



Biofuels development in Canada and the US

Donald L. Smith

James McGill Professor

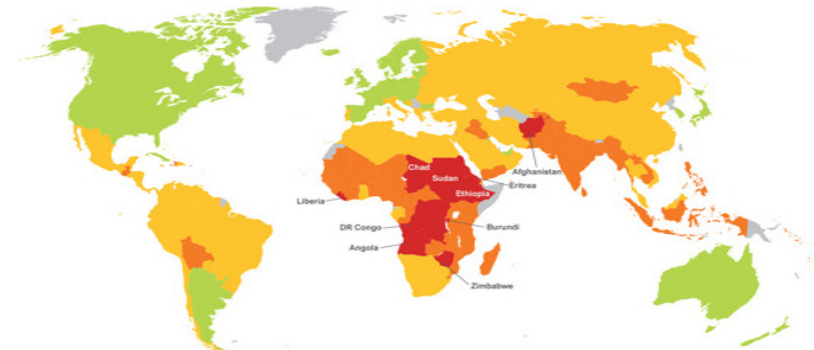
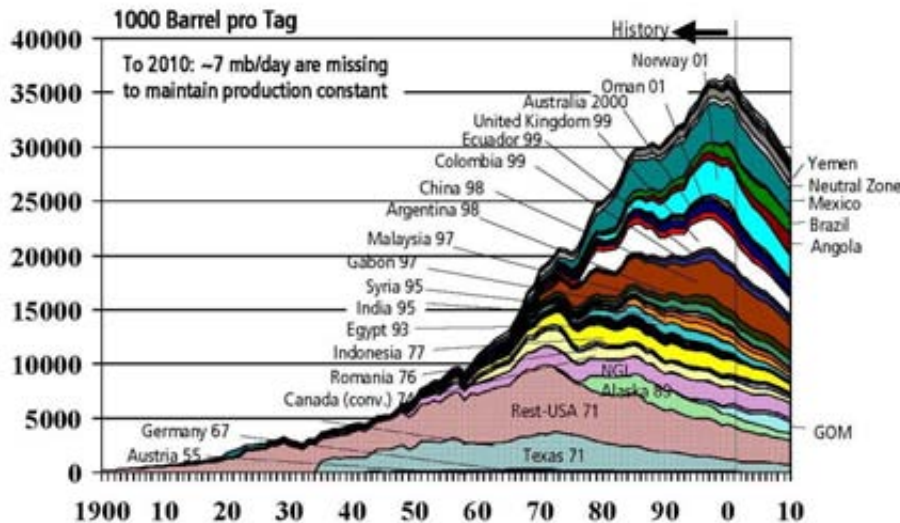
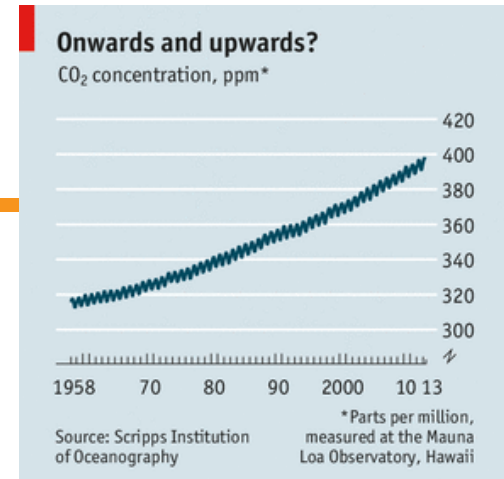
CEO & Scientific Director

BioFuelNet Canada



Motivations

- Greenhouse accumulations
- Climate change
- Energy security
- Food security



Legend	Rank	Country	Rating	Rank	Country	Rating
Extreme risk	1	Afghanistan	Extreme	6	Ethiopia	Extreme
High risk	2	DR Congo	Extreme	7	Angola	Extreme
Medium risk	3	Burundi	Extreme	8	Liberia	Extreme
Low risk	4	Eritrea	Extreme	9	Chad	Extreme
No Data	5	Sudan	Extreme	10	Zimbabwe	Extreme

