IEA Bioenergy

Task 42 Biorefining

Country Report
Canada

November 2014

Forest Biorefinery
ALPAC, Alberta

Agriculture-based Biorefinery
IGPC, Ontario

Municipal Solid Waste
MSW Biorefinery
ENERKEM, Alberta

Maria Wellisch, Agriculture and Agri-Food Canada

Content

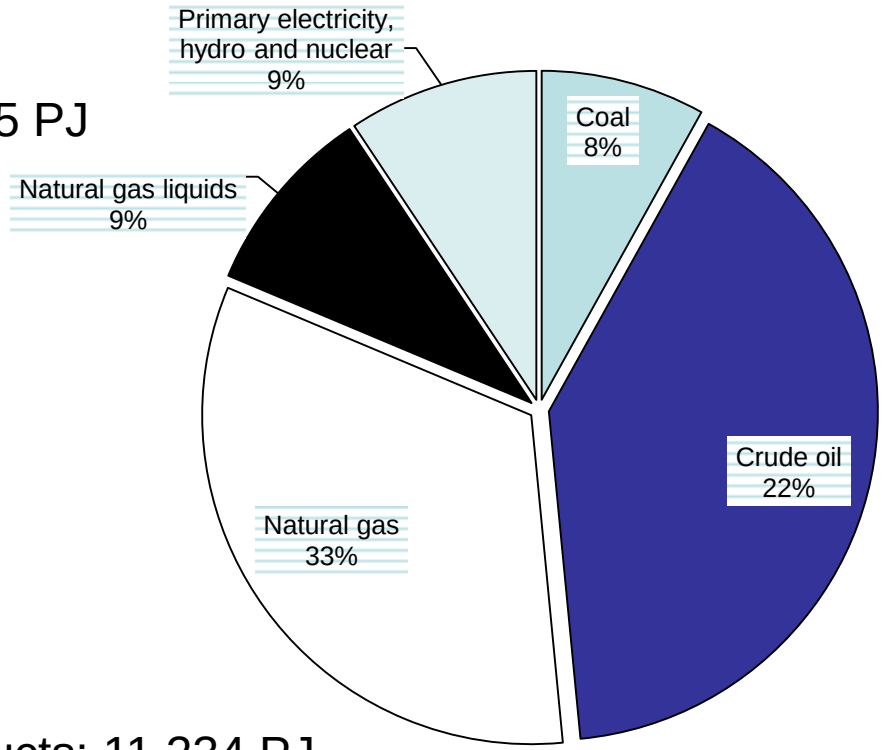
- Energy production and consumption
  - Renewable energy production
- Biomass Flows for energy and non-energy applications
  - Forest Products
  - Agriculture
- Bioenergy related policies
- Sustainability – economic, social, environmental
- Biorefineries
  - Running commercial biorefineries
  - Biorefinery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

2012 Energy Production and Consumption

Primary Energy Production: 17,335 PJ

- Crude oil production: 43%
- Natural gas: 35%
- Primary electricity: 10%
- Coal: 8.6%
- Gas plant NGLs: 3.6%

Energy Consumption: 8,179 PJ

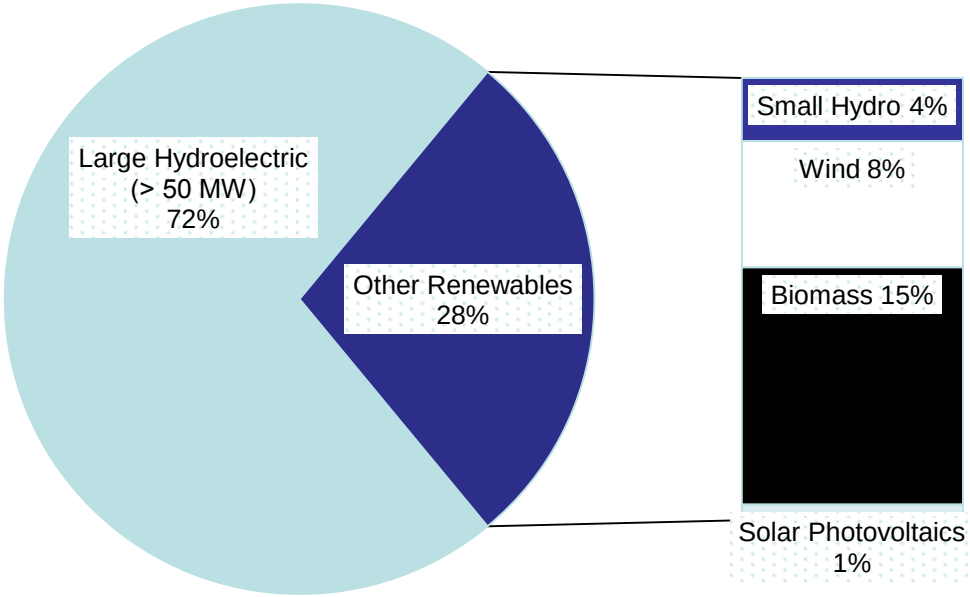


Exported energy and energy products: 11,234 PJ

- 58% of primary energy production was exported, primarily to the US

Source: Report on Energy Supply and Demand in Canada – 2012

Total Renewable Energy Capacity and Generation in 2013



Total Renewable Capacity: 99 GW

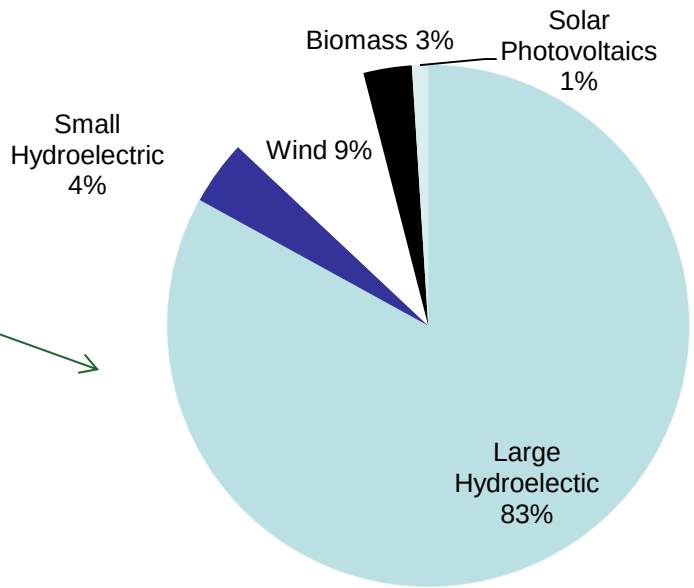
Renewable Resource	Annual Generation (GWh)	Capacity Utilization
Large Hydroelectric	373,103	59%
Small Hydroelectric	19,307	60%
Wind	22,915	33%
Biomass	93,260	74%
Biogas	1,998	73%
Solar Photovoltaic	1,253	15%
Other	255	
* Municipal Solid Waste		58%
* Tidal		17%

