The Future of Biofuels

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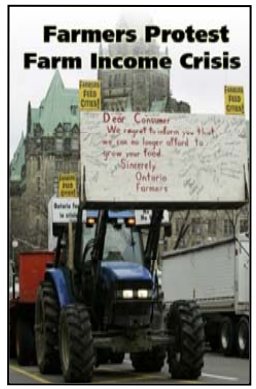
Session 1B: Focus on Alternative and Emerging Energy
***2008 Energy Futures Workshop** Ottawa, Ont - Jan. 22, 2008*

Special Thanks to:

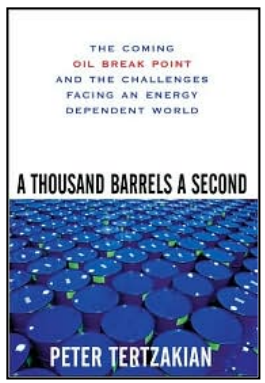
Why Biofuels?

Primary 'Driver' for 1st Generation Biofuels



Rural Economy

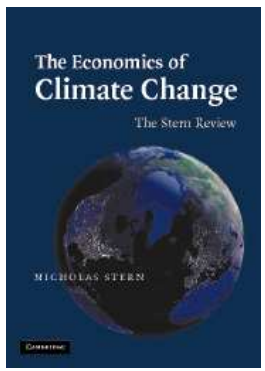
- *New markets*



Energy Security

- *NA access to oil & NG;*
- *Peak oil (& NG) concerns;*

Emerging 'Driver' for Biofuels



Climate Change

… the future of biofuels depends on an alignment of policies with key 'Drivers'.

Fundamental Assumption Differences

Driver	NEB	This Analysis
Energy Security *(price, access, availability)*	➢ Less than today: $35 - $85/boe; ➢ No mention of peak oil or gas; ➢ No discussion of possible fuel shortage	➢ More than today: $100 - $150/boe; ➢ If not peak oil, then NA access problems for oil & LNG; ➢ Potential for fuel shortage
Climate Change	➢ Status quo on climate change policies (except Triple E, then some CCS);	➢ A price on carbon; ➢ GHG emission regulations; ➢ C sequestration (geo. & bio)

