

# Country Report Canada 2015



Forest Biorefinery  
ALPAC, Alberta



Municipal Solid Waste  
MSW Biorefinery  
ENERKEM, Alberta

Bio Succinic Acid Production  
BioAmber, Ontario



Maria Wellisch, Agriculture and Agri-Food Canada

- Energy production and consumption
  - Renewable energy production
  - Bioenergy capacity and production
- Biomass Flows for energy & non-energy applications
  - Forest Products
  - Agriculture and Agri-Food
- Bioeconomy related policies
- Sustainability: economic, social & environmental
- Biorefineries
  - Running commercial biorefineries
  - Biorefinery demonstration and pilot plants
- Major R&D networks
- National stakeholders involved in the field of biorefining

# 2013 Energy Production and Consumption

## Primary Energy Production: 17,335 PJ

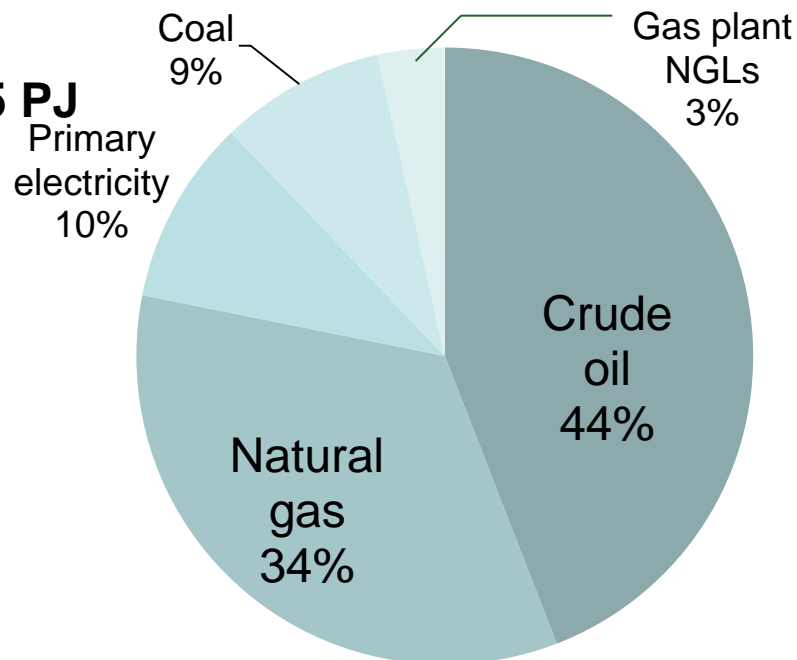
- Crude oil production
- Natural gas
- Primary electricity
- Coal
- Gas plant NGLs

## Energy Consumption: 8,289 PJ

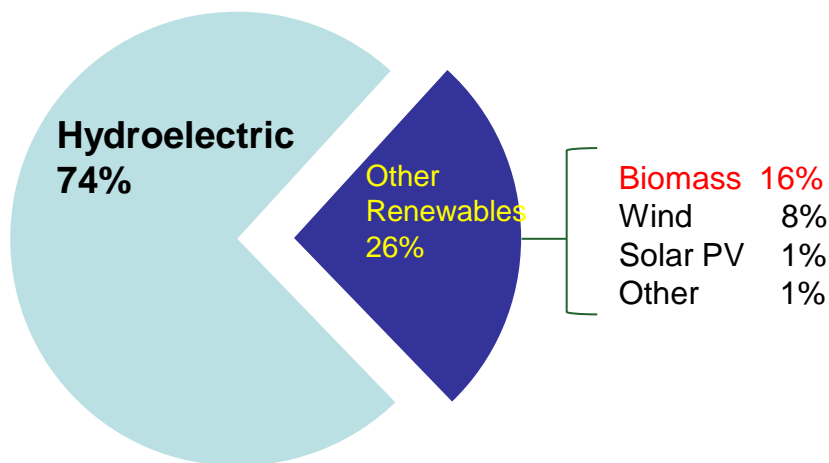
## Net energy exporter

Exported energy and energy products: 11,623 PJ

- 59% of primary energy production was exported in 2013, mostly to the US



# Total Renewable Energy Capacity ( >100 GW) in 2014



Total Renewable Capacity: **102 GW**

Renewable Resource	Annual Generation (GWh)	Average Capacity Utilization
Hydroelectric	377,755	57%
Wind	20,436	30%
Biomass (incl biofuels)	76,060	44% therm – 75% ele
Biogas	1,436	44% therm – 75% ele
Solar Photovoltaic	928	11%
Other	1,507	
* Municipal Solid Waste		56%
* Tidal		17%
<b>Total</b>	<b>&gt; 478,000</b>	

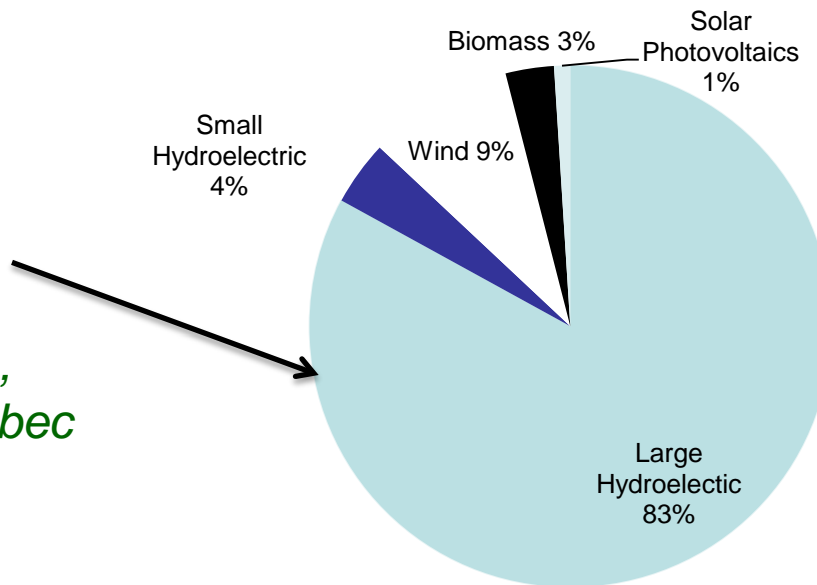
*16% of primary energy production*

Source: CIEEDAC (2015).  
Renewable Energy in Canada (2014)

# Renewable Capacity - electricity and heat 2014

## Renewable Electricity

- Total Capacity: 87 GW
- Dominated by large hydroelectric (75 GW)
  - *Provinces: British Columbia, Manitoba, Newfoundland, Québec*



## Renewable Heat

- Total Capacity: 13 GW
- Wood biomass provides 94% of thermal capacity (12.3 GW)
- Remainder: 124 MW is thermal energy from biogas; 670 MW is from a variety of sources, including solar thermal and earth energy.

# Bioenergy: solid biomass, biogas and biofuels - 2014

Province – Territory	Biomass Energy Capacity (MW)	Biogas Energy Capacity (MW)
British Columbia	6,028	127
Alberta	1,946	7.8
Saskatchewan	533	0.2
Manitoba	414	0.2
Ontario	3,174	84
Quebec	2,169	51
New Brunswick	801	1.3
Nova Scotia	303	3.7
Prince Edward Island	17	0
Newfoundland and Labrador	138	0
Nunavut	0	0
Northwest Territories	14	0
Yukon	2	0

*Dominated by woody biomass (forest products industry)*

*Dominated by biogas from municipal landfills and waste water treatment plants*

### Biofuel Production & Consumption

#### Ethanol (2014):

- Production: 1.72 B litres
- Consumption: 2.9 B litres

#### Biodiesel (2014):

- Production: 340 ML FAME
- Consumption: 398 ML FAME  
185 ML HVO

Source: CIEEDAC (2015).  
Renewable Energy in Canada (2014)



## Biofuels – Domestic Production Capacity 2014



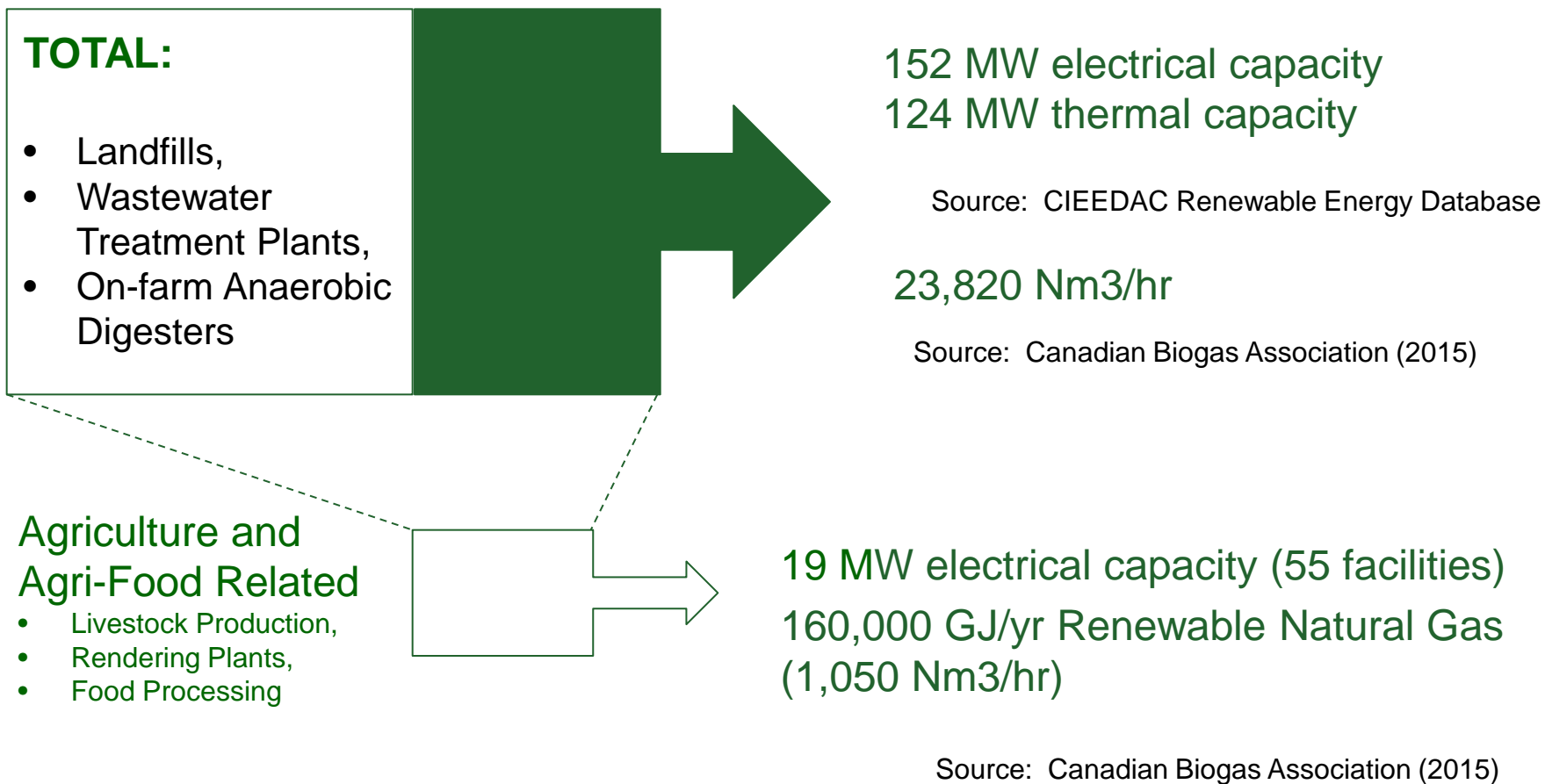
23 Facilities  
(commercial  
operating)