Source: CIEEDAC (2014) Renewable Energy in Canada (2013)

Renewable Capacity - electricity and heat

Renewable Electricity

- Capacity: 130 GW
- Dominated by hydroelectricity
  - *Provinces: British Columbia, Manitoba, Newfoundland, Quebec*



Renewable Heat

- Thermal energy = 10.9 GW
- Wood biomass provides 98% of thermal capacity
- Remainder is derived from sewage gas, landfill gas, and municipal solid waste, earth energy (via heat pump) and solar water heaters.

Source: CIEEDAC Renewable Energy in Canada (2013)

Bioenergy: solid biomass, biogas and biofuels

Dominated by woody biomass (forest products industry)

Province – Territory	Biomass Energy Capacity (MW)	Biogas Energy Capacity (MW)
British Columbia	5,694	119
Alberta	1,741	7
Saskatchewan	488	0
Manitoba	407	60
Ontario	3,160	114
Quebec	1,668	66
New Brunswick	801	1
Nova Scotia	298	4
Prince Edward Island	17	0
Newfoundland and Labrador	138	0
Nunavut	0	0
Northwest Territories	12	0
Yukon	1	0

Dominated by landfill gas (municipal and industrial waste)

Biofuel Production & Consumption

Ethanol (2013):

- Production: 1.8 B litres
  Consumption: 2.5 B litres

Biodiesel (2013):

- Production: 124 M litres
- Consumption: 557 M litres

Source: CIEEDAC (2014) Renewable Energy in Canada (2013)

Biogas Energy Capacity - Power & Heat (2013)

Landfills
- Municipal and Industrial Waste

124 MW electrical capacity
118 MW thermal capacity

Livestock Production, Rendering Plants, Food Processing Facilities

17 MW electrical capacity
(*not all facilities are accounted for*)

Sources: CIEEDAC and Biogas Association

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Biofuels – Domestic Production Capacity

Year 2014

32 Facilities

Ethanol
1.8 B litres
Biodiesel
720 M litres

Co-products:

- 1,300 kt DDGS + CO_2, glycerol, corn oil, etc.

Biomass Flows

for Non-Energy and Energy Applications and Export

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

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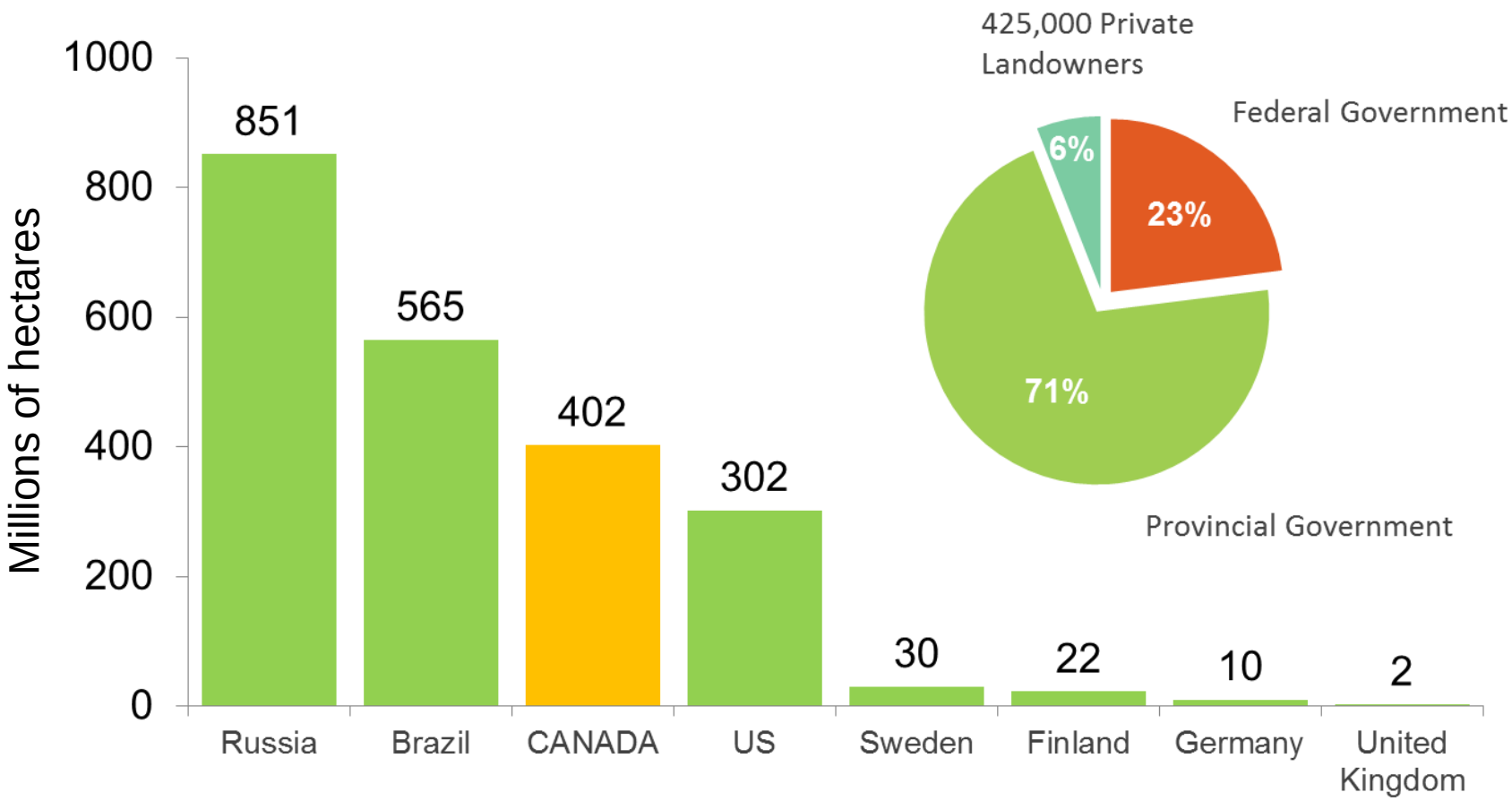
Canada's Forest Land