Biomass as an Energy Resource

Energy Comparison

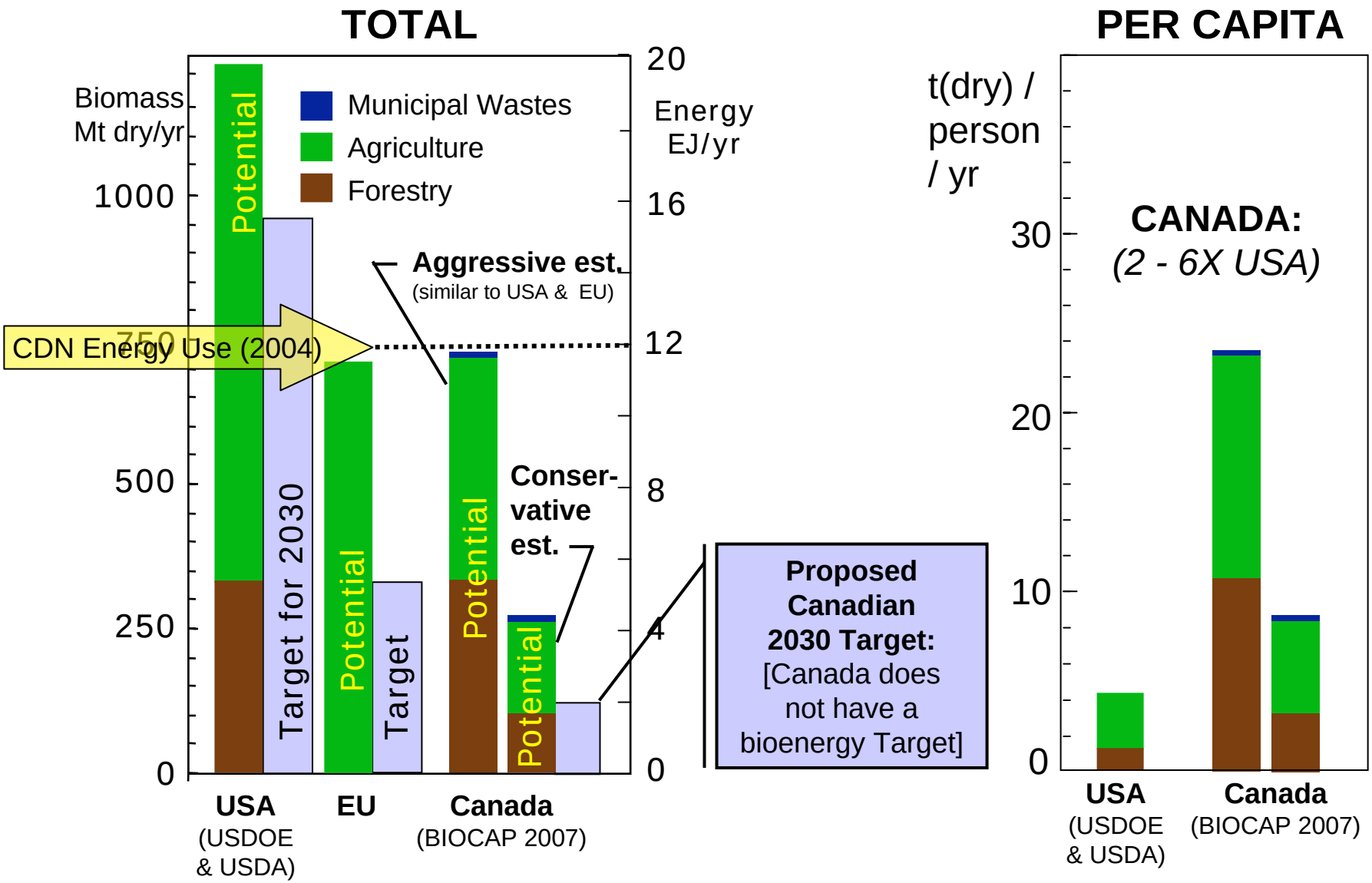
= ~3 barrels oil

