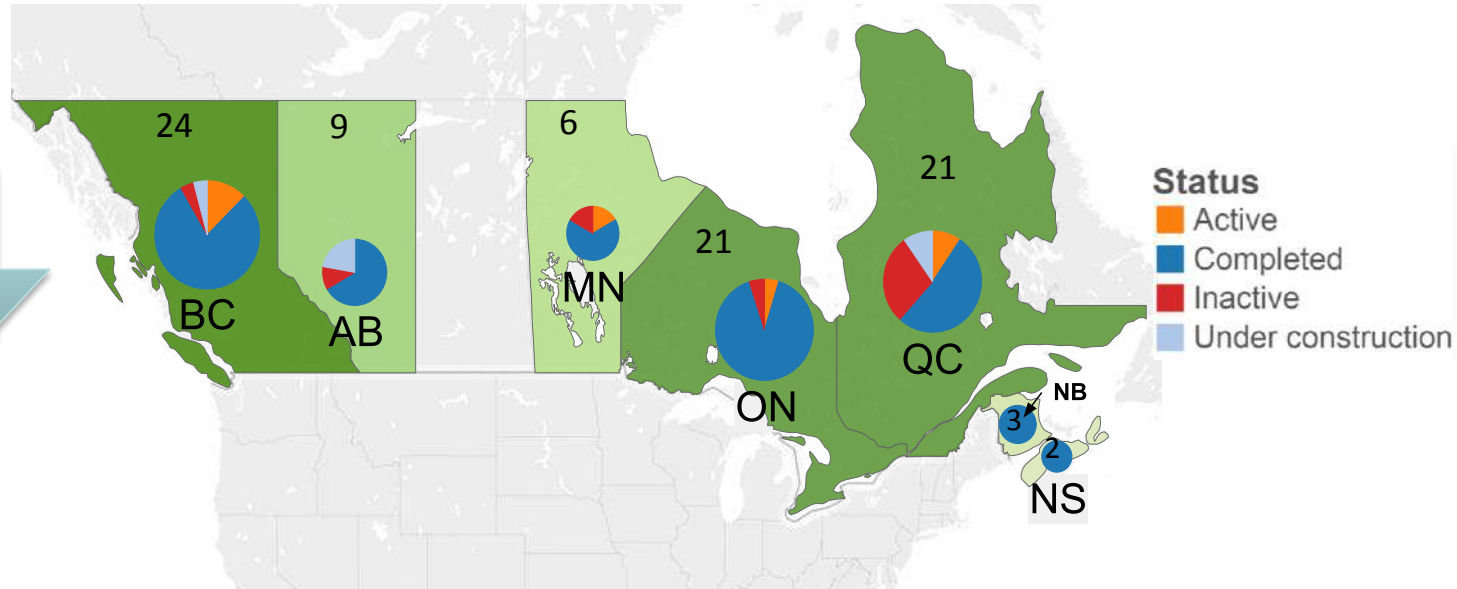
- Built an Excel-based database that considers all demonstration projects funded by the GoC since 2000



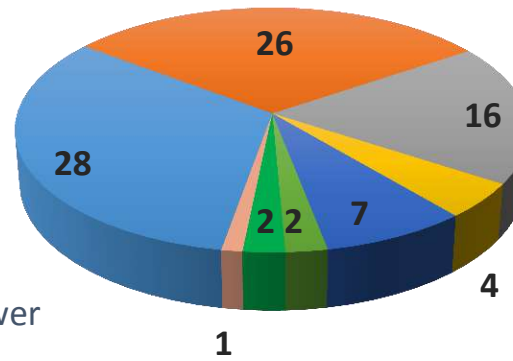
- Normalized the project classification approach
  - ❖ Status of the project: completed, under construction, active or inactive
  - ❖ Maturity level using TRL scale
  - ❖ Conversion pathway: from feedstock to product(s) towards a series of unit operations platforms and technologies