Source: Forest Products Association of Canada (FPAC)

Biomass use for materials and energy: Forest Products

Forest Biomass - Wood production forest

Harvest (2012):
152 million m^3 from 0.6 million hectares

Source: NRCan CFS

Production in 2013 (NRCan CFS)	
Hardwood lumber (cubic metres)	1,306,200
Softwood lumber (cubic metres)	57,687,700
Newsprint (tonnes)	3,972,000
Printing and writing paper (tonnes)	3,466,000
Wood pulp (tonnes)	17,254,000
Structural panels (plywood and oriented strandboard) (cubic metres)	7,132,294

Export + Domestic Use

Biomass Consumed for Energy in 2012 (CIEEDAC)		
	Wood Waste	Spent Pulping Liquor
Pulp and Paper Industry	99,053 TJ	197,964 TJ
Wood Products industry	70,499 TJ	

Wood Pellets (1,800 kt)
92% exported in 2013

Bioenergy (stand alone)
- electricity generation (1,947 GWh)
- thermal heat generation (520 GWh)

fpac.ca
Forest Products Association of Canada

EXTENSION OF ESTABLISHED BUSINESS MODEL

- Implemented
- In Progress
- Not Yet Implemented

MANUFACTURING PROCESS

- Kraft Pulping
- Sawmilling
- Mechanical Pulping
- Power Production
- Biomass Boiler
- Biorefining

MANUFACTURED GOODS

- Panel & Boards
- Lumber
- Market Pulp
- Paper
- Biofuels
- Biochemicals
- Biomaterials
- Energy

NEW MARKET APPLICATIONS

- Printing & Packaging
- Automotive
- Tissue
- Energy (power, heating & transportation)
- Food Additives
- Construction
- Pharmaceuticals
- Industrial Chemicals & Products
- Plastics
- Textiles
- Consumer & Personal Care Products
- Cosmetics
- Building Systems

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Biomass use for food, feed & bioproducts: Agriculture

Agricultural Crop Production

28.7 M ha harvested area (in 2012)

GRAIN

TOTAL (Grain) – 77.3 M tonnes (2012)

Barley	Mixed grains
Beans, all dry	Mustard seed
Borage seed	Oats
Buckwheat	Peas, dry
Canary seed	Rye, all
Canola	Safflower
Caraway seed	Soybeans
Chick peas	Sugar beets
Corn for grain	Sunflower seed
Fababeans	Triticale
Flaxseed	Wheat, all
Lentils	

Export + Domestic Use

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

Domestic Production (straw) – 18.9 M dry tonnes (2011 Census)

- Bedding – 3.6 M dry tonnes
- Feed + Other Uses (including soil replenishment, etc.)

FORAGE Production

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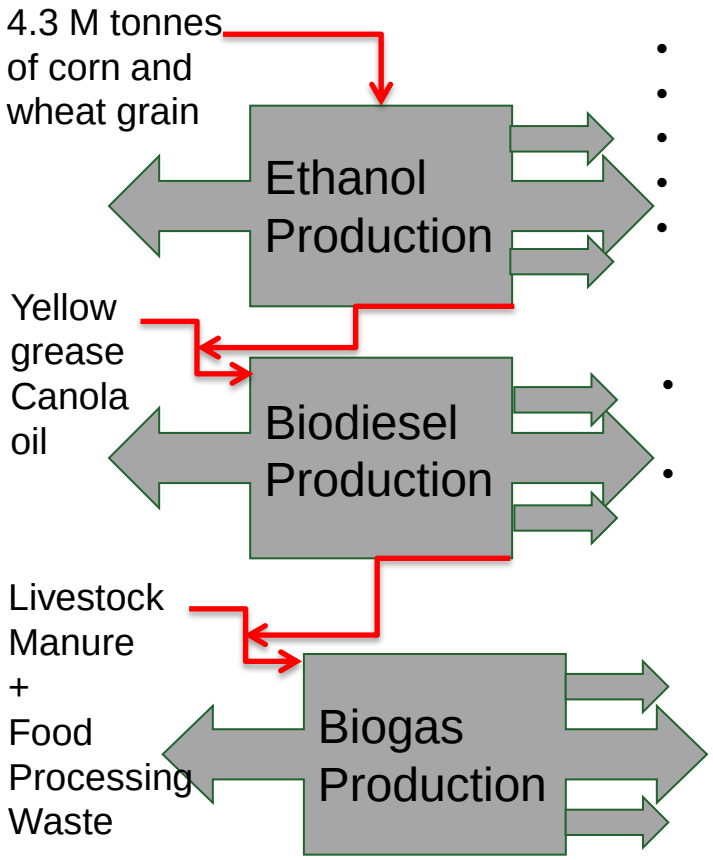
Biofuel and Biogas Co-products - Feedback Loops



- 1.8 B litres Ethanol (blended with gasoline – transportation fuel)
- DDGS – 730 kt corn DDGS + 430 kt wheat DDGS (animal feed)
- CO_2 (industrial uses and greenhouse heating)
- Corn Oil (biodiesel production)
- Energy – Cogen, Heat (energy for facility)

- 720 M litres Biodiesel (blended with diesel – transportation fuel)
- Glycerol (industrial uses, supplement for anaerobic digester, etc.)