About $50 to $100

About $250-$300.

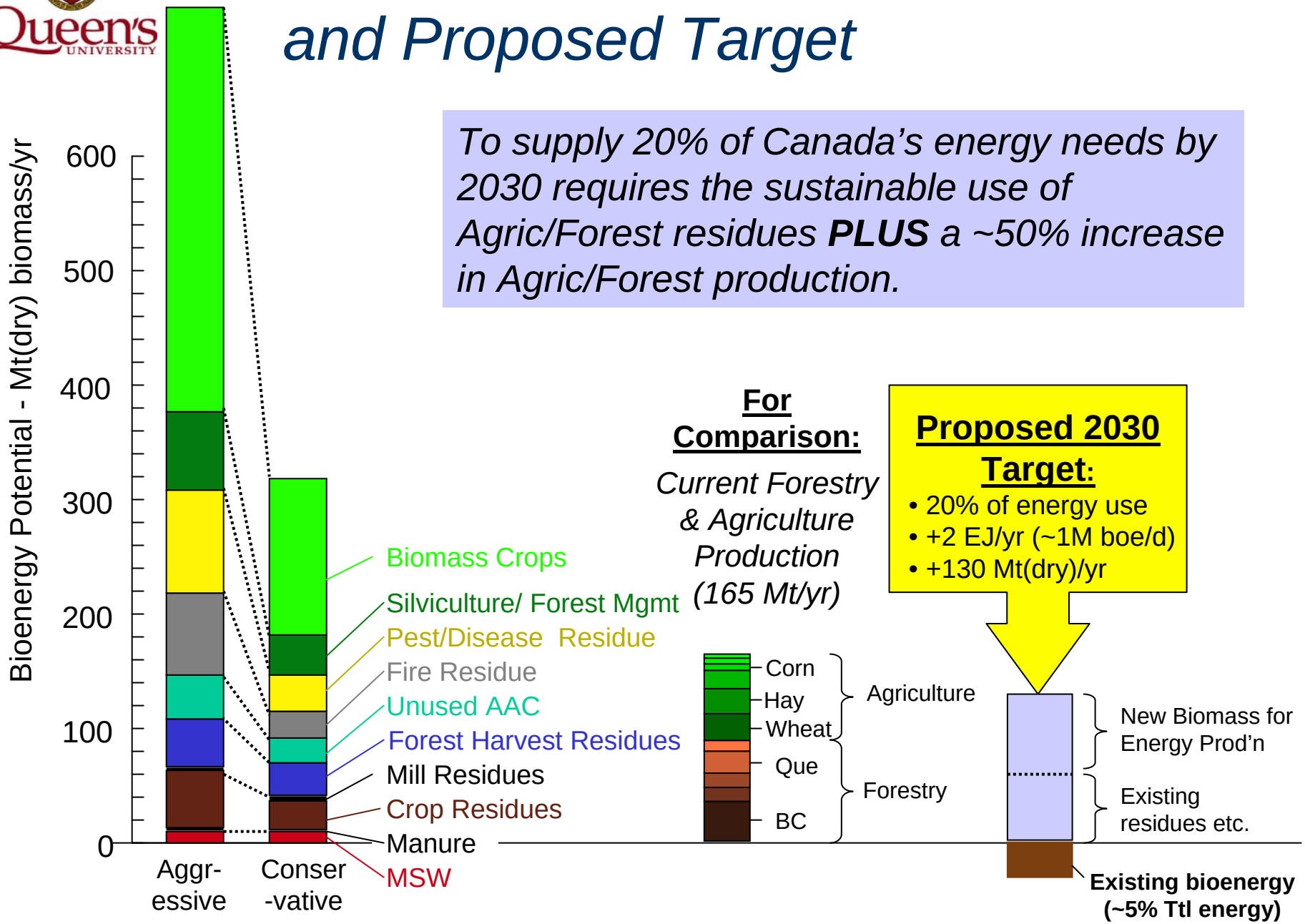
Farm gate, forest road or wellhead price