# Location and Number of Projects per Canadian Province

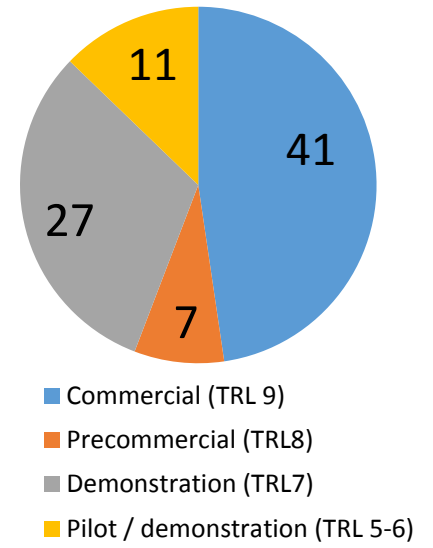
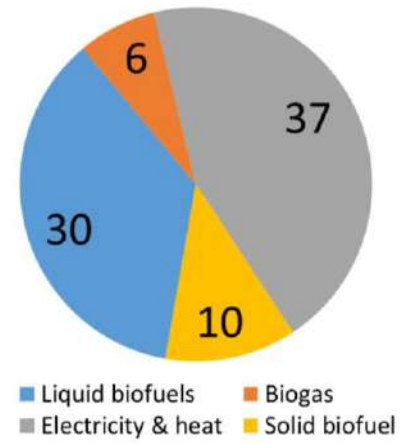
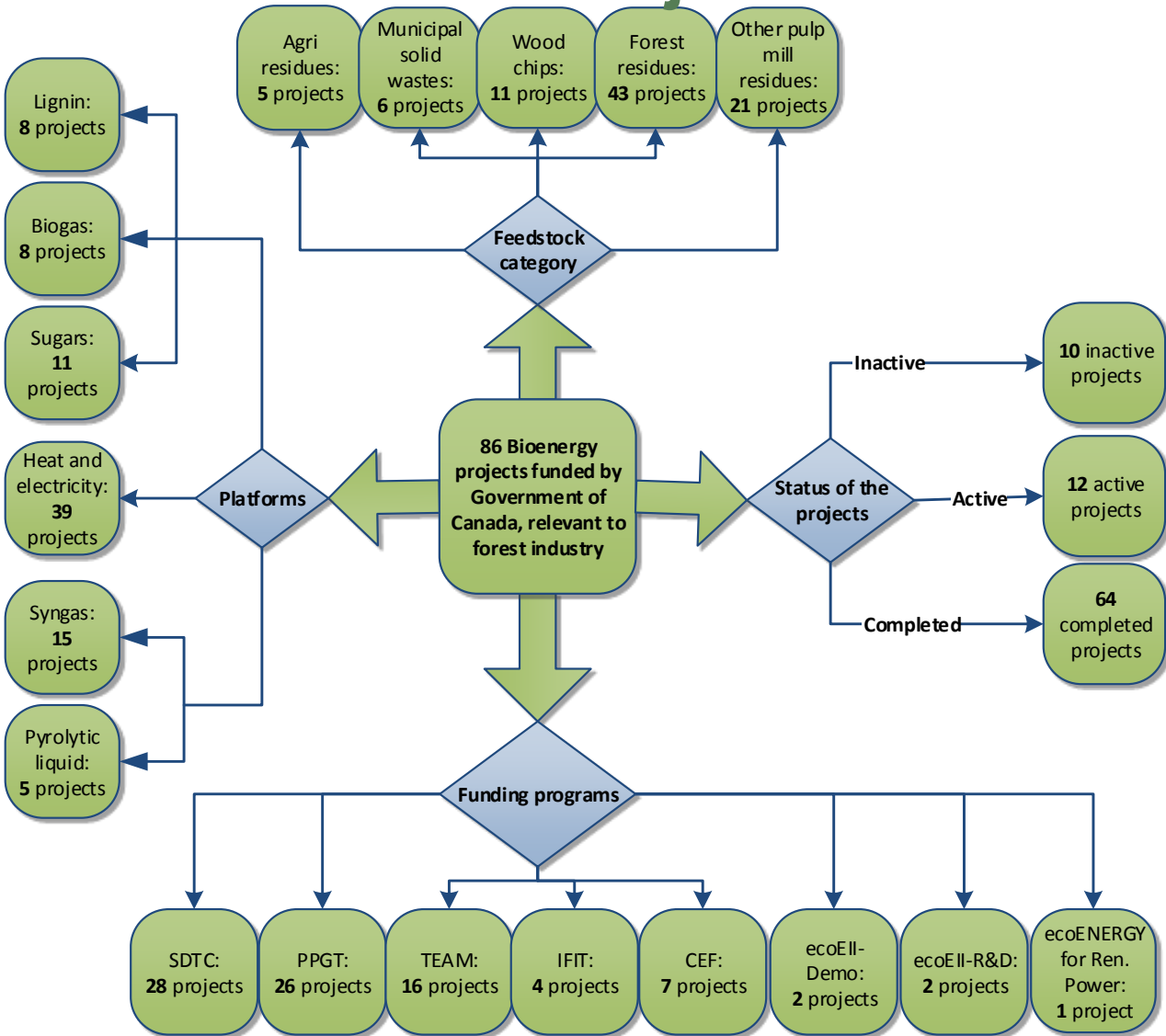
86 demonstration projects producing bioenergy and bioproducts