- Biogas (mainly used for electricity (> 17 MW) and heat)
- Digestate – liquids (fertilizer applied to agricultural land)
- Digestate – solids (fertilizer applied to agricultural land)

Crop production

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 the 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

Renewable Energy Policies provincial

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

Provincial governments are promoting the use of renewable energy through:

- Request for proposals – all provinces (but Alberta) use this
- 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

Source: Canada – A Global Leader in Renewable Energy, August 2013
https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/www/pdf/publications/emmc/renewable_energy_e.pdf

Biofuel Mandates (federal and provincial)

Federal Renewable Fuel Regulations :

- 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
- 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

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

Ontario

- Micro-FIT program (10 kW or less); contract price per kWh: 16.4 cents per kWh

Quebec

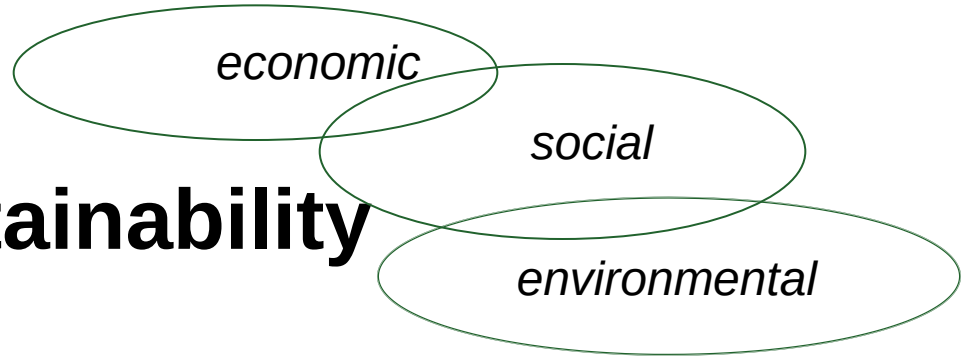
- Landfill ban on organic waste by 2020
- Policy to decarbonize fleet and use biogas to produce fuel
- Funding support for digester construction

Nova Scotia

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

Source: Canadian Biogas Study - Technical Document. December 2013.

Sustainability



Sustainable

Resource Use

LEEAFF 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 cfs.nrcan.gc.ca/pubwarehouse/pdfs/32560.pdf 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	$20.9B contribution to nominal GDP (2013); declining demand for paper; Significant R&D investment – public-private partnership
F	Feedstocks (and inputs)	152 Mm^3 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.

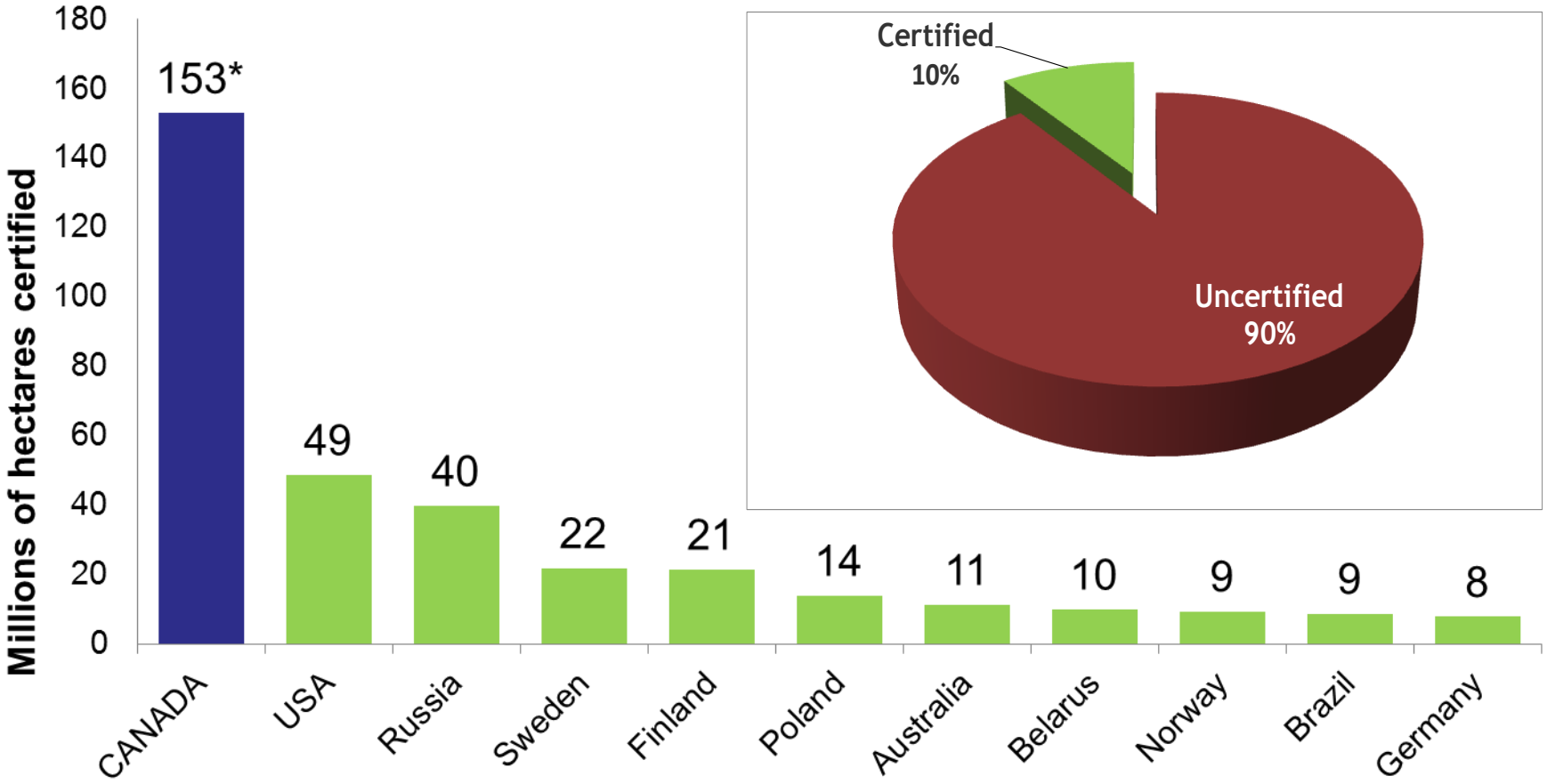
• In forest management planning: rigorous, comprehensive and open process in all provinces and territories.