Advanced biofuels are produced from *non-food* materials



Agro-forestry waste



Energy crops



Algae



Municipal waste

Advanced biofuels

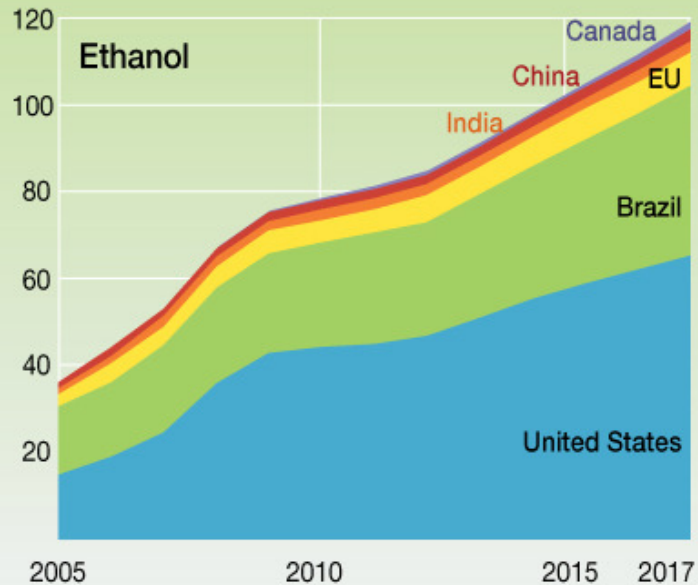
Renewable biofuels can provide:

- **Sustainable** source of energy
- **Reduced** GHG emissions
- **Reduced** reliance on food crops for biofuel production

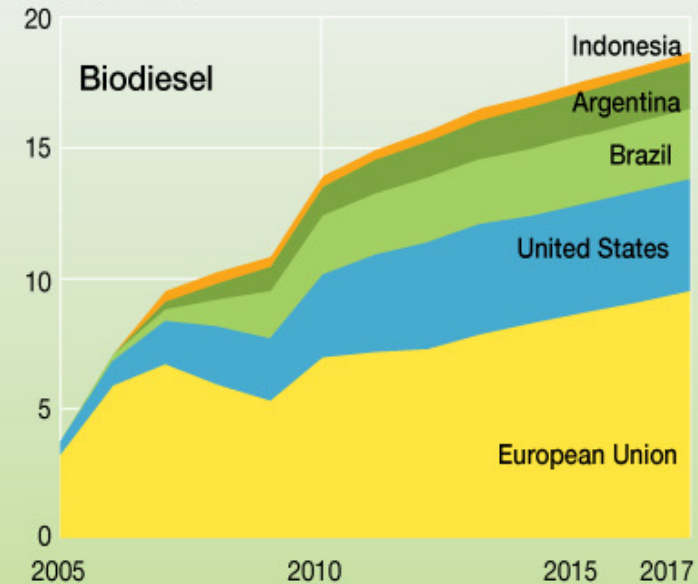


World biofuels production trends

Billions of litres



Billions of litres



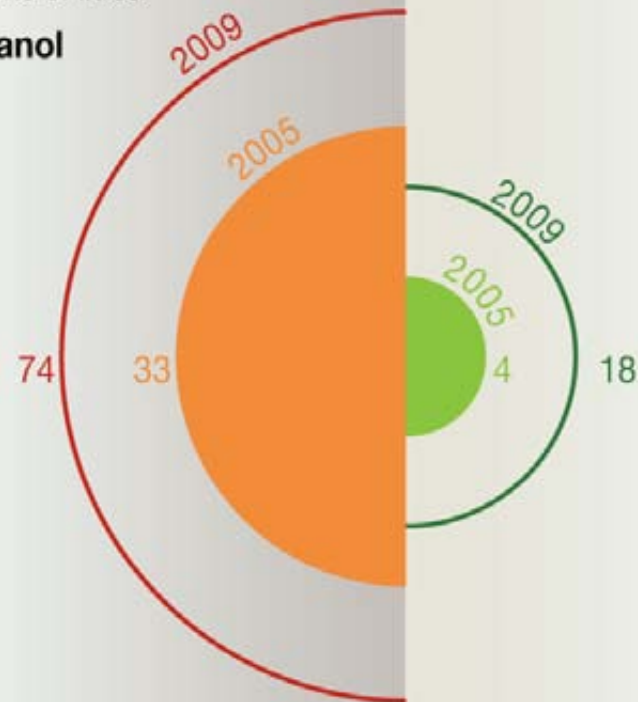
Source: FAPRI, U.S. and World Agricultural Outlook, 2008.