- SDTC
- PPGT
- TEAM
- IFIT
- CEF
- ecoEII- Demo
- ecoEII- R&D
- ecoENERGY for Ren. Power



# Brief Description of the 86 Bioenergy Demonstration Projects Relevant to Forest Industry



# Wrap-up

Funding Programs	Nb. of Projects	Total Value of Projects (\$M)	GoC funding (\$M)	Private Leverage (\$M)	Avoided GHG (kilo tonnes of CO <sub>2</sub> -eq/year)	Bioenergy Production Capacity (TJ/year)
CEF	7	47.3	17.3	29.0	17.2	762
ecoEII - Demo	2	17.8	6.2	11.6	8.0	30
ecoEII - R&D	2	6.2	2.2	4.0	N.A.	N.A.
ecoENERGY for Renewable Power	1	46.5	32.5	14.0	371.0	1,467
IFIT	4	96.8	28,9	62.0	10.5	108
PPGT	26	736.2	509.8	226.4	729.5	7,792
SDTC	28	606.3	171.4	434.9	251.0	3,677
TEAM	16	149.2	33.6	117.4	131.5	1,091
<b>Total</b>	<b>86</b>	<b>1,706.3</b>	<b>801.9</b>	<b>899.3</b>	<b>1,518.7</b>	<b>14,929</b>



# The I-BIOREF Software



## Key Features

- **I-BIOREF** supports decision-makers in selecting viable biorefinery solutions
- **I-BIOREF** evaluates the benefits of integrating commercially available biorefinery processes
- **I-BIOREF** provides several criteria to assess the biorefinery project from different perspectives
- **I-BIOREF** performs sensitivity analysis to evaluate the impacts on resources utilization

## Metrics

- **6 economic metrics (PBP, IRR, NPV, ROCE, ROI, EBIDTA)**
- **2 competitiveness metrics (CAB, RTMU)**
  - Competitive access to biomass
  - Resistance to market uncertainties
- **17 LCA-based metrics**
  - Mid-point impact category (carcinogens, respiratory inorganics, land occupation, etc.)
  - Damage category (climate change, human health, ecosystem quality, etc.)

## Process and Technology Models

- **Pulp and paper processes:** Kraft and TMP
- **Biomass pretreatment processes:**
  - Steam explosion; Liquid hot water; Acid hydrolysis; Alkaline hydrolysis; Instant controlled pressure; Organosolv; Torrefaction
- **Pre-extraction processes**
  - Near-supercritical fluids (e. g. H<sub>2</sub>O-CO<sub>2</sub>); Hot water; Enzymatic
- **Lignin recovery processes:** LignoBoost™, LignoForce™, SLRP™
- **Sugar streams conversion processes:**
  - Detoxification; Fermentation; Separation / Purification
- **Thermochemical processes:**
  - Gasification; Pyrolysis; Catalysis