Biomass for Energy:
Potentials & Targets



Canada's Bioenergy Potential and Proposed Target

*To supply 20% of Canada's energy needs by 2030 requires the sustainable use of Agric/Forest residues **PLUS** a ~50% increase in Agric/Forest production.*



*Canada has a large bioenergy potential and there is a growing interest in how best to use it to address **energy security** and **climate change** priorities.*

…THE key issue is how to make bioenergy sustainable from an:

- *Environmental,*
- *Economic, and*
- *Ethical/Social*

perspective.

Optimal Use of Biomass to Address Climate Change

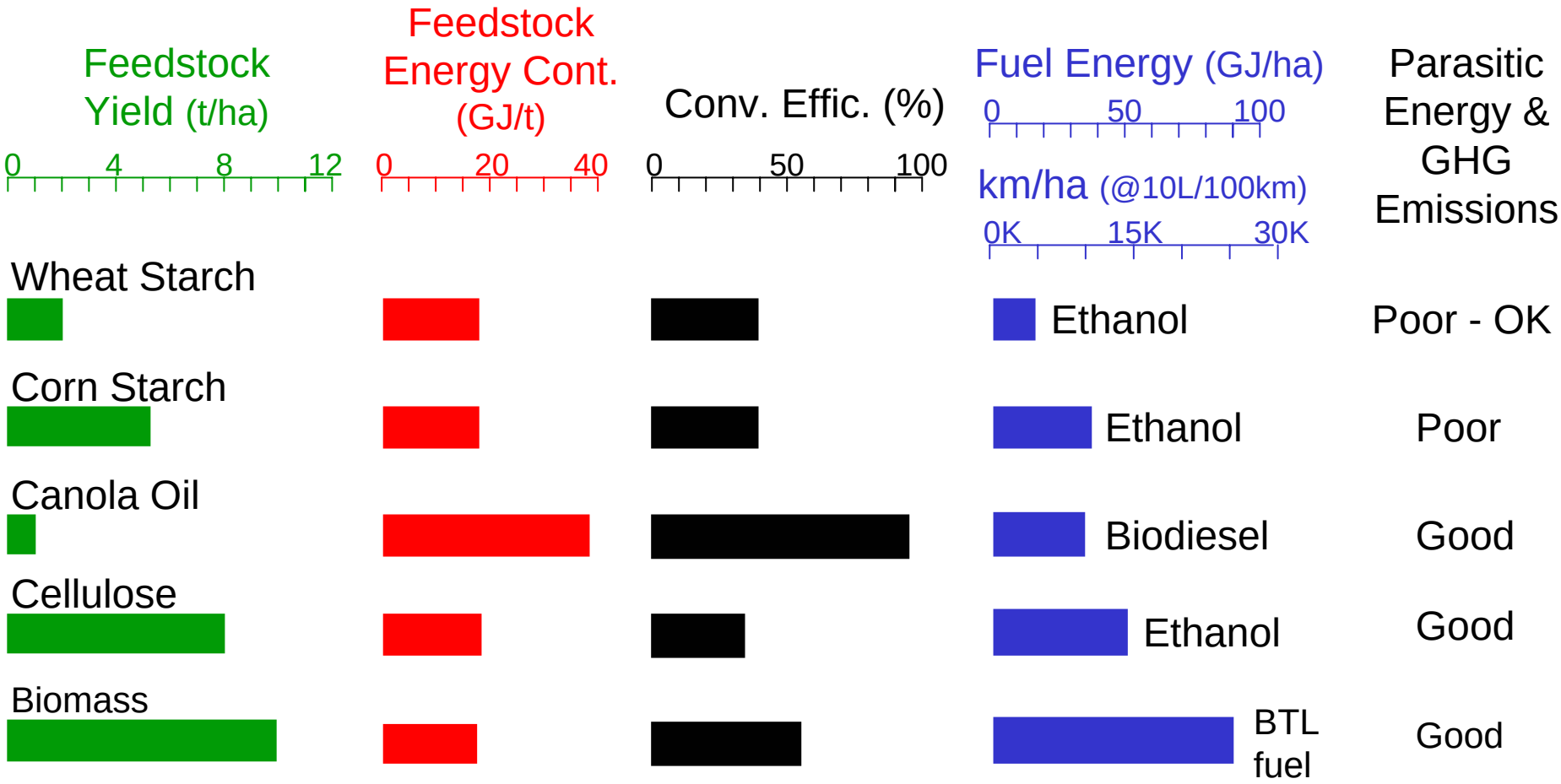
Feedstock	Process	Product	To replace…	Climate Benefit	Mit. Price $/tCO$_2$e
Starch Grains	Fermentation	Ethanol	Gasoline	Small	~$100-530
Oil Seeds	Trans-esterification	Biodiesel	Diesel	Medium	~$100
Straw or Wood	Combustion or Gasification	Power, Cement, Indust. Heat	Coal	High	~$8-70

Refs: Robinson et al 2003; Layzell et al. 2006; Kampman et al. 2006; Zhang et al 2007; Samson et al. 2008

*If climate change is the major driver, **solid biofuels** would be the biofuel of choice. However, the security in the supply of **liquid transportation fuels** will be paramount in North America.*