• 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 as of Dec 31/13
www.fsc.org as of Dec 16/13
www.pefc.org as of Dec 31/13

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)

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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 2.1 million people in 2012; food service industry largest industrial sector; Diversification as producers of renewable energy: 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; Mixed view of biofuels; Bioproducts generally accepted for their added value; Growing link between food, nutrition and health
F	Finances	Agriculture and Agri-Food Sector generated $103.5B (6.7% of GDP) in 2012 and exports of $43B; Goal: Financially sustainable without subsidies
F	Feedstocks (and inputs)	Main ag inputs: nitrogen, phosphorus, potassium, manure, pesticides and energy; 77 M tonnes of grains produced (in 2012)

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 2015 for indicator trends 1981-2011

Environmental farm plans (voluntary): In 2013, 35% of 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

- Sustainable Feed (McDonalds)

Canadian Roundtable on Sustainable Crops

- Shift from individual commodity groups to the whole of agriculture

Canadian Biorefinery* Facilities

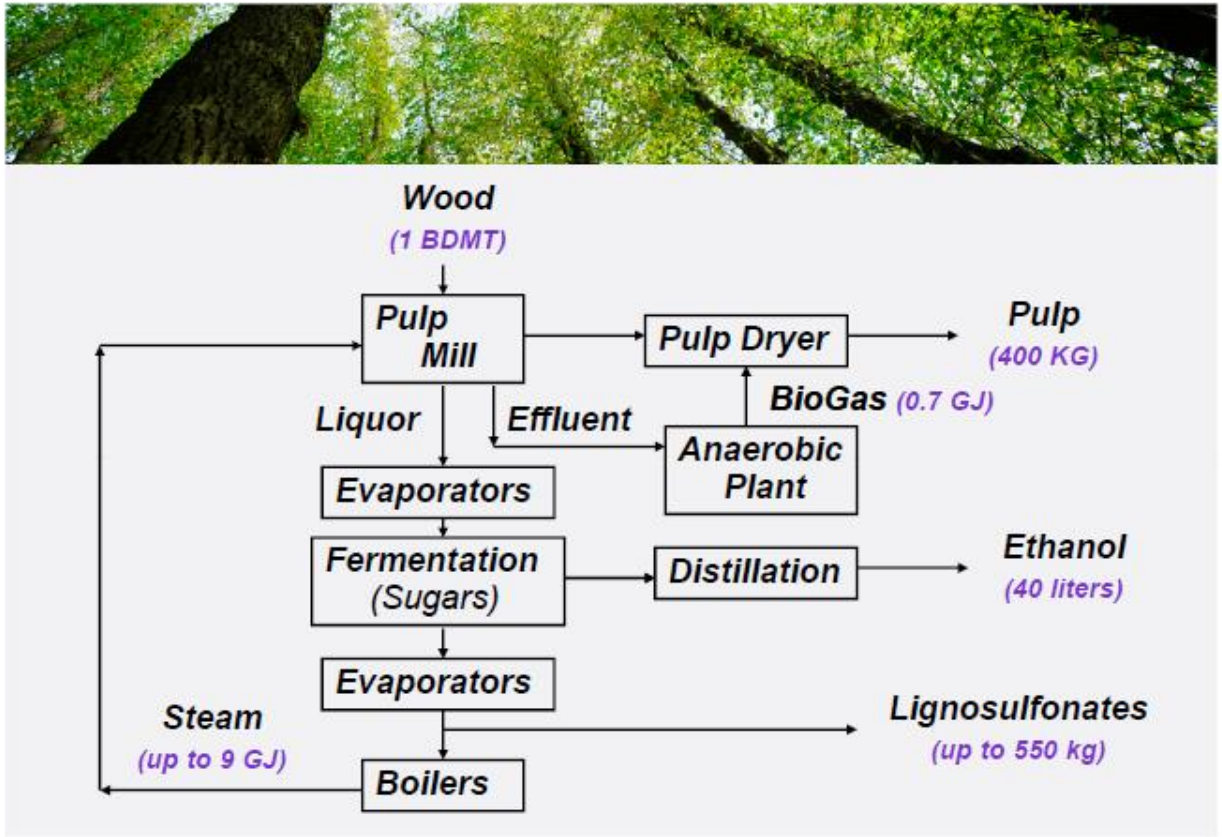
- **Running commercial biorefineries**
- **Demonstration plants**
- **Pilot plants**

Dominant Types:
- Pulp and Paper mills
- 1G Bioethanol plants
- Value to MSW

* As defined by IEA Task 42

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	www.highmark.ca
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	www.ensyn.com
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_2	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	www.permolex.com
GreenField Specialty Alcohols Inc.- commercial facility (Chatham, ON)	Corn (grain)	Ethanol, corn oil, DDGS sold for animal feed, CO_2 sold for industrial uses; 2013: use of CO_2 and heat by adjacent greenhouse	Conventional biochemical conversion process to produce ethanol (197 million litres per year) and DDGS (132,000 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	http://www.gfsa.com/