Global production of biofuels

Billions of litres

Ethanol

Biodiesel



Source: Biofuels Platform, Geographic distribution of bioethanol and biodiesel production in the world in 2008, Ren 21, Renewables status report, 2006 and 2010.

Biofuels mandates around the world

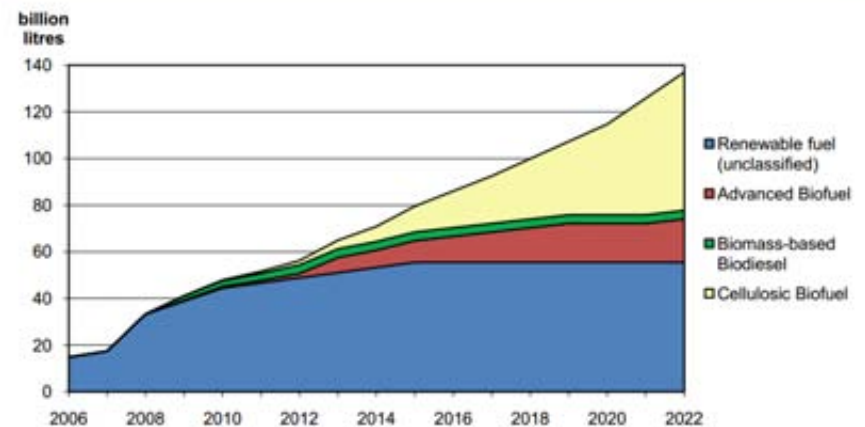
Country	Total renewable fuels mandate	Advanced biofuels mandate
Canada	Ethanol: 5% Biodiesel: 2%	—
Brazil	Ethanol: 18-20% Biodiesel: 5%	—
US	66 B L (9.7%) 144 B L by 2022	10.8 B L (1.6%)
EU	5.75% 10% by 2020	6% cap for first generation biofuels
China	10 provinces require 10% ethanol 15% by 2020	—
India	Ethanol: 5% 20% by 2017	—



United States

- Largest biofuels producer in world
- Corn-based ethanol: over 89% of fuel ethanol production in the United States
- Renewable Fuel Standard (RFS): requires increase in consumption of lignocellulosic ethanol
- RFS calls for min. GHG savings for advanced biofuels of 50-60% compared to fossil fuel

Figure 7. Biofuel Mandate in the United States Renewable Fuels Standard



Renewable fuel: includes all types of biofuel; Advanced Biofuel: biofuels other than corn-based ethanol with GHG savings >50%; Biomass-based Biodiesel: biodiesel with GHG savings >50%; Cellulosic Biofuel: lignocellulosic biofuel with GHG saving >60%.

Source: U.S. Renewable Fuels Standard



Commercial scale advanced biorefineries in US

INEOS Bio - New Planet Energy -- Indian River BioEnergy Center

- Vero Beach, Florida
- Opened July 2013
- Capacity: 32 M L yr⁻¹ and 6 megawatts (gross) of renewable power

INEOS Bio

POET-DSM -- Project Liberty

- Emmetsburg, Iowa
- Opened Sept 2014
- Capacity: 100 M L yr⁻¹



DuPont -- Nevada Site Cellulosic Ethanol Facility

- Nevada, Iowa
- Operational Date: Q4 2014
- Capacity: 120 M L yr⁻¹

Creating Sustainable Supply
Chains for Cellulosic Biofuels



The miracles of science™

Abengoa -- Bioenergy Hugoton Cellulosic Ethanol Facility

- Location: Hugoton, Kansas
- Operational Date: Q2 2014
- Capacity: 100 M L yr⁻¹ plus 21 megawatts of renewable electricity