14 Ethanol  
9 Biodiesel

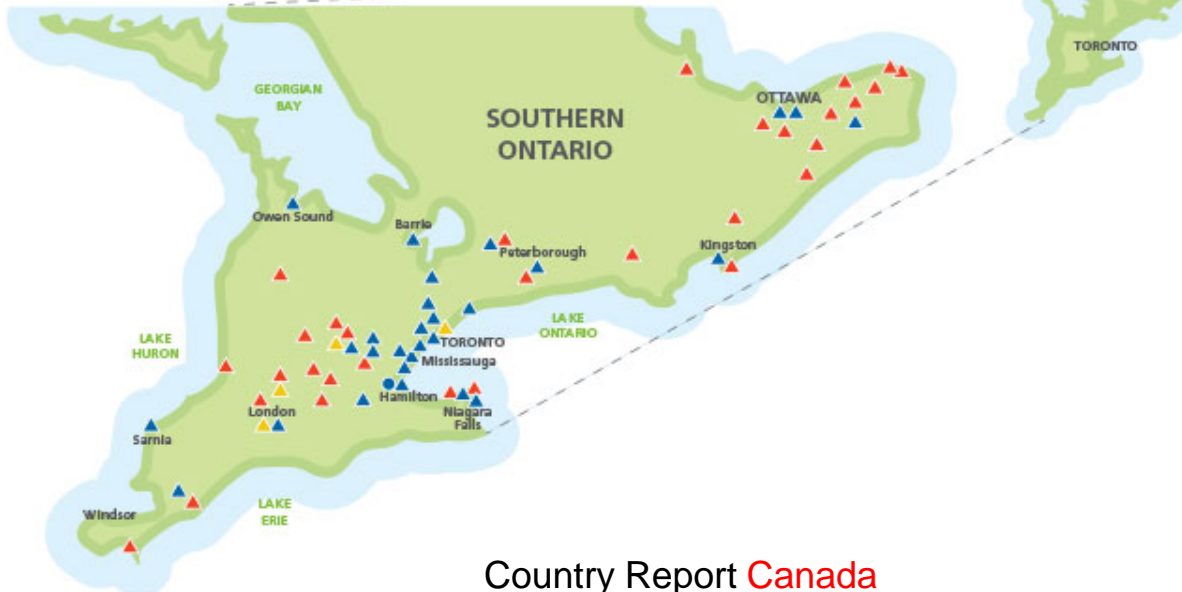
Capacity  
1.8 BL ethanol  
725 ML  
biodiesel  
(FAME)

+  
Distillers  
grains,  
Glycerol, Corn  
distillate,  
CO<sub>2</sub>, etc.

# Biogas Energy Capacity - Power, Heat & RNG (2014)







**LEGEND**

- ▬ Agricultural Biogas
- ▬ Municipal Biogas
- ▬ Commercial Biogas

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- ▲ Electricity
- Renewable Natural Gas



# **Biomass Flows for Non-Energy and Energy Applications and Export**

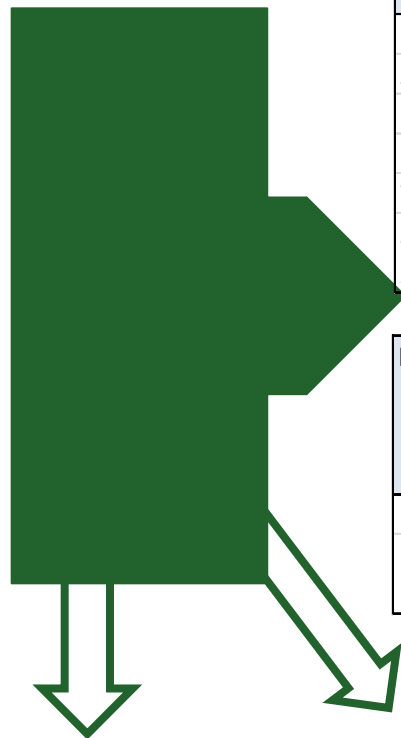
- **Forest Biomass**
- **Agricultural Biomass**

# Biomass use for materials and energy: Forest Products

Forest Biomass -  
Wood production  
forest

Harvest (2013):  
152 million m<sup>3</sup> from  
0.74 million hectares

Source: NRCan CFS



Production in 2014 (NRCan CFS)	
Hardwood lumber (cubic metres)	1,459,500
Softwood lumber (cubic metres)	58,158,300
Newsprint (tonnes)	4,014,000
Printing and writing paper (tonnes)	3,268,000
Wood pulp (tonnes)	16,962,000
Structural panels (plywood and oriented strandboard) (cubic metres)	7,687,126



Export  
+  
Domestic  
Use

NAICS	Industry Sector	Bioenergy Consumption in 2013 (TJ)		
		Hogfuel	Spent Pulping Liquor	Wood waste
		18 GJ/tonne	14 GJ/tonne	18 GJ/tonne
322	Paper Manufacturing	106,936	219,867	
321	Wood Product Manufacturing			87,932

Wood Pellet production  
(2013): 2,453 kt



Exports (86%)

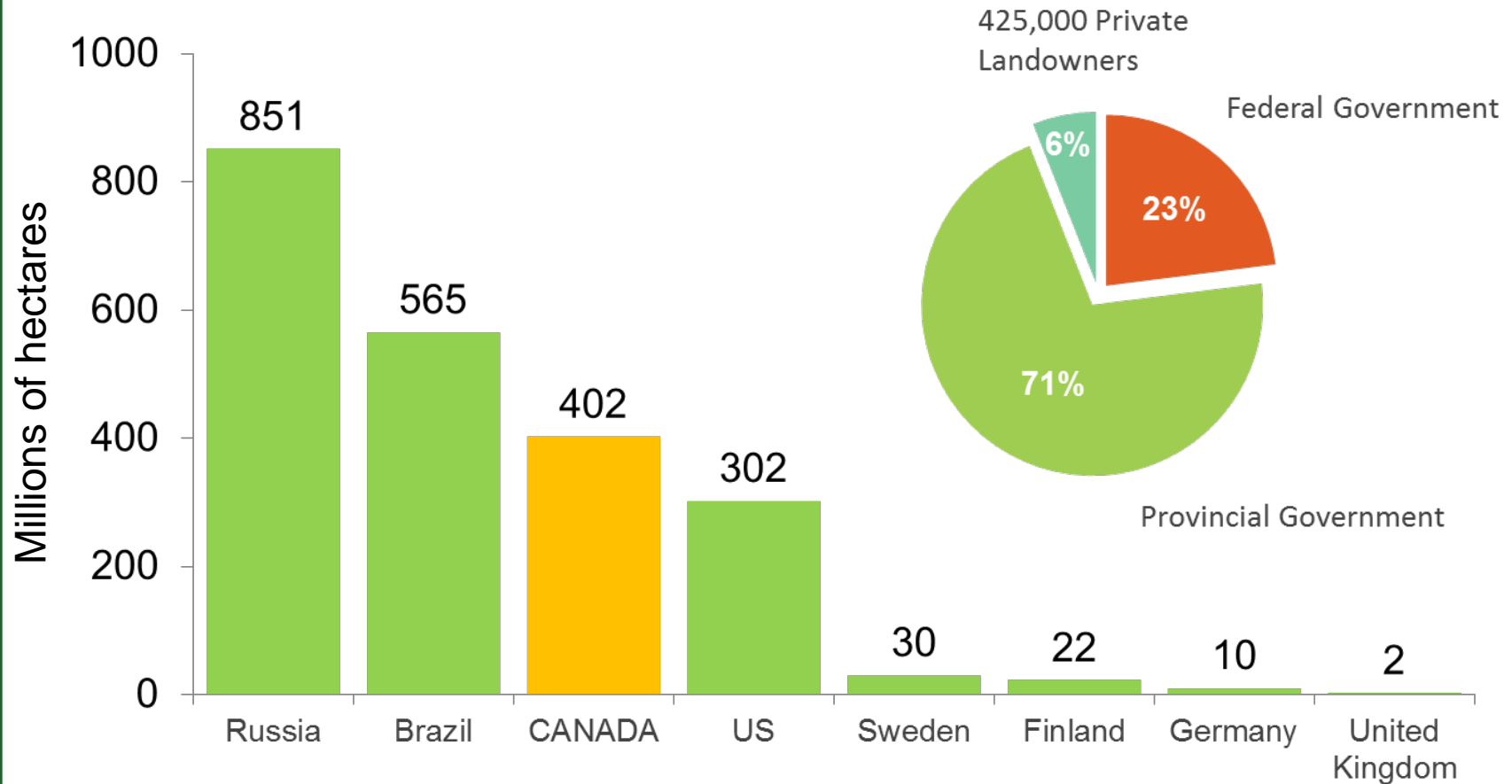


Domestic  
(Community heating, etc.)