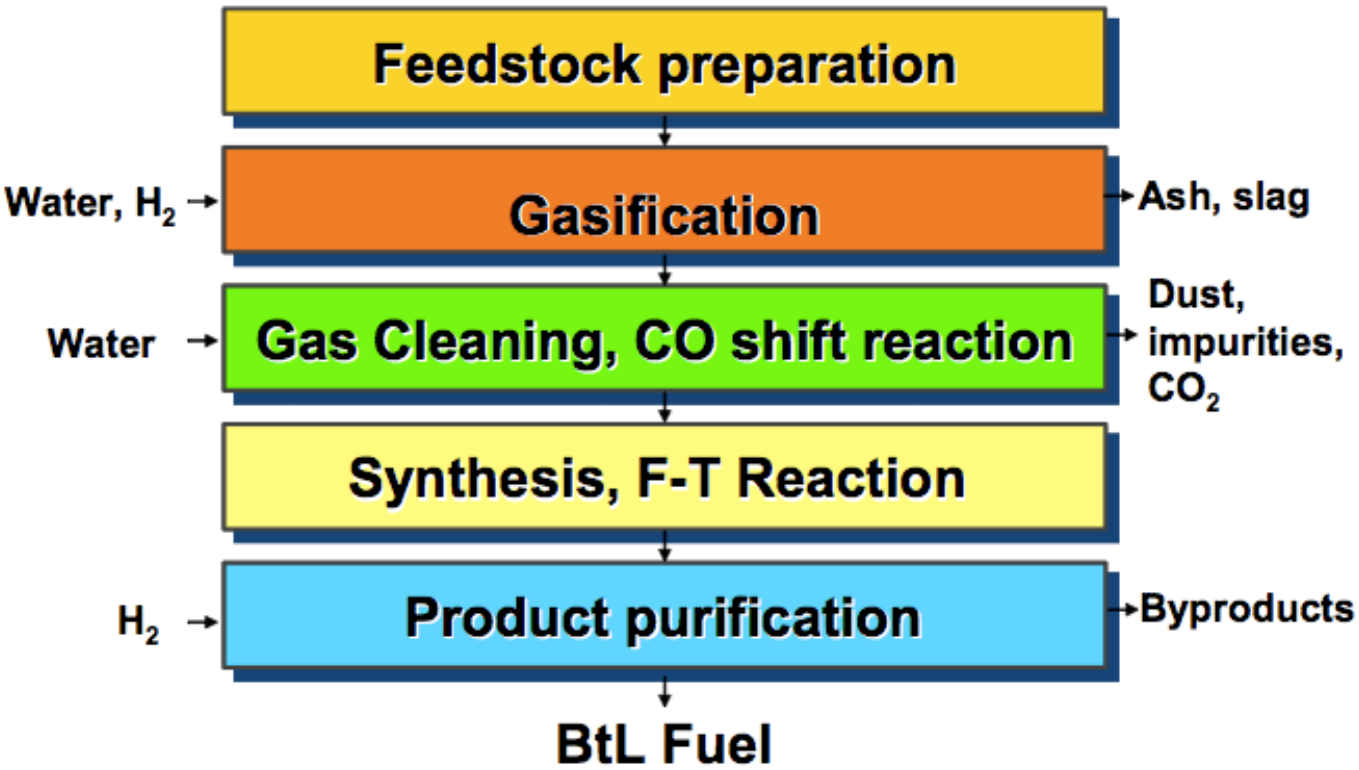
A Biofuel Comparison

… fuel energy per hectare



In a world where energy security is a priority, the high km/ha of biomass-to-liquid (BTL) fuels are likely to be a major asset.