ABENGOA

Innovative technology solutions for sustainability

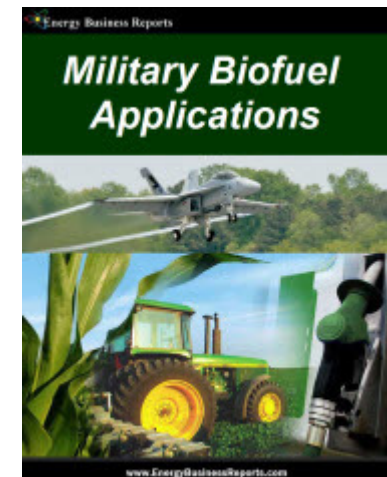


US Military

- The US Air Force, Navy, Army and Marine Corps: very ambitious targets to reduce dependence on fossil fuels and to develop renewable fuels
- US Navy and the US Marine Corps: 50% of its total energy from alternative sources by 2020
- US army plans to use 25% renewable energy by 2025
- Marines will demonstrate the Great Green Fleet, by 2016

The US DoD recently awarded \$210 M to the following companies to build biorefineries:

- Emerald Biofuels
- Fulcrum BioEnergy
- Red Rock Bio



Cost-competitive (<\$3.50 per gallon; \$0.88 L⁻¹) drop-in military biofuels - 400 million L yr⁻¹



Canada

- Canadian biofuels production has increased 10 fold in the last 10 years.
- Canada needs 2.2 billion liters of ethanol per year to fill 5% mandate
- ~41 percent of Canada's 5% mandate is met through US corn ethanol imports
- Canadian biofuels mandates were implemented in 2010





Canada

- Half of Canada's bioethanol production is in the three provinces: Saskatchewan, Manitoba, and Ontario.
- Main ethanol feedstocks: corn and wheat
- Main biodiesel feedstocks: canola



Canadian provincial mandates

Province	Ethanol	Biodiesel
British Columbia	5%	4%
Alberta	5%	2%
Saskatchewan	7.5%	2%
Manitoba	8.5%	2%
Ontario	5%	

- Concerns: with each provincial government implementing its own complex production and/or consumption incentives with differences in eligibility and duration, there may be barriers to trade and production in areas not well suited to bioethanol production.
- Canada's refineries are mostly in western Canada (Alberta) and on the east coast (Newfoundland and Labrador), while most gasoline is used in central Canada (Quebec and Ontario).



Advanced biorefineries in Canada

Commercial scale:



Enerkem – Alberta Innovates

- Edmonton (municipal waste)
- Operational (opened in June 2014)

Enerkem - GreenField Ethanol Inc

- Varennes, Quebec (waste from institutional, commercial and industrial sectors as well as construction and demolition debris)
- In construction



Both 38 M L yr⁻¹

Enerkem has demonstration plants: Westbury and Mississippi



Canadian biofuel potential

- Crop residues – 1 to 12% of gasoline
- Purpose grown crops – 6 to 285%
- Forest residue – 3 to 34%
- Mill residues – 1 to 4%
- MSW – 2 to 6%
- TOTAL – 13 to 341%



With careful management Canada could supply its transportation fuel through biomass

Mabee and Saddler 2010

BioFuelNet: Network premise

There is an urgent need to develop sustainable and renewable energy sources that do not compete with food production and do not harm the environment

- **Greenhouse gas emissions**
- **Climate change**
- **Energy prices**
- **Food security**





Advantages of advanced biofuels

- **Sustainable** source of homegrown renewable energy
- **Compatible** with the existing petrochemical infrastructure
- **Enhanced** energy security/independence
- **Revitalizing** rural economies and job creation
- **Reduced** carbon footprint compared to petroleum

BioFuelNet: Our vision & mission

- **Our vision** is a Canada with a thriving advanced biofuels industry that is socially, economically and environmentally sustainable.
- **Our mission** is to support the growth of Canada's advanced biofuels industry through coordinated research, innovation, effective education, smart policy and strategic partnerships.



BioFuelNet: About the network

BioFuelNet Canada is a Network of Centres of Excellence (NCE) that brings together the Canadian biofuels research community.

Operates under a \$25 million grant over 5 years (2012 to 2017) through the NCE program, \$35 million from partners. If funded for three cycles (15 years) almost \$200 million.