Independent Heat & Power  
Production Capacity (2013):

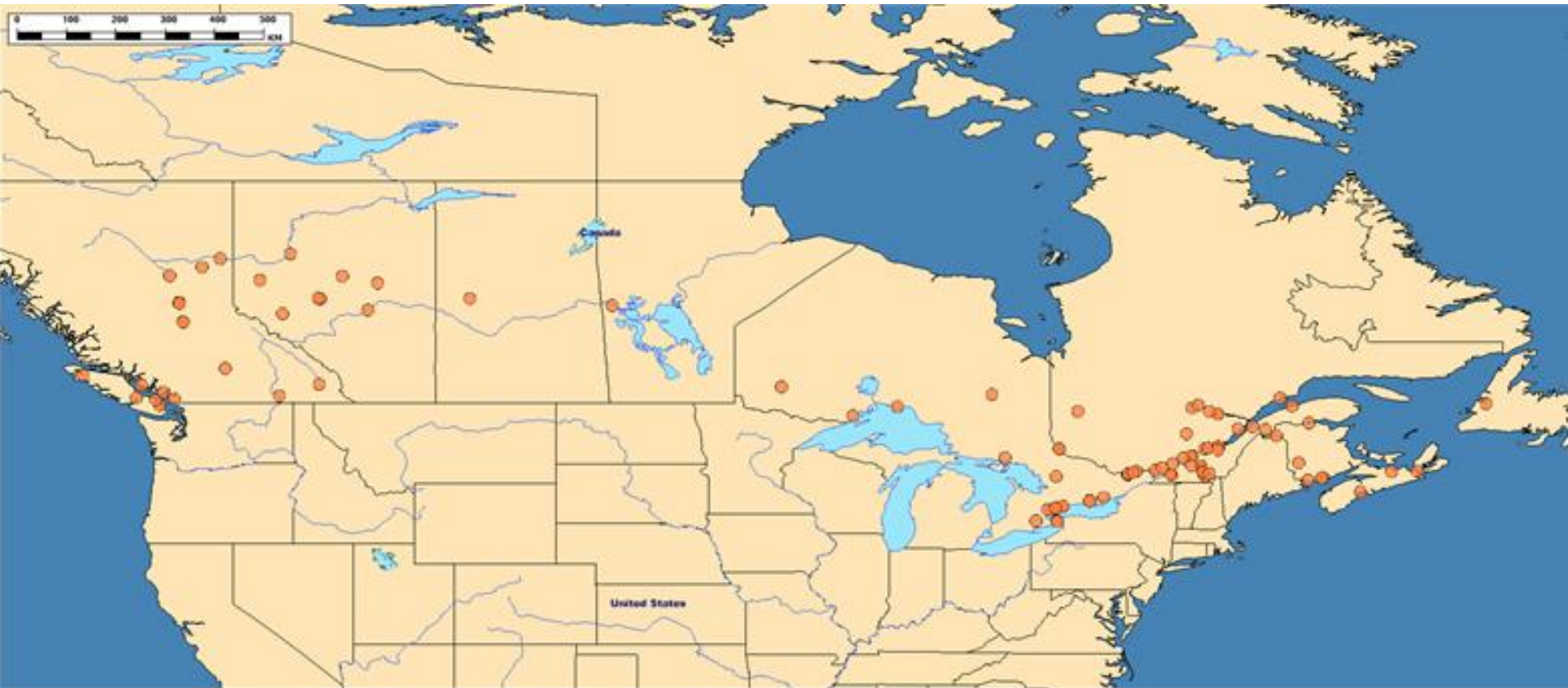
- electric capacity (540 MW)
- thermal capacity (148 MW) – 4 cogen IPPs

# Canada's Forest Land



Source: Forest Products Association of Canada (FPAC)

# Canada's 97 Pulp & Paper Mills



Source: Forest Products Association of Canada (2015)





- Implemented
- In Progress
- Not Yet Implemented

## MANUFACTURING PROCESS



## MANUFACTURED GOODS



## NEW MARKET APPLICATIONS



# Biomass use for food, feed & bioproducts: Agriculture

Agricultural  
Crop  
Production

28.8 M ha  
harvested for  
grain (in 2013)

6.1 M ha  
seeded for hay  
(in 2013)

GRAIN

STRAW

(wheat,  
barley, flax,  
oats, corn  
stover)

TOTAL (Grain) – 96.9 M tonnes (2013)

Crop	Production (kt)
Wheat	37,530
Coarse Grains (barley, corn, oats, rye, mixed grains)	28,715
Oilseeds (canola, soybeans, flaxseed)	24,049
Special Crops (canary seed, chick peas, dry peas, lentils, mustard seed, sunflower seed)	6,649



Export  
+  
Domestic  
Use

Domestic Production (straw) – 37.4 M  
oven dry tonnes (avg 1985-2010)

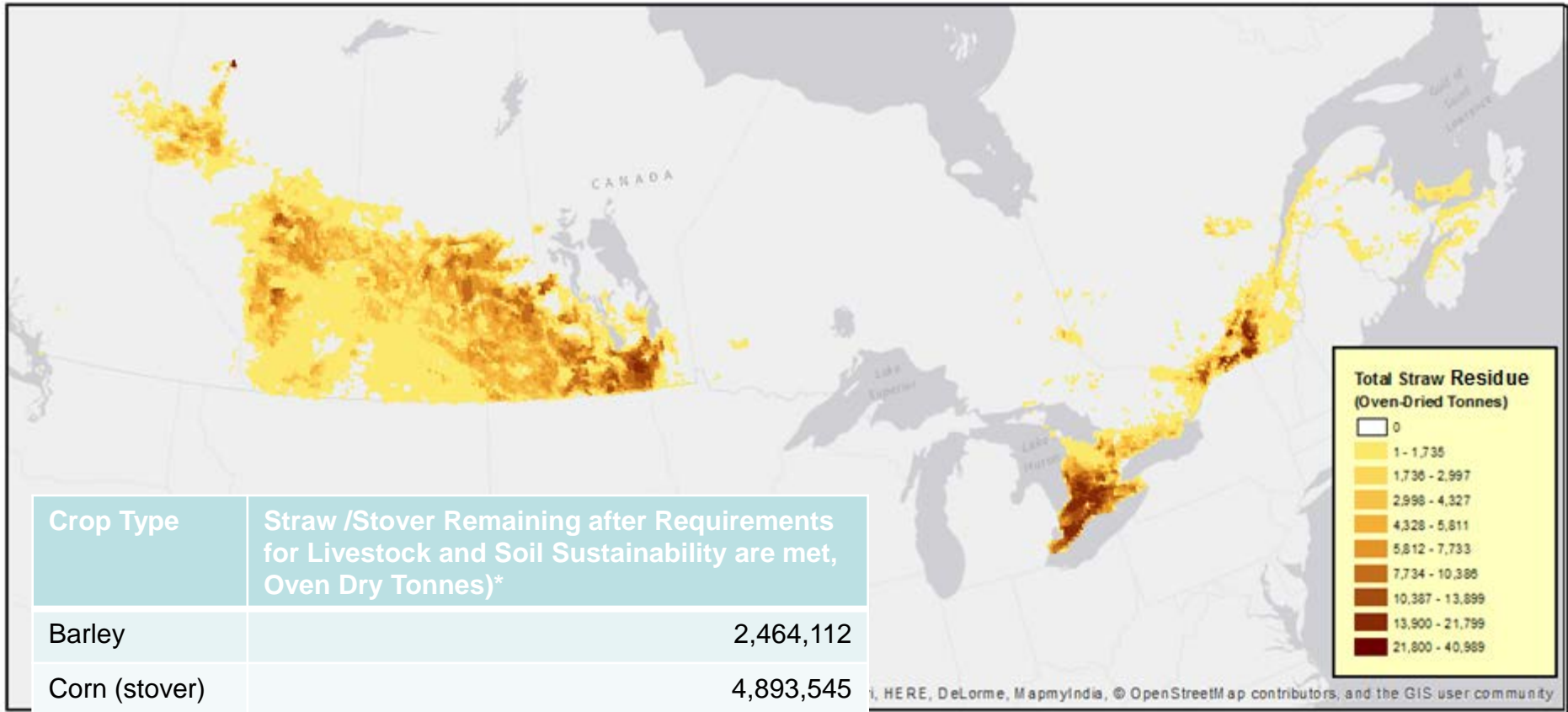
- Livestock Uses – 7.6 M odt
- *Soil Sustainability* – 6.7 M odt

Tame Hay Production – 26.4 M tonnes (2013)