# Case study: Integration of a Biorefinery Technology in a Canadian Softwood Kraft Pulp Mill



Integrated Biorefinery

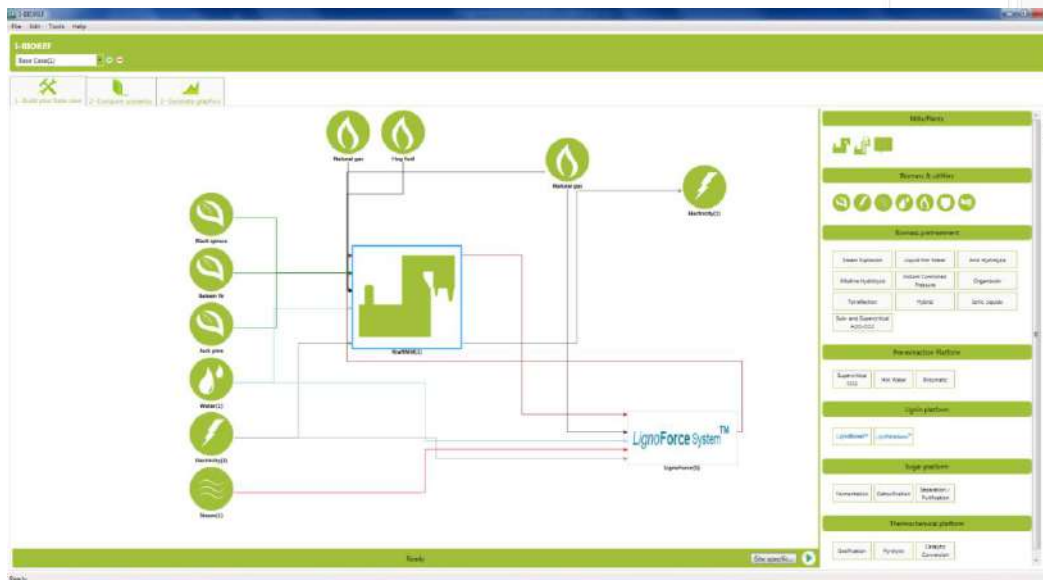
Process data Economic data Impacts Economics/Environmental Footprint

Base Case(1) Scenario(1) Scenario(2)

Operating cost

THE INTEGRATED BIOREFINERY

Total operating cost	\$/yr	974,978	11,370,368	13,447,670
Biomass cost	\$/yr	0	7,748,837	7,748,837
<b>Chemicals</b>				
Total chemical reactants operating costs	\$/yr	0	748,418	1,245,253
Carbon dioxide	\$/yr	0	299,700	899,100
Sulfuric acid	\$/yr	0	99,900	299,700
Sodium Hydroxide	\$/yr	0	319,680	399,040
<b>Utilities</b>				
Total utility cost	\$/yr	576,024	1,511,184	1,880,893
Water	\$/yr	0	652,846	656,941
Steam	\$/yr	576,692	561,377	677,817
Effluents treatment	\$/yr	0	90,903	92,258
Electricity	\$/yr	0	142,350	162,550
Fuel	\$/yr	-3,001,418	-2,937,709	-2,810,292
<b>Miscellaneous costs</b>				
Total miscellaneous costs	\$/yr	300,720	328,259	350,371
Labour	\$/yr	0	279,720	279,720
Maintenance	\$/yr	0	18,529	40,011
Technical support	\$/yr	0	30,000	30,000
Other Costs	\$/yr	0	0	0
<b>Implementation technology risk</b>				
	\$/yr	98,634	1,033,670	1,232,513
<b>MILL</b>				
Total incremental operating cost	\$/yr	634,361	10,046,910	10,174,944
Incremental Biomass cost	\$/yr	0	7,748,837	7,748,837
Total incremental utility cost	\$/yr	576,692	1,384,717	1,501,157





# Thank you for your time and attention!

**For further information, please contact:**

Eric Soucy, Director

Industry Program, CanmetENERGY – Varennes

Tel.: (450) 652-4299 | Email: [eric.soucy@canada.ca](mailto:eric.soucy@canada.ca)

Website: <http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca>



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