Company Tembec
Facility: Temiscaming, QC



Development Timeline

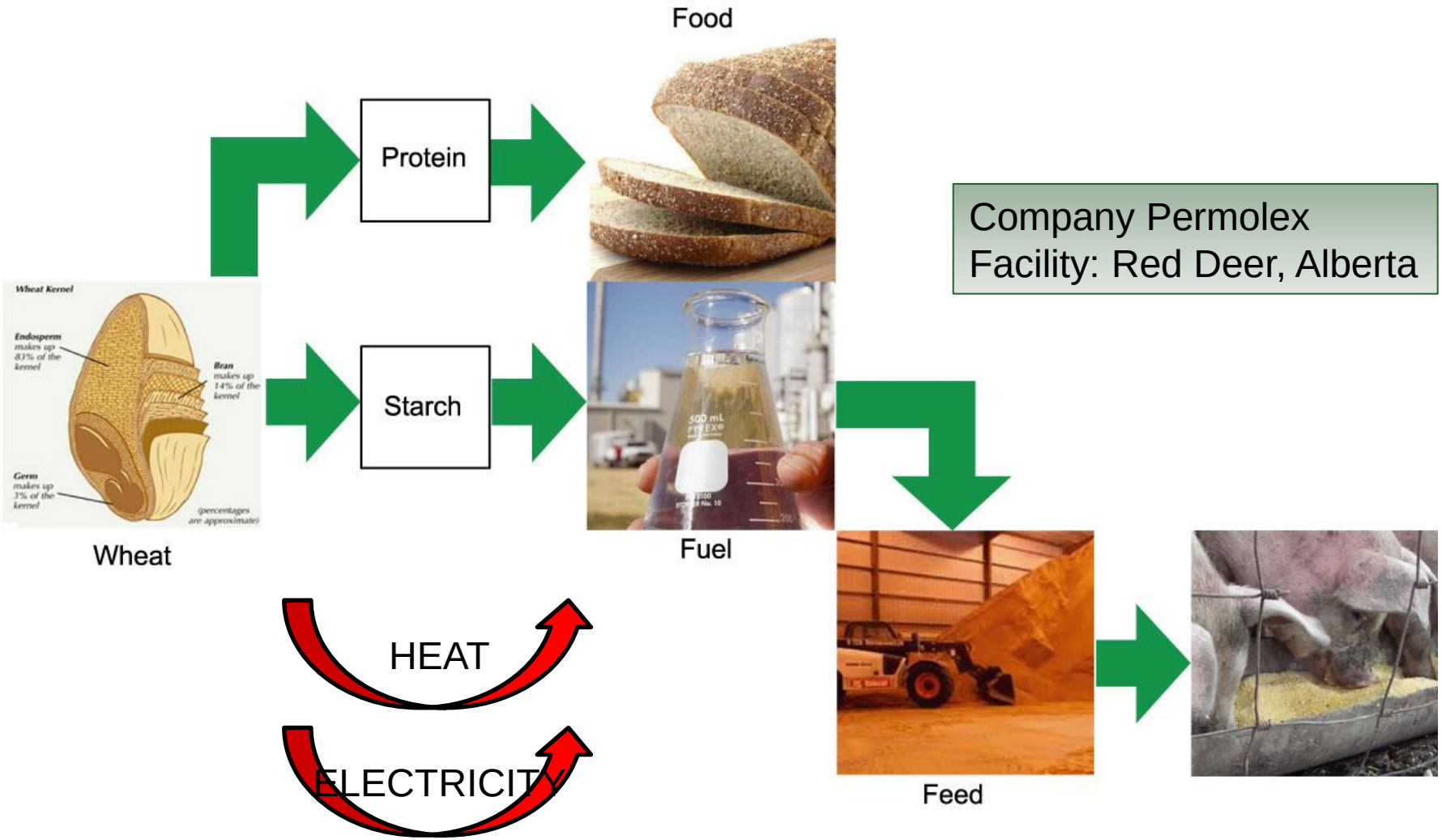
1981
- Capture lignosulfonate energy and chemical value from waste stream
- Included boiler modifications, acid recovery equipment

1982
- Venture into lignosulfonate market to enhance value
- Included spray dryer, equipment to change base of lignosulfonates
- 1991
- Production of commercial alcohol to extract further value from lignosulfonates
- Installation of fermentation and distillation equipment

2006
- Production of biogas to extract energy value from waste stream
- Installation of anaerobic wastewater reactor and burner modifications

2012
- Tembec announces first phase of $310M investment to reinforce its position as a global leader in specialty cellulose

2014
- New projects underway …



Source: Jeff Bell, Alberta Bioproducts (2013)

Company Enerkem Alberta Biofuels
Facility: Edmonton, Alberta

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

Winter 2014

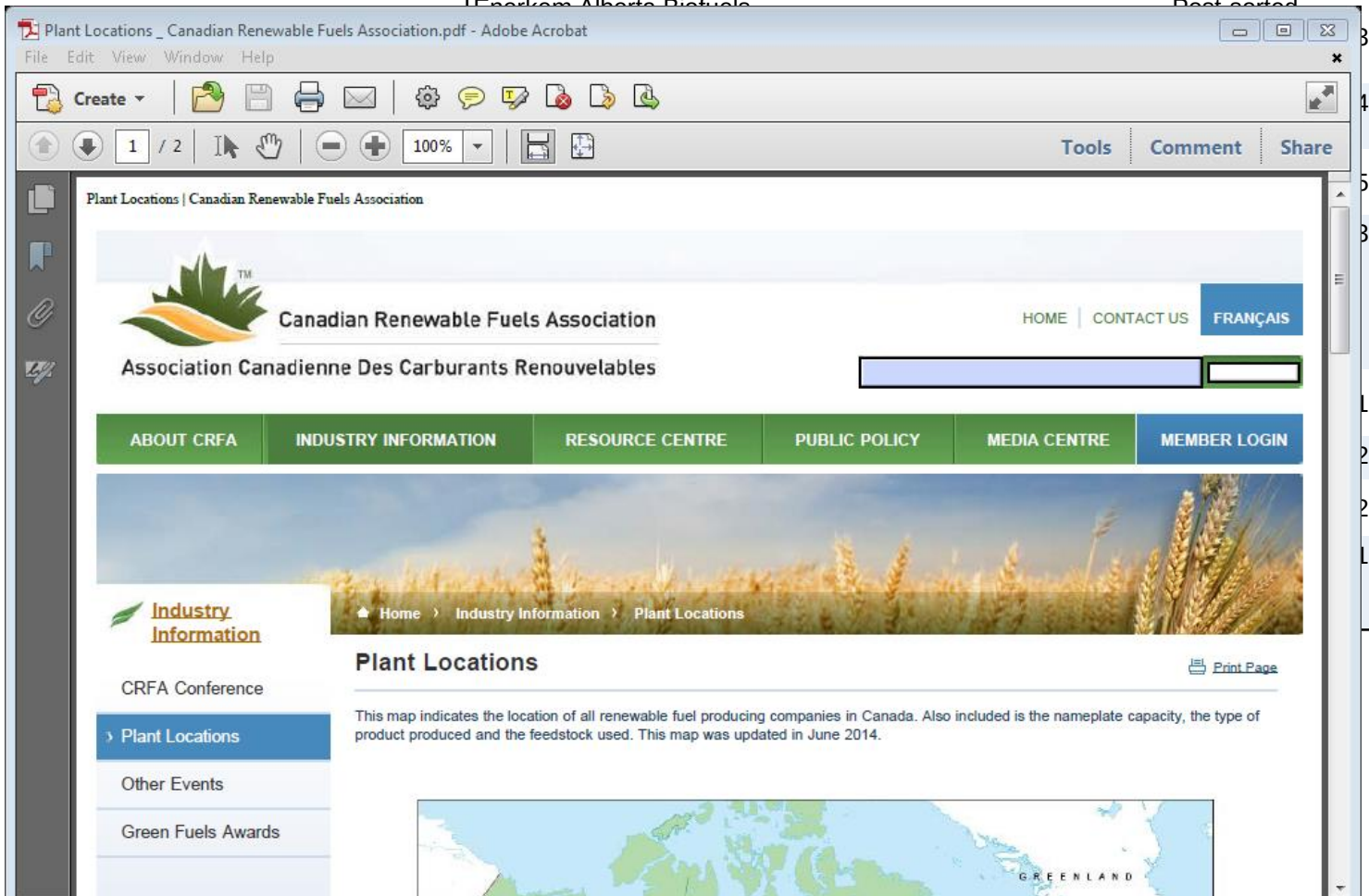
Source: Jeff Bell, Alberta Bioproducts (2013)