# Total Straw & Stover Available (25 year avg)

with Soil Sustainability and Livestock Requirements Met\*

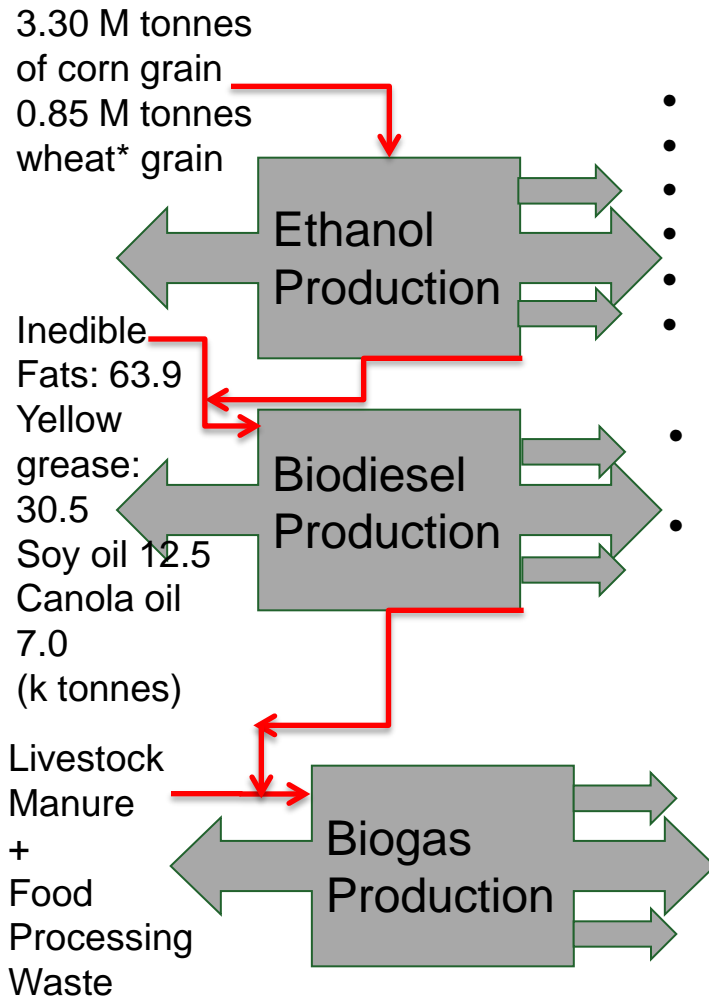


Crop Type	Straw /Stover Remaining after Requirements for Livestock and Soil Sustainability are met, Oven Dry Tonnes)*
Barley	2,464,112
Corn (stover)	4,893,545
Oat	2,421,664
Wheat	12,867,994
Flax	417,207
<b>Total:</b>	<b>23,064,522</b>

\* Based on average yields for 25 year period (1985-2010)

# Feedback Loops to the Agriculture Sector

(Data: 2013-2014)



- 1.7 B litres Ethanol (blended with gasoline – transportation fuel)
- 0.97 M tonnes DDGS (animal feed)
- 0.38 M tonnes WDGS
- 0.18 M tonnes corn distillate/ distillers condensed syrup
- CO<sub>2</sub> (industrial uses and greenhouse heating)
- Energy – Cogen, Heat (energy for facility)
- X M litres Biodiesel FAME (blended with diesel – transportation fuel)
- 14.3 M litres Glycerol (industrial uses, supplement for anaerobic digester, etc.)
- Biogas (mainly used for electricity (19 MW); 160,000 GJ of renewable natural gas - RNG)
- Digestate – liquids (fertilizer applied to agricultural land)
- Digestate – solids (fertilizer applied to agricultural land)

↙ Crop production

\* Wheat and other grains (barley, triticale, rye)

# **Biomass Energy Related Policies that Support Its Production and Use**

# Renewable Energy Policies federal

Targeted complimentary policy initiatives undertaken by federal and provincial governments have promoted **growth in the production and use of renewable electricity** across the country.

### ❖ Tax and Financial Measures

2002 – \$324M Wind Power production incentive program  
2007 - \$1.4 B ecoENERGY for Renewable Power program

Accelerated Capital Cost Allowance under Class 43.2 – Income Tax Act:  
Expanded its eligibility to new renewable energy equipment

Canadian Renewable and Conservation expenses can be fully deducted in the year incurred, carried forward or renounced to shareholders through flow-through share agreement

### ❖ Development and Demonstration of Renewable Energy Technologies

Federal: PERD (Program of Energy Research & Development)  
Provincial programs

❖ **Integration of renewables** – facilitate addition of intermittent renewable power to electric system to ensure system reliability

# Industry Policies federal

### ❖ Pulp and Paper Green Transformation Program (PPGTP)

*"In 2009, the federal government announced the Pulp and Paper Green Transformation Program, a \$1 billion fund to improve the environmental performance of Canada's pulp and paper mills and renew the industry's position in the global marketplace. In total, 24 companies received credits based on black liquor production, and 98 project proposals were approved in 38 communities nationwide. Funding ranged from \$80 000 to over \$100 million per project. Projects undertaken included boiler and turbine upgrades, installation of energy-efficient motors and emission-control equipment and renewable energy production. The program helped to support more than 14,000 jobs and resulted in 195 MW of new renewable energy capacity."*

### ❖ Investments in Forest Industry Transformation (IFIT)

*"\$100 million aimed at first-in-kind technologies in the area of bioenergy as well as biomaterials and biochemical. Renewed with another \$90.4 million in 2014."*

Source: Bradburn, K. (Dec 2014) 2014 CanBio Report on the Status of Bioenergy in Canada.

# Renewable Energy Policies provincial

Provincial Governments have principal responsibility for energy and electricity. The Constitution provides for exclusive provincial power over resources management within provincial boundaries.

In July 2015, the Provinces released the Canadian Energy Strategy.

Provincial governments are promoting the use of renewable energy through:

- Request for proposals – all provinces use this (except for Alberta)
- Offset program – Alberta
- Renewable portfolio standards are legislated in Nova Scotia, New Brunswick, and Prince Edward Island
- Standard offer and feed-in-tariff programs are used in Ontario, Nova Scotia, PEI and BC

# Biofuel Mandates (federal and provincial)

### Federal Renewable Fuel Regulations :

- o fuel producers and importers required to have an average renewable content of at least **5%** based on the volume of gasoline that they produce or import
- o fuel producers and importers of diesel fuel to have an average annual renewable fuel content equal to at least **2%** of the volume of diesel fuel that they produce and import

Province	British Columbia	Alberta	Saskatchewan	Manitoba	Ontario
Renewable Fuels Required	Renewable gasoline: 5% Renewable diesel: 4%	Renewable alcohol: 5% Renewable diesel: 2%	Ethanol: 7.5% Renewable diesel: 2%	Ethanol: 8.5% Biodiesel 2%	Ethanol : 5% Biodiesel: 2% started April 2014
Additional	10% reduction in carbon intensity by 2020	25% fewer GHG emissions than gasoline/diesel fuel			Biodiesel 30% fewer GHG emissions than diesel fuel
		Additional requirements to address direct land use concerns for sugarcane and palm as well as renewable component of municipal solid waste			



# Provincial Biogas-related policies & incentives

## British Columbia

- FortisBC offers customers renewable natural gas (RNG) with an extra levy

## Ontario

- Ontario offers multiple procurement options including: microFIT, FIT (10kW-<500kW), Large Renewable Procurement (>500kW), and Combined Heat and Power programs

## Québec

- Landfill ban on organic waste by 2020
- Policy to decarbonize fleet and use biogas to produce fuel
- Funding support for digester construction

## Nova Scotia

- Landfill ban on organic waste since 1998
- COMFIT program 17 cents per kWh for biogas projects



# Sustainability

*economic*

*social*

*environmental*



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**Resource Use**

# LEE AFF Sustainability Framework (Forest)

L	Land Use	Parks and protected areas; majority (91%) of Canada's wood production forest is publicly owned; 6.2% private and 2% aboriginal; tenure arrangements
E	Environment	Forest: Criteria & Indicator framework reporting <a href="http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/32560.pdf">cfs.nrcan.gc.ca/pubwarehouse/pdfs/32560.pdf</a> Forest products manufacturing: continuous reductions in water use, BOD (water); Total Reduced Sulphur and Total Particulate Matter (air); 70% reduction in GHG emissions since 1990; reduction in landfilling; carbon neutrality goal; Vision 2020 targets
E	Employment	Direct and indirect employment of 321,300 people in 2013; Average wage (2012): \$68,575; recruitment goal of 60,000 (20,000 new jobs)
A	Acceptability	192 forest dependent communities; Active NGO community; Public participation and consultation integral to SFM; Chain of custody certification of products and third party certification of SFM
F	Finances	\$20.1B contribution to real GDP (2014); declining demand for paper; Significant R&D investment – public-private partnership
F	Feedstocks (and inputs)	152 Mm <sup>3</sup> of wood; 73% paper recovery rate (in 2012); Energy use: over 60% renewable energy