Gasifying biomass to Liquid Fuels

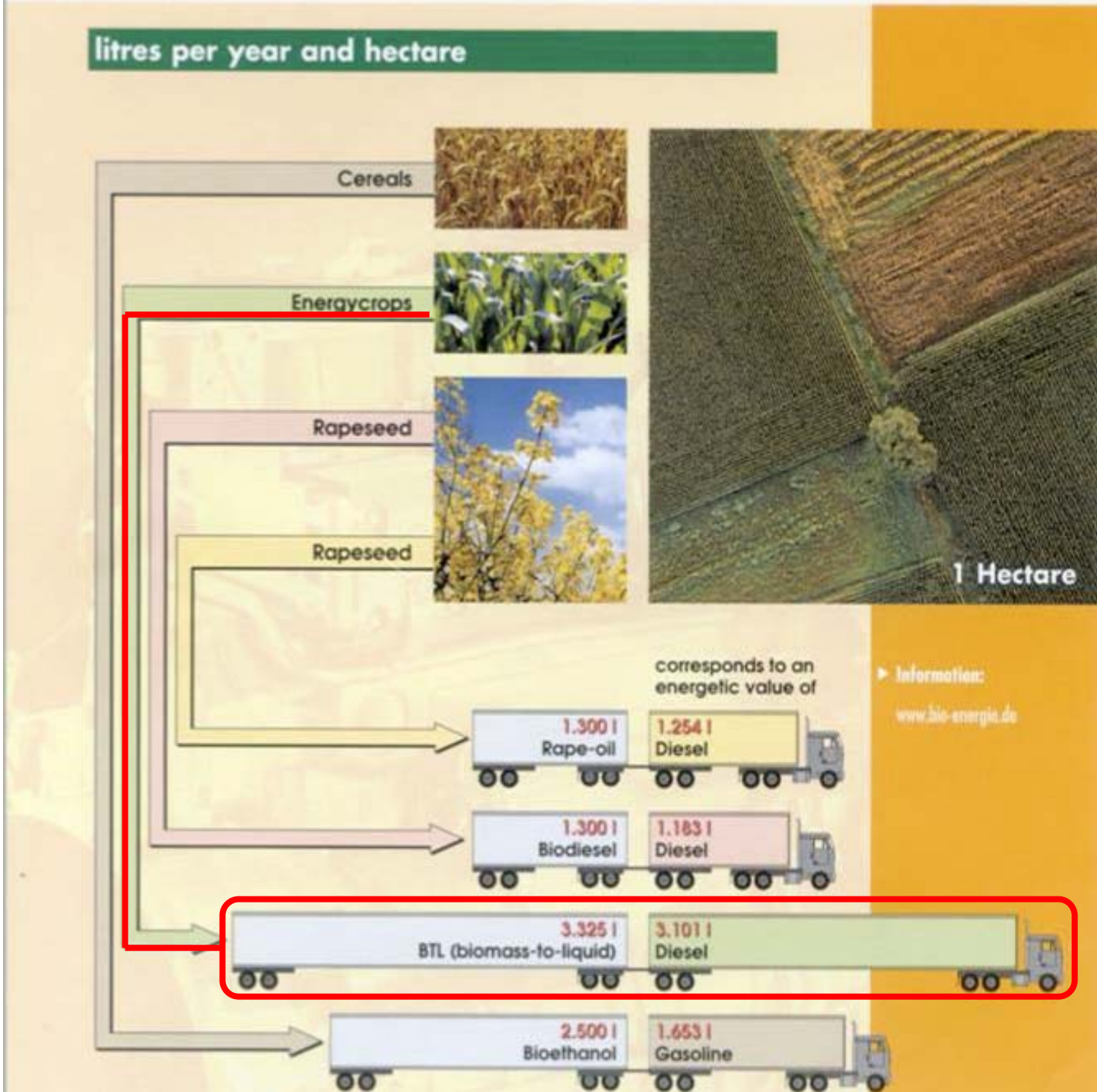


Gasification:

- 900°C +;
- Oxygen limited;
- Produces syngas ($CO + H_2$);
- Syngas can be chemically converted to liquid fuels *(alcohols, diesel, dimethylether, methane);*
- More efficient at larger scale;
- Similarity to Coal to Liquid Technology (CTL)