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, 15 M litres high purity ethanol, 170,000 kt lignosulphonate, up to 600k GJ/yr biogas	Biorefinery integrated into dissolving pulp production. Pulping liquor passed through fermentation and distillation to produce high purity ethanol. Effluent streams passed through Paques high rate anaerobic wastewater reactor to produce biogas used in the High Yield pulp drying process.	Multiple bio-products including specialty pulps, ethanol, lignosulfonates and biogas using wood chips as a feedstock	http://tembec.com/
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	www.alpac.ca Methanol production: *http://www.alpac.ca/content/files/BioMethanolNewsRelease.pdf*

COMMERCIAL Facility Name – (City, Prov.)	Biomass Feedstock	Bioproducts	Description (e.g.technology, capacity, status)	Classification	Website
Enerkem Alberta Biofuels waste-to-biofuels facility - Commercial under construction (Alberta, QC)	Sorted municipal solid waste	Cellulosic ethanol, biomethanol	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	www.enerkem.com
Vanerco waste-to-biofuels facility - Commercial under development (Varennes, 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	www.enerkem.com

+ 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
Enerkem Alberta Biofuels			Post-sorted	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



Evolution to More Complex Biorefineries

IGPC Ethanol Inc.
Aylmer, Ontario

Task 42 Site Visit
December 4, 2014

PILOT Facility Name – (City, Prov.)	Biomass Feedstock	Bioproducts	Description (e.g.technology, capacity, status)	Classification	Website
Lignol 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	www.lignol.ca/ info@lignol.ca
Bio-economy Technology Centre – pilot plant located at Resolute 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	www.resolutefp.com Pilot plant: http://www.cribe.ca/projects/content/projects/article/fpinnovations-lignin-pilot-plant
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	www.enerkem.com
GreenField Specialty Alcohols Inc. cellulosic ethanol pilot facility (Chatham, ON)	Low to high lignin cellulosic feedstocks (residues and purpose grown crops)	Cellulose and hemicellulose sugar monomers, cellulosic ethanol, acetic acid, distillers grain, CO_2, lignin used for process energy	Percolation/hot water/steam explosion pretreatment equipped with proprietary Modified Extruder Technology followed by hydrolysis, fermentation of C5 and C6 sugar monomers, and the production of acetic acid	4-platform (C6&C5 sugar, distillers grains, acetic acid, heat) biorefinery using agriculture and forest residues for bioethanol, chemicals, value added products and bioenergy	http://www.gfsa.com/

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	www.enerkem.com
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	www.domtar.com Demo plant: www.celluforce.com

Major R&D Consortia & Projects

Major national stakeholders involved in the field of biorefining

IEA Bioenergy

Task 42 Biorefining

Major R&D Consortia (Forest)

R&D Consortium or Network	Coordinator	Description: Goal, Methodology, Results	Start Date	End Date
NSERC FIBRE Network www.fibrenetwork.org	Dr. Theo van de Ven (McGill University)	Organization that builds synergies among eight forest NSERC funded strategic research & development networks in support of the priorities of Canada's vital forest sector innovation system		
ForValueNet Network www.forvaluenet-foretvaleur.ca	Daniel Breton (Universite Laval)	Aim: to develop a series of new and integrated models to support value-added wood decision-making strategy for Canada's boreal forests.		
Value Chain Optimization Network www.reseauvco.ca	Catherine.Savard (Universite 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.	2010	
Bioconversion Network www.nsercbioconversion.net	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 www.lignoworks.ca	Dr. John Schmidt (FPInnovations)	Aim: To generate new knowledge to develop innovative, high value-added lignin-based materials and chemicals.		
Sentinel Bioactive Paper Network www.bioactivepaper.com	Robert Pelton (McMaster Univ)	Aim: To develop bioactive paper that will detect, capture and deactivate water and airborne pathogens.		
NEWBuildS – Network on Engineered Wood-based Building Systems http://newbuildscanada.ca	Dr. Y. H. Chui (University of New Brunswick)	Goal: To advance scientific knowledge and construction technologies that will enable wood-based products to be used in mid-rise and non-residential construction, or integrated into hybridized construction.		
Innovative Green Wood Fibre Products Network www.greenfibrenetwork.ca	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.		
ArboraNano – Canadian Forest NanoProducts Network www.arboranano.ca		ArboraNano brought together researchers from vastly different industries to research and develop products that were based on plant-derived nanomaterials – nanocellulose, and also brought together scientists and engineers focused on using nanotechnology to develop advanced new high-value forest products and enhance the performance of traditional paper and building products.		March 2014