# Sustainable Forest Management (SFM)

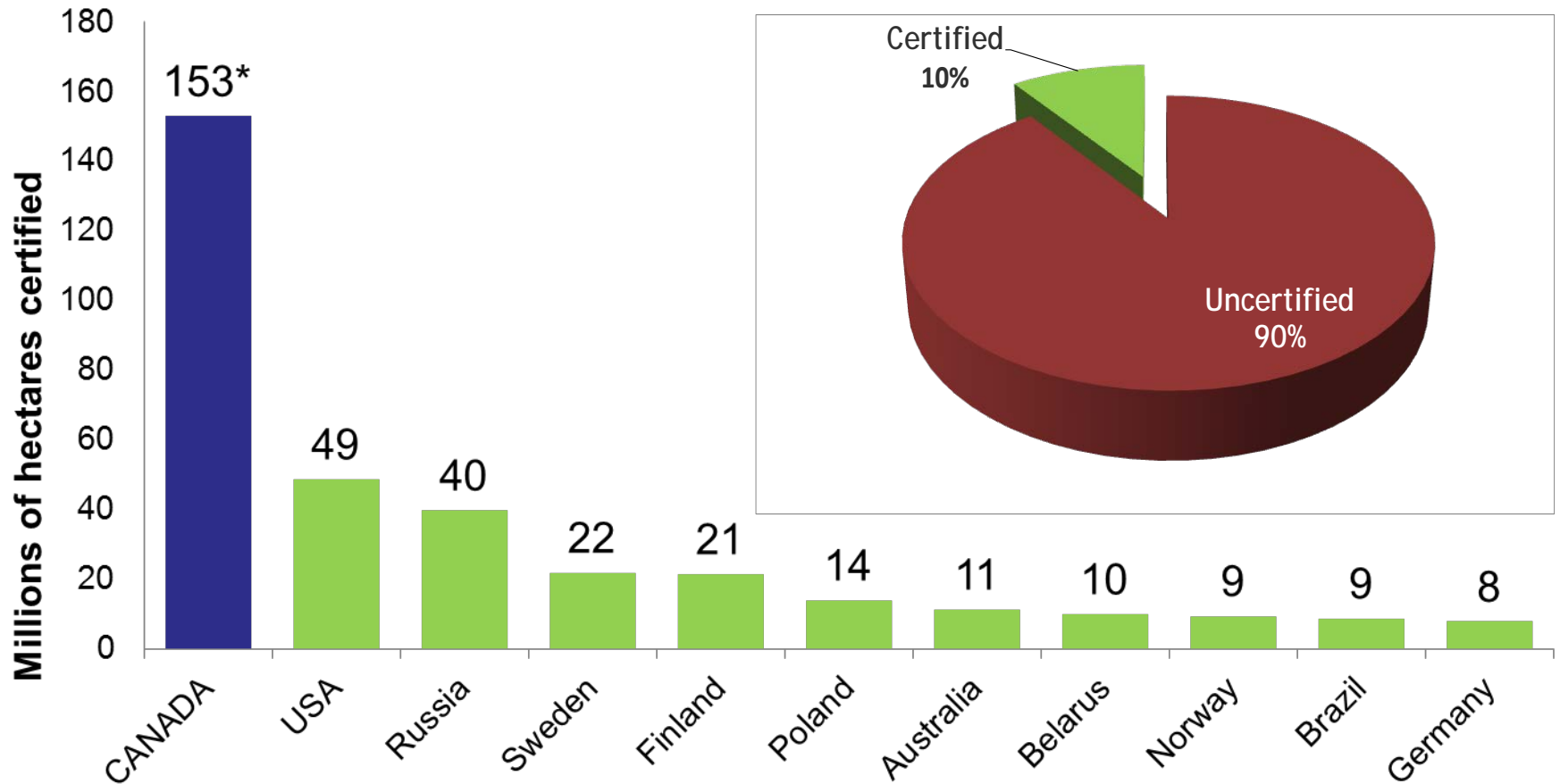
Since 1992, Canada has been committed to developing and adopting “sustainable forest management” (SFM). Today, the SFM model is in place across all of Canada’s public forests.

- In policy and law: addressed in every national forest strategy since 1992; The Canadian Council of Forest Ministers has endorsed adoption and implementation of SFM across the country.
- In forest management planning: rigorous, comprehensive and open process in all provinces and territories.
- In monitoring and evaluation: regular reporting on science-based indicators; and company third-party forest certification.

Source: <http://www.nrcan.gc.ca/forests/canada/sustainable-forest-management/13183>

# Canadian Certification in the Global Context

## 2013 Year-end



\*Double counting of areas certified to more than one standard has been removed from this figure.

Sources: [www.certificationcanada.org](http://www.certificationcanada.org) as of Dec 31/13  
[www.fsc.org](http://www.fsc.org) as of Dec 16/13  
[www.pefc.org](http://www.pefc.org) as of Dec 31/13

2014 Update:  
161 Mha – third party certified

# Industry Sustainability Commitments

- ❖ Certification (2002)
- ❖ Sustainability Initiative (2005)
- ❖ Illegal Logging (2006)
- ❖ Traceability (2006)
- ❖ Conservation Planning (2006)
- ❖ Carbon-neutrality (2007)
- ❖ Bio-pathways (2010)
- ❖ Canadian Boreal Forest Agreement (2010)



Source: Forest Products Association of Canada (FPAC)



# LEEAFF Sustainability Framework (Agriculture)

L	Land Use	Agricultural land is privately owned; 205,730 census farms (in 2011) down 10% from 2006; Increasing farm size and land use intensity; Total area relatively constant; Cropland area has increased as forage land and summer fallow areas have declined.
E	Environment	Sustainable intensification; Agri-Environmental Indicators at the production system level and compiled up; Status: soil quality-good to desired for soil erosion, soil organic carbon change, soil salinization; Water quality: good but at risk of declining due to nutrient application rates; Air quality: GHGs and particulate reductions but NH3 increases; Soils are a significant net sink – 13 Mt CO2e per year due to reduced tillage, less summer fallow.
E	Employment	Agriculture and Agri-Food Sector employed 2.2 million people in 2013; food service industry was largest industrial sector; Diversification as producers of renewable energies: solar, wind, biogas
A	Acceptability	Farmers = Stewards of the land; Priorities: food safety and quality for markets; Co-existence of traditional and organic agriculture; Support rural economy; Public = Growing link between food and health; Mixed views of biofuels; Bioproducts generally accepted if price and performance are comparable.
F	Finances	Agriculture and Agri-Food Sector generated \$107B (6.7% of GDP) in 2013 and exports of \$46B; Net cash income among Cdn farms \$12.9B in 2013. Public investments in R&D estimated \$643M in 2013-2014.
F	Feedstocks (and inputs)	Main ag inputs: nitrogen, phosphorus, potassium, manure, pesticides and energy; Record grain harvest in the first half of 2013: 97 M tonnes of grains, oilseeds and special crops in 2013.



# Sustainable Agriculture: Advances being made

Agri-Environmental Indicators (1981 – 2006) show impacts of Best Management Practices; Mapped here: <http://www.agr.gc.ca/atlas/geoplatform#home>

Next report available in 2016 for indicator trends 1981-2011

Environmental farm plans (voluntary): In 2013, 35% of Canadian farms had environmental plans.

Sustainability Drivers: Regulatory + Market-driven

- Started with Biofuels – Climate Change
  - ISCC Certification
  - US RFS Pathway
  - Roundtable on Sustainable Biomaterials
- Today: Food Companies – Consumers - NGOs
  - Unilever, General Mills, Walmart, McCain, etc.

Industry-driven response: Sustainable Agriculture

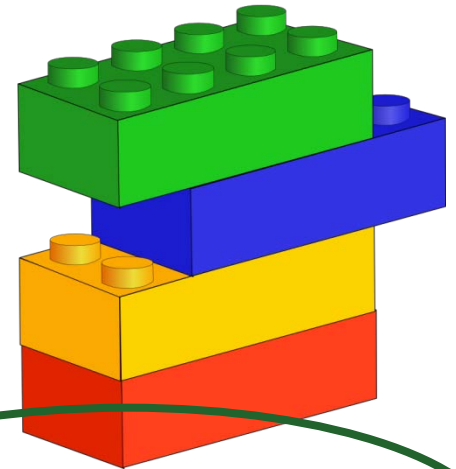
Canadian Roundtable on Sustainable Beef

Canadian Roundtable on Sustainable Crops

- Shift from individual commodity groups to the whole of agriculture

# Canadian Biorefinery\* Facilities

- Running commercial biorefineries
- Demonstration plants
- Pilot plants



Mostly additions to:

- 1G Biofuel plants (23)
- Pulp and Paper mills (97)

\* As defined by IEA Task 42

# 1G Biofuel Facilities (Biorefineries)

www.greenfuels.org

Plant Name	City	Province	Feedstock	Capacity	Status
Atlantec Bioenergy Corporation	Cornwall	Prince Edward Island	Energy beets	n/a	Demonstration Facility
Enbridge Alberta Biofuels			Distillers	36 Mmly	Under Construction
				475,000 Litre/y	Demonstration Facility
				5 Mmly	Demonstration Facility
				38 Mmly	Proposed Demonstration Facility
				195 Mmly	Operational
				200 Mmly	Operational
				27 Mmly	Operational
				120 Mmly	Operational


Plant Locations \_ Canadian Renewable Fuels Association.pdf - Adobe Acrobat

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Plant Locations | Canadian Renewable Fuels Association



Canadian Renewable Fuels Association  
Association Canadienne Des Carburants Renouvelables

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Industry Information

CRFA Conference


Plant Locations

Other Events

Green Fuels Awards

Plant Locations

This map indicates the location of all renewable fuel producing companies in Canada. Also included is the nameplate capacity, the type of product produced and the feedstock used. This map was updated in June 2014.



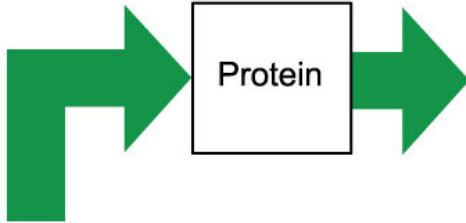
COMMERCIAL Facility Name – (City, Prov.)	Biomass Feedstock	Bioproducts	Description (e.g.technology, capacity, status)	Classification	Website
Highmark Renewables (Vegreville, AB)	Wheat grain, cattle manure, slaughtering waste	Ethanol, DDGS used as animal feed, fertilizer, electricity and heat (used internally)	Conventional biochemical conversion process to produce ethanol integrated with an anaerobic digester next to a cattle feedlot	Biogas and C6 sugars biorefinery for bioethanol, animal feed, fertilizer, electricity and heat from organic residues and starch crops	<a href="http://www.highmark.ca">www.highmark.ca</a>
Ensyn - commercial facility (Renfrew, ON)	Wood residues from flooring plant and sawmill	Food flavouring, polymer resins and bioenergy used internally	Fast pyrolysis using Rapid Thermal Processing (RTP) technology; pyrolysis oil fractionation	Pyrolytic liquid biorefinery for resins, food flavouring, and heat from wood residues	<a href="http://www.ensyn.com">www.ensyn.com</a>
Permolex International - commercial facility (Red Deer, AB)	Wheat, wheat starch, corn, barley, rye & triticale	Ethanol, flour and gluten food ingredients, DDGS sold for animal feed, CO <sub>2</sub>	Integrated flour mill, gluten plant and ethanol production facility; grain fractionation; conventional grain ethanol plant Capacity: 42 Million litres per year of ethanol	C6 sugar biorefinery for bioethanol, animal feed, and food ingredients from starch crops	<a href="http://www.permolex.com">www.permolex.com</a>
GreenField Specialty Alcohols Inc.- commercial facility (Chatham, ON)	Corn (grain)	Ethanol, corn oil, DDGS sold for animal feed, CO <sub>2</sub> sold for industrial uses; 2013: use of CO <sub>2</sub> and heat by adjacent greenhouse	Conventional biochemical conversion process to produce ethanol (197 million litres per year) and DDGS (150,000 tonnes per year); High speed centrifuge extraction produces 3,500 tonnes per year of corn oil.	C6 sugar biorefinery for bioethanol and 2 animal feed products from starch crops	<a href="http://www.gfsa.com/">http://www.gfsa.com/</a>