- **64 project grants**
- **Facilitates collaboration**
- **Supports commercialization**
- **Government interaction**
- **Represents Canada**
- **Trains students**



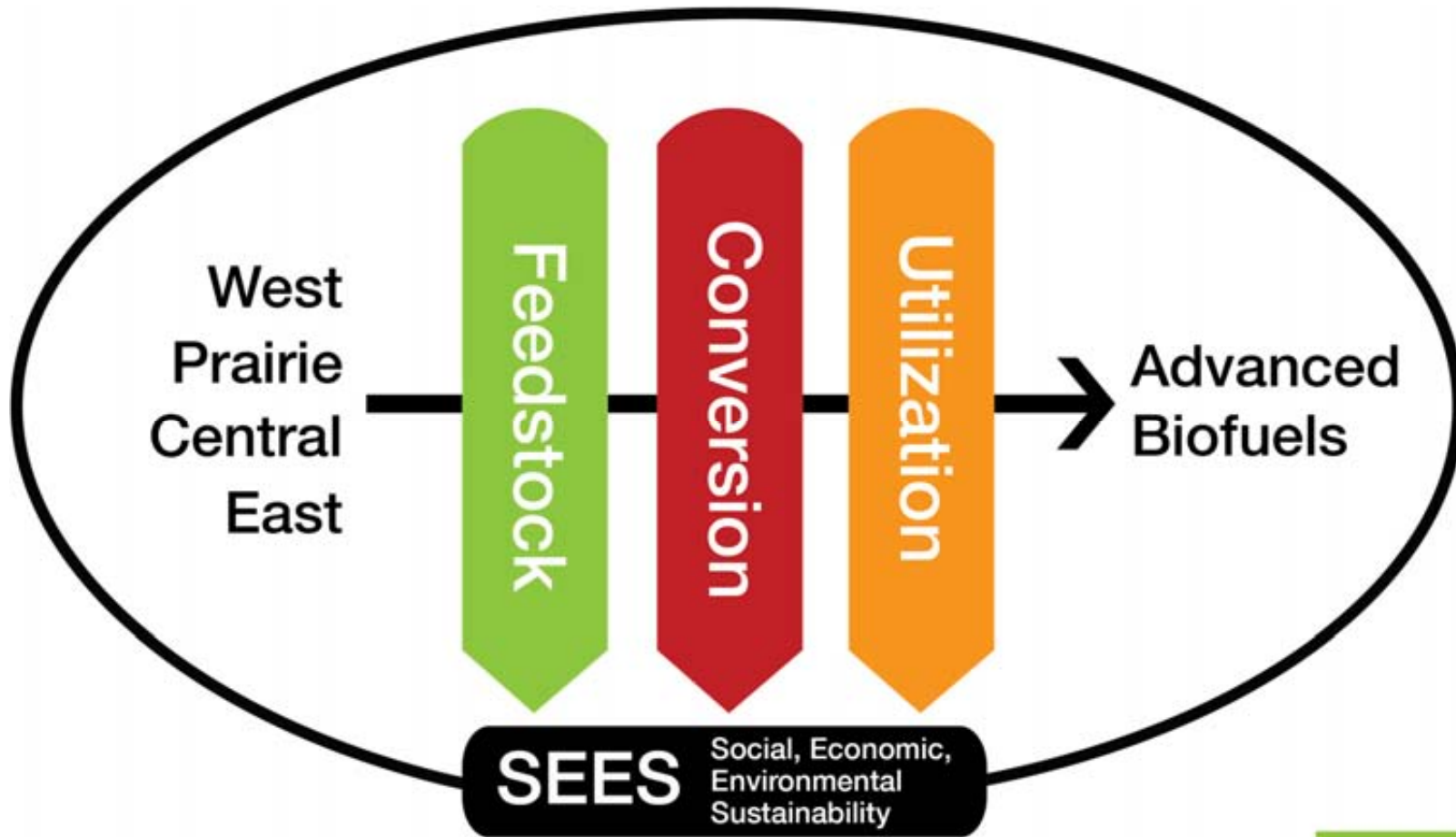


Who is involved?

- McGill University (Host)
- 27 universities
- ~130 researchers
- ~57 industry partners
- Over 140 partners
- 278 Highly Qualified Personnel (HQP)
- Numerous national & international contacts



BioFuelNet: Network structure



Key research collaborations & partnerships



BioFuelNet: Benefits to Canada

Economic

Employment creation
Energy security
Commercialization

Environmental

Reduced emissions
Land use optimization
Sustainable energy

Social

Professional training
Rural revitalization
Policy Recommendations



Thank you!



Dr. Donald Smith
CEO & Scientific Director
BioFuelNet Canada

514-508-2884 / donald.smith@mcgill.ca / www.biofuelnet.ca