RÉSEAU BIOFUELNET CANADA

Largest advanced biofuels network in Canada

Operates under a $25 million grant over 5 years (2012 to 2017) through the Networks Centres of Excellence program of the Federal Government

- 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
- Accelerates commercialization; supports the growth of Canada's advanced biofuels industry
- 68 project grants (unique research projects)
- Facilitates collaboration/partnerships
- Government engagement
- Trains graduate students

www.biofuelnet.ca

Major R&D Consortia

R&D Consortium or Network	Coordinator	Major Objective	Start Date
Biorefining Conversions Network www.bcn.ualberta.ca	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 www.biofuelnet.ca	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.	2013
Bioproducts Cluster www.bicsarnia.ca	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 www.fibrecity.ca	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 www.nrc-cnrc.gc.ca/eng/solutions/collaborative/algal_index.html	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 www.nrc-cnrc.gc.ca/eng/solutions/collaborative/industrial_bio_index.html	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 *(under development)*	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

FPInnovations

NGOs

University Networks (NSERC)

Provincial & Territorial Governments
Forestry Departments

Industry Associations (FPAC, etc.)

Natural Resources Canada
Canadian Forest Service

Forest Product Companies

Agriculture and
Agri-Food Canada

Bioproducts Interdepartmental Working Group (federal government)

Bio Pathways Network
www.fpac.ca/index.php/en/bio-pathways-network

Fisheries and
Oceans
Canada

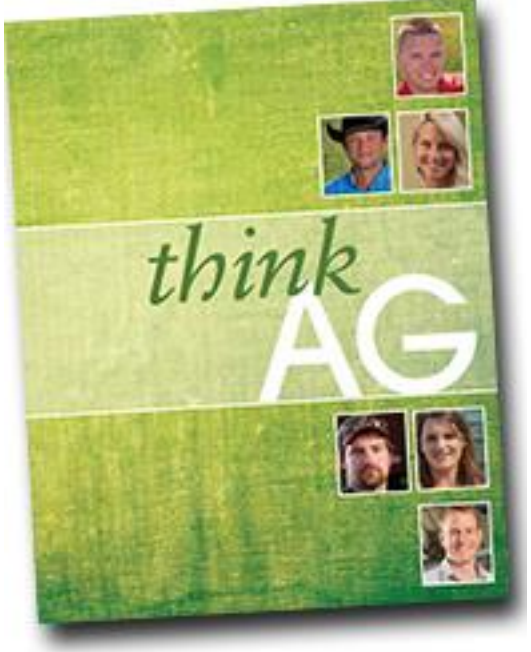
Natural Resources Canada
Innovation and Energy Technology

Connections with other industries, new product markets

Industry Canada

Canadian Biomass Innovation Network
cbin.gc.ca

Canadian Stakeholders



Agriculture and Agri-Food Canada

Provincial Governments Agriculture Departments

Federal-Provincial-Territorial Bioproducts Working Group

Industrial Bioproducts Value Chain Committee (IBVCC)*
Goverment and Industry co-chaired by Dr. Murray McLaughlin (BIC)

CanBIO

Ontario Agri-Food Technologies

Alberta Innovates

AgWest Bio

Soy 2020

BIOTECanada

Canadian Renewable Fuels Association

Canadian Federation of Agriculture

PEI BioAlliance

* 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

Agriculture Products

- Food Processing
  - Functional Foods
- Chemical Industry
- Biofuels Production
- Electric Utilities

Waste Management

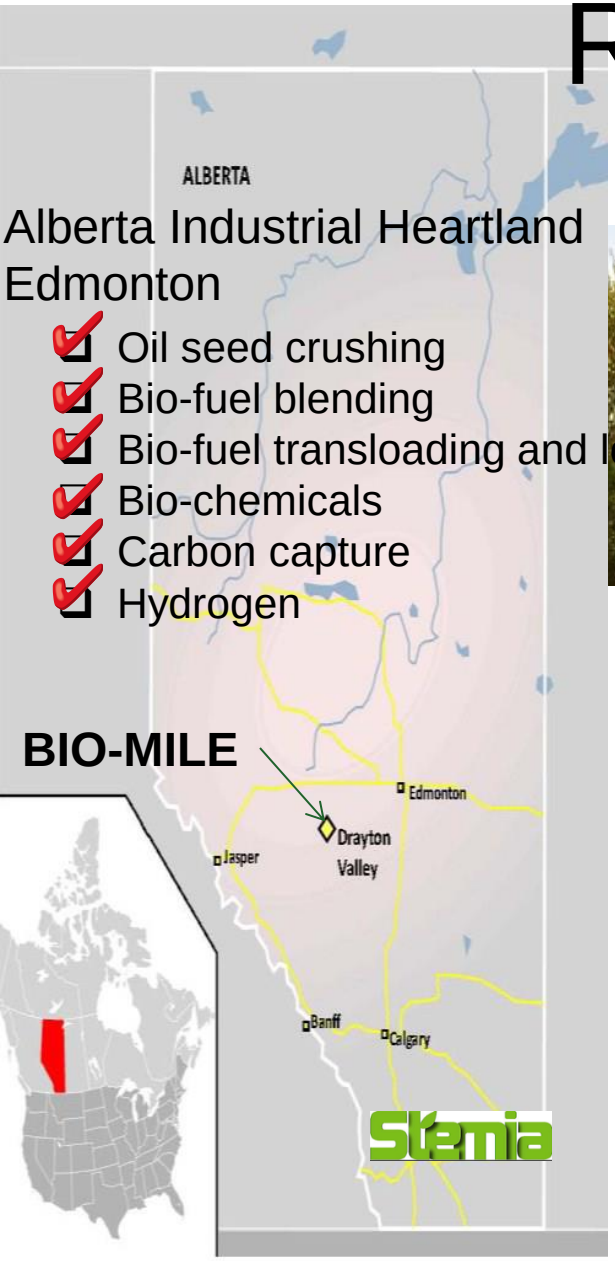
- Electric and Natural Gas Utilities

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

Regional Clusters

Alberta Industrial Heartland
Edmonton

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



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