Food



Protein



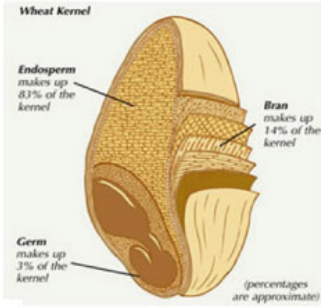
Starch



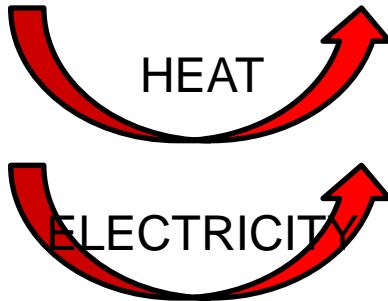
Fuel



Company Permolex  
Facility: Red Deer, Alberta



Wheat



Feed





COMMERCIAL Facility Name – (City, Prov.)	Biomass Feedstock	Bioproducts	Description (e.g.technology, capacity, status)	Classification	Website
Tembec (Temiscaming, QC)	Wood; Forest Stewardship Council® Certification for all directly-managed forests	160,000 tons of Specialty Pulp, 315,000 tons of High Yield Pulp and 180,000 tons of Coated Bleached Board, 170,000 kt lignosulphonate, up to 600,000 GJ of biogas annually	Biorefinery integrated into dissolving pulp production. Effluent streams passed through Paques high rate anaerobic wastewater reactor to produce biogas used in the High Yield pulp drying process.  (Note: The ethanol plant is no longer operating.)	Multiple bio-products including specialty pulps, lignosulfonates and biogas using wood chips as a feedstock	<a href="http://tembec.com/">http://tembec.com/</a>
Alberta Pacific Forest Industries - commercial pulp mill with new methanol purification system (Boyle, AB)	Wood (aspen, poplar) from sustainably managed forest certified under Forest Stewardship Council	650,000 tons of bleached Kraft pulp per year; 50 MW cogeneration plant selling power to the grid; 4,000 tons per year of biomethanol used internally or sold as solvent, antifreeze, fuel, or for formaldehyde production.	Traditional Kraft pulp production with new 4,000 t/yr bio-methanol extraction & purification commercial demo unit. The unit, a 2 stage distillation proprietary technology, was developed by A.H. Lundberg Systems Ltd. It converts steam stripper off gas, a by-product stream from the chemical recovery area of the Kraft pulping process, into high purity methanol.	3 platform (pulp, stripper off gas, electricity & heat) biorefinery using wood chips for Kraft pulp, electricity and biomethanol	<a href="http://www.alpac.ca">www.alpac.ca</a> Methanol production: <a href="http://www.alpac.ca/content/files/BioMethanolNewsRelease.pdf">http://www.alpac.ca/content/files/BioMethanolNewsRelease.pdf</a>



## Company Enerkem Alberta Biofuels Facility: Edmonton, Alberta



- Increases landfill diversion from 60% to ~90%
- MSW → syngas:
  - Methanol → Ethanol



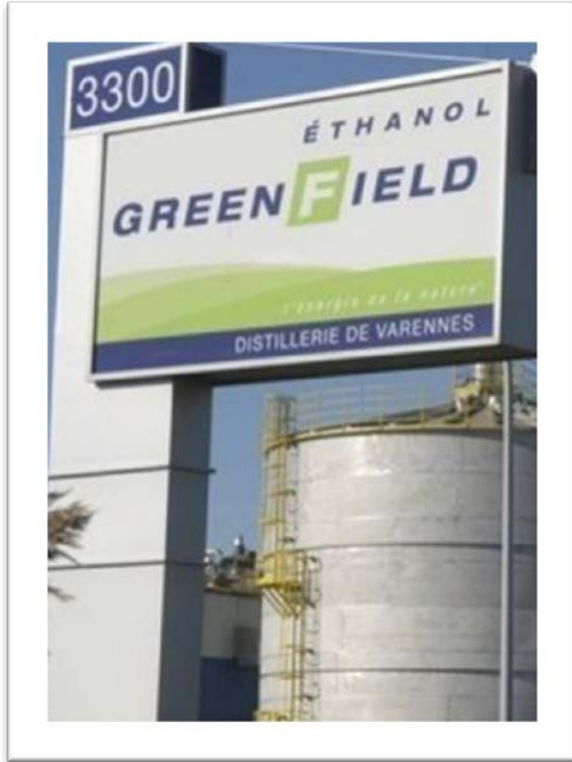
Winter  
2014

Source: Jeff Bell, Alberta Bioproducts (2013)



<b>COMMERCIAL Facility Name – (City, Prov.)</b>	<b>Biomass Feedstock</b>	<b>Bioproducts</b>	<b>Description (e.g.technology, capacity, status)</b>	<b>Classification</b>	<b>Website</b>
Enerkem Alberta Biofuels waste-to-biofuels facility - Commercial under construction (Edmonton, AB)	Sorted municipal solid waste	Biomethanol; cellulosic ethanol (2016)	Biomass gasification, catalytic conversion of syngas Capacity: 38 million litres per year Subsidiary of Enerkem Inc.	Syngas biorefinery using municipal solid waste for biofuels and biochemicals	<a href="http://www.enerkem.com">www.enerkem.com</a>
Vanerco waste-to-biofuels facility - Commercial under development (Varenes, QC)	Sorted industrial, commercial and institutional waste	Cellulosic ethanol, biomethanol	Biomass gasification, catalytic conversion of syngas Capacity: 38 million litres per year 50/50 joint venture between Enerkem and GreenField	Syngas biorefinery using industrial, commercial and institutional waste for biofuels and biochemicals	<a href="http://www.enerkem.com">www.enerkem.com</a>

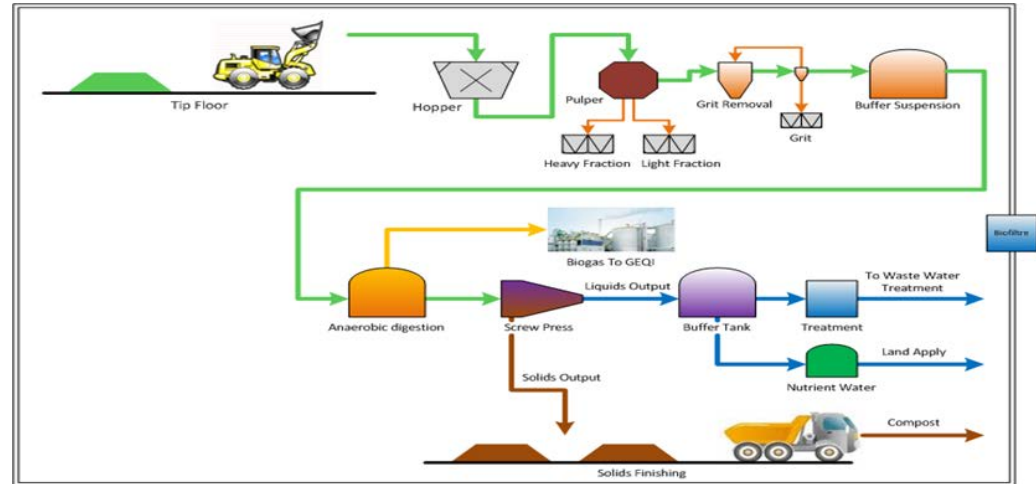
# Evolution to More Complex Biorefineries



The Varennes, Québec 1G grain ethanol plant produces 175 million litres of ethanol per year from 12 million bushels of feed corn. Co-products include: 140,000 tonnes of Dried Distillers Grains with Solubles (DDGS) and 70,000 tonnes of Wet Distillers Grains (WDGS) that are sold as animal feed, corn oil, and CO<sub>2</sub> valorized in dry ice.

## SEMECS Varennes Anaerobic Digestion Project:

GreenField Specialty Alcohols Varennes plant is participating in a PPP to install a 50,000 tonnes per year anaerobic digestion plant. The Province of Québec's has put in place a policy to ban compostable organics from landfills as of 2020. Feedstock for the Varennes plant will consist of organic commercial and industrial waste as well as municipal organic waste from the 92,000 households in 27 rural and suburban municipalities on the south shore of the Saint Lawrence River, east of Montréal.



By early 2017, the resulting biogas, cleaned to pipeline gas quality, should replace up to 10% of the natural gas that now fuels the Varennes 1G ethanol plant. The pasteurized digestate will be provided as fertilizer to 400 agricultural producers who grow corn for the plant.



DEMO Facility Name – (City, Prov.)	Biomass Feedstock	Bioproducts	Description (e.g.technology, capacity, status)	Classification	Website
Enerkem - demo facility (Westbury, QC)	wood waste from used utility poles	Cellulosic ethanol, methanol	Biomass gasification, catalytic conversion of syngas Production capacity: 5 million litres per year	Syngas biorefinery using wood waste and other residues for biofuels and biochemicals	<a href="http://www.enerkem.com">www.enerkem.com</a>
GreenField Specialty Alcohols Inc. Advanced Biofuels Demo #1 Facility (Chatham, ON)	Low to high lignin cellulosic feedstocks (e.g. poplar chips; corn cobs and stover); sugar beets (in 2016)  (See notes below*)	Cellulose C6 and hemicellulose C5 sugar monomers that can be converted into cellulosic ethanol  =====  In addition to products of existing corn grain ethanol facility	Percolation/hot water/steam explosion pretreatment equipped with proprietary Modified Extruder Technology followed by hydrolysis and fermentation of C5 and C6 sugar monomers. Following 6 years of operation of its 1 tpd pilot plant, GreenField is now demonstrating its technology at ~ 5 tpd capacity using mobile (skid-mounted) equipment. Located at its existing 1G ethanol plant, this addition enables new feedstocks to be processed in tandem with traditional ethanol processes, and higher value to be extracted from process streams.	4-platform (C6&C5 sugar, C6 sugar (from lignin, electricity & heat) biorefinery using agriculture residues and/or pulp mill streams for bioethanol (from grain and cellulose), chemicals, value added products and bioenergy	<a href="http://www.gfsa.com/">http://www.gfsa.com/</a>
GreenField Specialty Alcohols Inc. Advanced Biofuels Demo #2 Facility (Chatham, ON)	Thin stillage from 1G ethanol plant; In 2016, a variety of feedstocks some of which require pretreatment Demo #1 (agriculture crop, sawmill and forest residues) and others not requiring pretreatment (sludges, municipal & industrial organic waste) will be fed to biogas plant.	Biogas (in 2015); In 2016, syngas (after reforming), and drop-in renewable transportation fuels (Biojet fuel, renewable diesel and gasoline after Fisher-Tropsch synthesis)	GreenField is developing a proprietary anaerobic digestion ('AD') / Gas-to-Liquid ('GTL') renewable drop-in transportation fuels centered on a novel 2-stage AD system that produces clean biogas (i) more efficiently and at less cost than traditional single stage AD, and (ii) from a variety of feedstocks such as pulp mills pre-hydrolysate liquor and waste water streams and lignocellulosic streams pre-treated with GreenField's 'Demo #1' process and equipment technologies . Biogas plant is starting operation in Nov 2015n and the dry reforming plant and FT synthesis will start up in 2016. Nameplate capacities: 1,100 m <sup>3</sup> total biogas per day, 1,000 m <sup>3</sup> syngas per day or 500 liters of mixed drop-in renewable fuels per day.	3-platform biorefinery (Advanced two-stage AD, Syngas biorefinery, and GTL drop-in transportation fuels ) for the production of biogas, syngas and drop-in renewable fuels from ag and forestry residues, industrial side streams and waste water streams and municipal and industrial organic waste streams.	<a href="http://www.gfsa.com/">http://www.gfsa.com/</a>





<b>DEMO Facility Name – (City, Prov.)</b>	<b>Biomass Feedstock</b>	<b>Bioproducts</b>	<b>Description (e.g.technology, capacity, status)</b>	<b>Classification</b>	<b>Website</b>
Domtar commercial Kraft pulp and paper mill with new demo facility - CelluForce joint venture between Domtar and FPInnovations (Windsor, QC)	Wood chips from sustainably managed forest certified under Forest Stewardship Council and Sustainable Forestry Initiative	Uncoated freesheet papers; Bleached hardwood market pulp; Bioenergy; nanocrystalline cellulose (NCC) for product development	Traditional Kraft pulp and paper production with new patented acid hydrolysis demo plant producing 1 t/d nanocrystalline cellulose (NCC); A portion of the mill's Kraft pulp is converted into NCC. The NCC plant includes acid recovery and anaerobic treatment of effluent that produces biogas.	3 platform (pulp & paper, nanocrystalline cellulose, electricity & heat) biorefinery using wood chips for pulp & paper, nanocrystalline cellulose and bioenergy	<a href="http://www.domtar.com">www.domtar.com</a> Demo plant: <a href="http://www.celluforce.com">www.celluforce.com</a>
<b>PILOT Facility Name – (City, Prov.)</b>	<b>Biomass Feedstock</b>	<b>Bioproducts</b>	<b>Description (e.g.technology, capacity, status)</b>	<b>Classification</b>	<b>Website</b>
Fibria Innovations Ltd – pilot-scale biorefinery (Burnaby, BC)	Wood, straw, energy crops	Cellulosic ethanol, lignin, specialty cellulose, acetic acid, lignin, furfural, sugars	Organosolv-based fractionation, hydrolysis, enzymatic saccharification, fermentation, lignin recovery and drying. 1 t/d feedstock pilot plant since 2009. Working on scale-up to 400 t/d.	C6 & C5 sugars and lignin biorefinery for bioethanol, chemicals and biomaterials from lignocellulosic crops or residues	<a href="http://www.lignol.ca/">www.lignol.ca/</a> <a href="mailto:info@lignol.ca">info@lignol.ca</a>
Bio-economy Technology Centre – pilot plant located at Rolute Forest Products pulp and paper mill (Thunder Bay, ON)	Wood chips from a sustainably managed forest certified under Forest Stewardship Council	574,000 tonnes per year of market pulp, newsprint, commercial printing papers; 43MW cogeneration plant; 10 kg/hr lignin sold for product development (e.g. industrial resins, carbon fibre)	Traditional Kraft mill production with new 10 kg/hr lignin pilot scale production facility. The lignin is separated from the black liquor using an acidification process.	3 platform (pulp & paper, lignin, electricity&heat) biorefinery using wood chips for pulp & paper, lignin and bioenergy	<a href="http://www.resolutefp.com">www.resolutefp.com</a> Pilot plant: <a href="http://www.cribe.ca/projects/content/projects/article/fpinnovations-lignin-pilot-plant">http://www.cribe.ca/projects/content/projects/article/fpinnovations-lignin-pilot-plant</a>
Enerkem - pilot facility (Sherbrooke, QC)	Over 25 different types of feedstocks	Small quantities of syngas, methanol, acetates and second-generation ethanol	Biomass gasification, catalytic conversion of syngas	Syngas biorefinery using a variety of biomass feedstock for biochemicals and biofuels	<a href="http://www.enerkem.com">www.enerkem.com</a>

# Major R&D Consortia & Projects

Major national stakeholders involved in the field of biorefining



# Major R&D Consortia (Forest)

R&D Consortium or Network	Coordinator	Description: Goal, Methodology, Results
NSERC FIBRE (Forest Innovation by Research & Education) <a href="http://www.fibrenetwork.org">www.fibrenetwork.org</a>	Dr. Theo van de Ven (McGill University)	Organization that builds synergies among forest NSERC funded strategic research & development networks in support of the priorities of Canada's vital forest sector innovation system
Value Chain Optimization Network <a href="http://www.reseauvco.ca">www.reseauvco.ca</a>	Catherine Savard (Université Laval)	Aim: to provide the industry and policy makers with new advanced planning and decision support systems to design and deploy optimized forest bioeconomy networks.
Bioconversion Network <a href="http://www.nsercbioconversion.net">www.nsercbioconversion.net</a>	Dr. Hung Lee (Univ of Guelph) and Dr. Jack Saddler (Univ of British Columbia)	Aim: To develop energy efficient, commercially viable and environmentally sustainable biomass conversion processes that generate ethanol and high-value co-products.
Lignoworks Biomaterials and Chemicals Network <a href="http://www.lignoworks.ca">www.lignoworks.ca</a>	Dr. John Schmidt (FPInnovations)	Aim: To generate new knowledge to develop innovative, high value-added lignin-based materials and chemicals.
Sentinel Bioactive Paper Network <a href="http://www.bioactivepaper.com">www.bioactivepaper.com</a>	Robert Pelton (McMaster Univ)	Aim: To develop bioactive paper that will detect, capture and deactivate water and airborne pathogens.
Innovative Green Wood Fibre Products Network <a href="http://www.greenfibrenetwork.ca">www.greenfibrenetwork.ca</a>	Dr. Theo van de Ven (McGill University)	Mission: To create technology platforms for developing green products based on wood fibres and wood fibre networks that will replace fossil-fuel based and other non-renewable products.



RÉSEAU  
**BIOFUELNET**  
CANADA

## Largest Advanced Biofuels Network in Canada

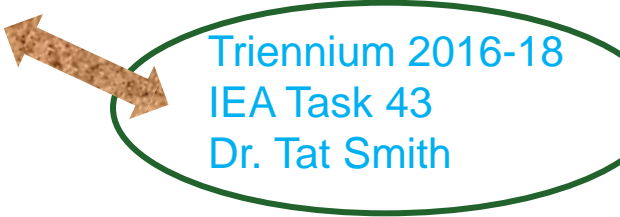
Accelerates commercialization and supports the growth of Canada's advanced biofuels industry

- Brings together the Canadian biofuels community: academia, industry, investment, government
- Includes 27 universities, ~130 researchers, over 140 partners, 278 grad students and post-docs, and numerous national and international contacts
- Operates under a \$25 million grant over 5 years (2012 to 2017) through the Networks Centres of Excellence program of the Federal Government

Pr 1 - Purpose-grown feedstock	Pr 6 - Emerging conversion technologies
Pr 2 - Residues & waste	Pr 7 - Combustion & engine operations
Pr 3 - Bioconversion	Pr 8 - Life cycle analysis & microeconomics
Pr 4 - Pyrolysis	Pr 9 - Domestic & international policy
Pr 5 - Gasification	Pr 10 - Supply-chain logistics

# BioFuelNet Task Forces

- **Task Force 1: Integrated biological biorefinery**
  - Leader: Dr. Jack Saddler, University of British Columbia
- **Task Force 2: Integrated thermal biorefinery**
  - Leader: Dr. Jean-Michel Lavoie, Université de Sherbrooke
- **Task Force 3: Low-cost sustainable feedstocks**
  - Leader: Dr. Kevin Vessey, St. Mary's University
- **Task Force 4: Policy**
  - Leader: Dr. Warren Mabee, Queen's University
- **Task Force 5: Forestry**
  - Leader: Dr. Michel Perrier, École Polytechnique
- **Task Force 6: Aviation**
  - Leader: Dr. Murray Thomson, University of Toronto

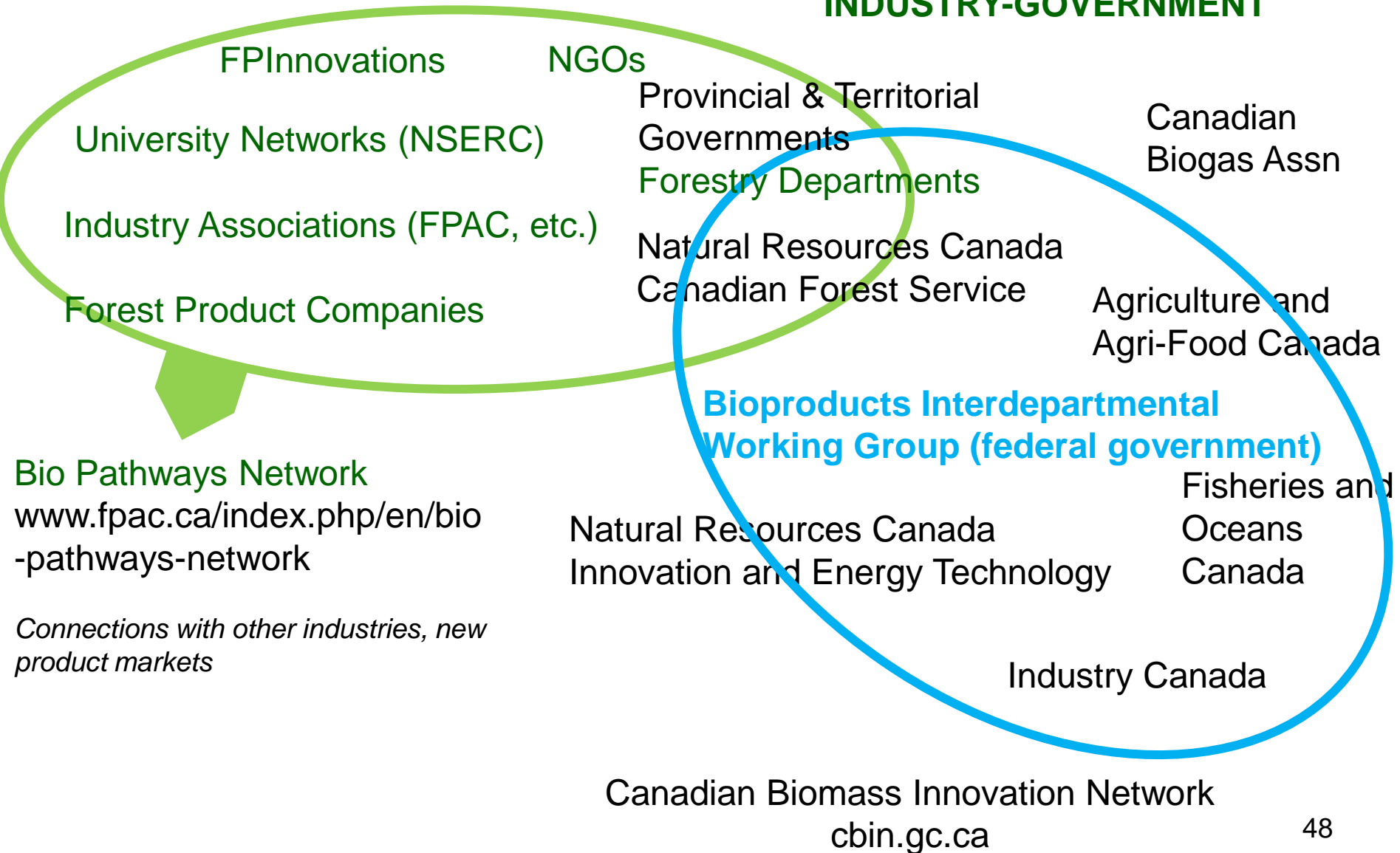


Triennium 2016-18  
IEA Task 43  
Dr. Tat Smith

R&D Consortium or Network	Coordinator	Major Objective	Start Date
Biorefining Conversions Network <a href="http://www.bcn.ualberta.ca">www.bcn.ualberta.ca</a>	Dr. David Bressler (University of Alberta)	Mission: To support Alberta's research community, industry, and other partners for the development of advanced technologies to convert biomass into "drop-in" chemicals and fuels compatible with both traditional and emerging industries.	2009
NCE BioFuelnet <a href="http://www.biofuelnet.ca">www.biofuelnet.ca</a>	Dr. Donald Smith (McGill University)	Objective: To aggressively address the challenges impeding the growth of an advanced biofuels industry, which is a key component of the energy mix of the future. BioFuelNet currently funds 64 collaborative research projects across the country, and facilitates the coordination and optimization of research by specifically addressing gaps that prevent commercialization of advanced biofuels.	2012
Bioproducts Cluster <a href="http://www.bicsarnia.ca">www.bicsarnia.ca</a>	Dr. Murray McLaughlin (Bioindustrial Innovation Canada)	Aim: To develop a cluster of organizations that will position Canada in a leadership role in the bioeconomy by investing in the development of commercially viable agricultural based bioproducts and creating new market opportunities for Canadian farmers.	2014
FIBRECity <a href="http://www.fibrecoity.ca">www.fibrecoity.ca</a>	Sean McKay (Composite Innovation Centre)	Aim: To develop a sustainable high-throughput phenotyping capability with the capacity to evaluate bio-fibres from multiple agricultural and natural sources	2014
NRC Algal Carbon Conversion (ACC) Flagship <a href="http://www.nrc-cnrc.gc.ca/eng/solutions/collaborative/algal_index.html">www.nrc-cnrc.gc.ca/eng/solutions/collaborative/algal_index.html</a>	Dr. Aleks Patrzykat (National Research Council)	Aim: To provide Canadian industry with a cost-competitive, value-generating solution to divert CO2 emissions into algal biomass, which can then be processed into biofuels and other marketable products.	2014
NRC Industrial Biomaterials Flagship <a href="http://www.nrc-cnrc.gc.ca/eng/solutions/collaborative/industrial_bio_index.html">www.nrc-cnrc.gc.ca/eng/solutions/collaborative/industrial_bio_index.html</a>	Nathalie Legros (National Research Council)	Objective: To work with key collaborators from across the biomaterials supply chain to develop high quality, sustainable and cost-effective non-food biomass-based materials.	2013
NRC Bio-based Specialty Chemicals Program	Dr. James Johnston (National Research Council)	Aim: to expedite the growth of Canada's bio-based chemical sector through a measured investment that helps industry more rapidly achieve commercial viability and sustainability. Targeted Products: Specialty bio-based chemicals (fine, intermediate and niche) for differentiated industrial and consumer markets	2015

# Canadian Bioeconomy Stakeholders

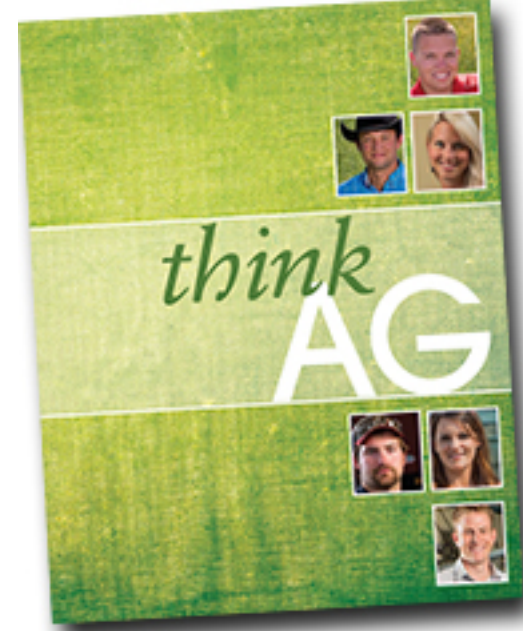
## INDUSTRY-GOVERNMENT



# Canadian Stakeholders

**Agriculture and Agri-Food Canada**

**Provincial Governments  
Agriculture Departments**



Federal-Provincial-Territorial  
Bioproducts Working Group

Industrial Bioproducts Value Chain  
Round Table (IBVCRT)\*  
Government and Industry co-chaired  
by Dr. Murray McLaughlin (BIC)

*PEI BioAlliance*

*Canadian Federation  
of Agriculture*

*BioAmber*

*Ontario Agri-Food Technologies*

*La Coop fédérée*

*AgWest Bio*

*Soy 2020*

*BIOTECanada*

*Canadian Renewable  
Fuels Association*

\* Not all organizations shown

# Intermediate Products for Downstream Manufacturing & Green Energy

## Forest Products

Construction Industry  
Furniture Manufacturing  
Paper Products Manufacturing  
Composites Manufacturing (e.g. equipment manufacturing)  
Textile Industry  
Chemical Industry  
Electric Utilities

- Commodity chemicals
- Specialty chemicals
- Construction
- Industrial textiles
- Equipment Manufacturing

## Agriculture Products

Food Processing  
- Functional Foods  
Chemical Industry  
Biofuels Production  
Electric Utilities

## Waste Management

Electric and Natural Gas  
Utilities





# Regional Clusters

innovationplace.com

## Alberta Industrial Heartland Edmonton

- ✓ Oil seed crushing
- ✓ Bio-fuel blending
- ✓ Bio-fuel transloading and logistics
- ✓ Bio-chemicals
- ✓ Carbon capture
- ✓ Hydrogen



## BIO-MILE



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