Many major energy and chemical companies are moving rapidly in this direction

Biofuel Production per ha-yr

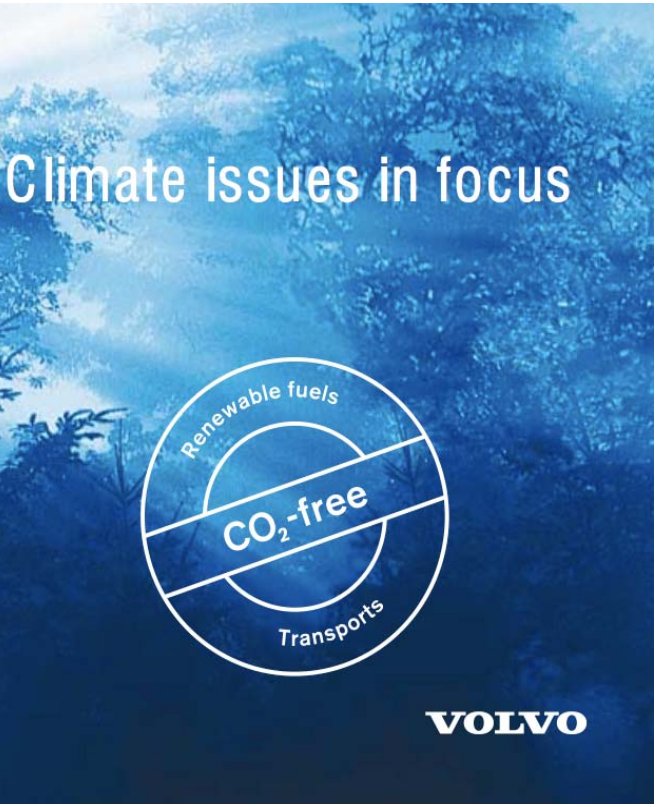


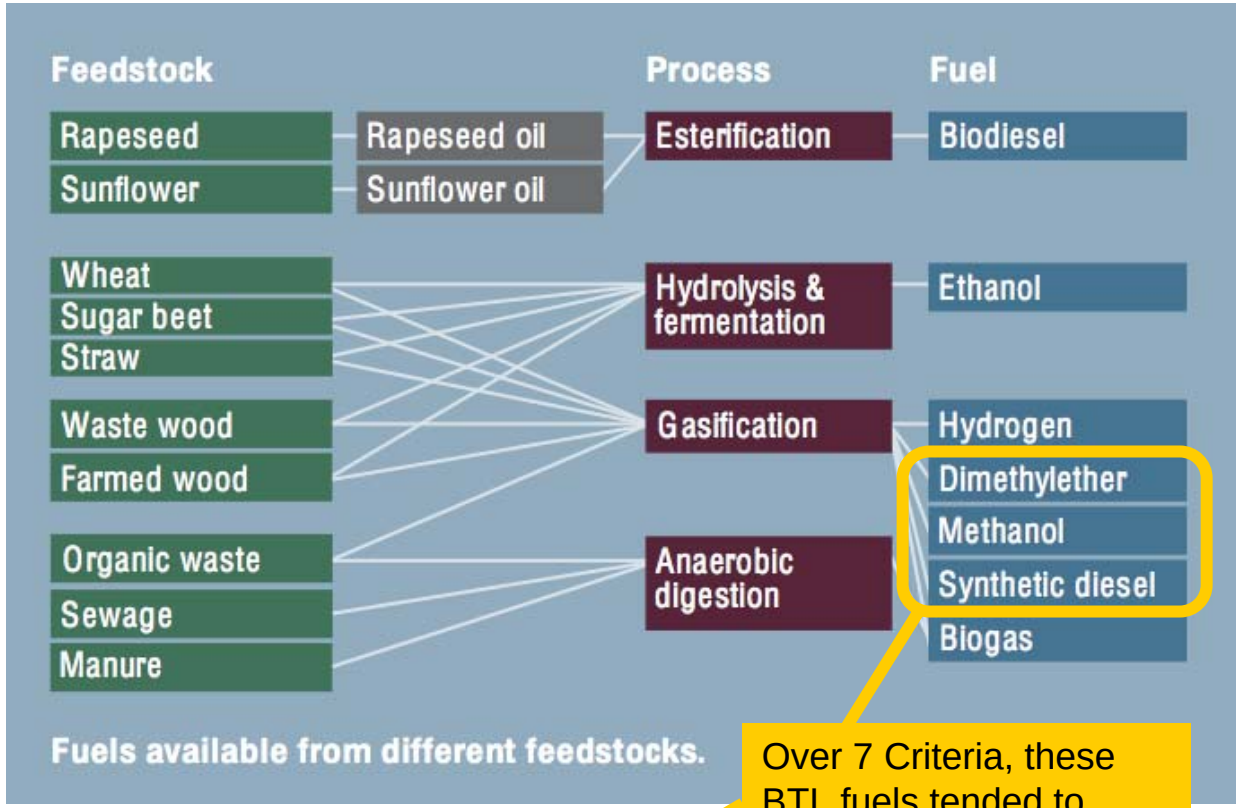
From:
German Gov't Biomass / Bioenergy Service
(www.bio-energie.de)

Volvo Renewable Fuel Study

Aug. 2007

http://www.volvo.com





Over 7 Criteria, these BTL fuels tended to have the highest ranking

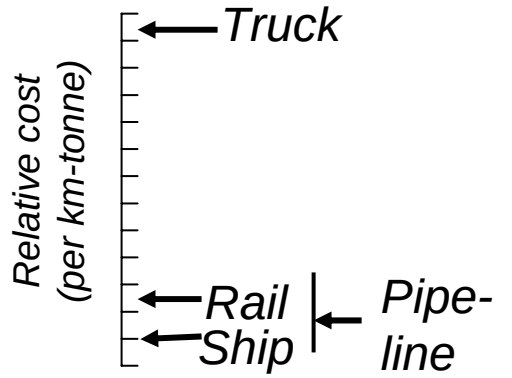
*What kind of **Transformative Systems** will Canada need to deliver on a renewable biomass energy target of 130 Mt biomass / yr?*

- *New high-yielding biomass crops;*
- *Commercial scale conversion technologies;*
- *Address the transportation challenge*

Addressing Energy Density / Transportation

Examples of Possible Solutions:

1. Distributed facilities processing 100s tonnes biomass per day for local heat & power, poss. Biofuels.



2. Build 'bioenergy corridors' around existing transportation systems:
   - Shipping, rail, pipelines;
   - Integrate biomass into fossil fuel infrastructure;

3. Establish dedicated bioenergy pipelines carrying biomass to larger 'biorefineries'
   - Crown lands valuable asset.

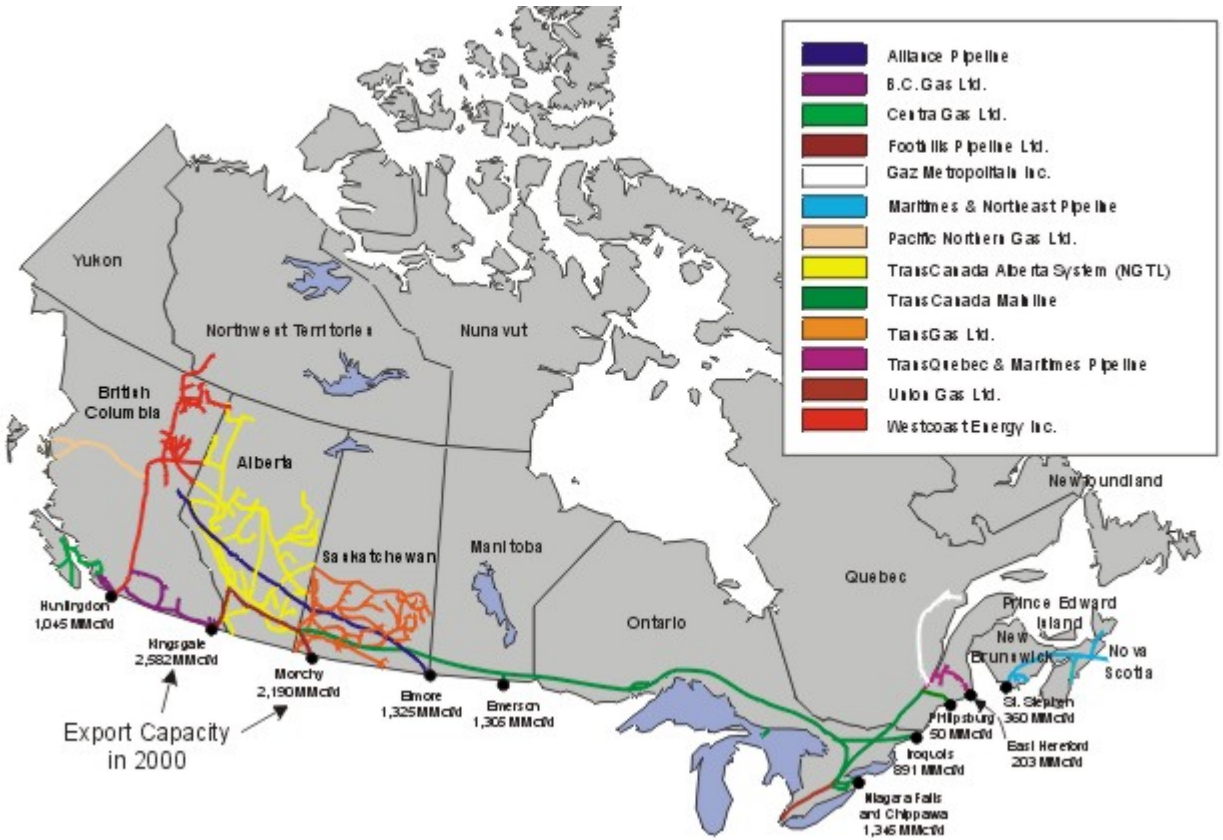
These strategies are needed to achieve a 20% bioenergy target.

Canada's Forest Inventory 2001
Natural Resources Canada
Canadian Forest Service

Inventaire des forêts du Canada 2001
Ressources naturelles Canada
Service canadien des forêts

Example 1: Biomass to synthetic natural gas (bio-SNG) along natural gas pipeline system

Natural Gas Pipelines in Canada



Sustainable biomass production & transport

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Gasification to CO & H_2

↓

Convert to Methane

↓

Upgrade to NG quality

↓

Bio-SNG in pipeline

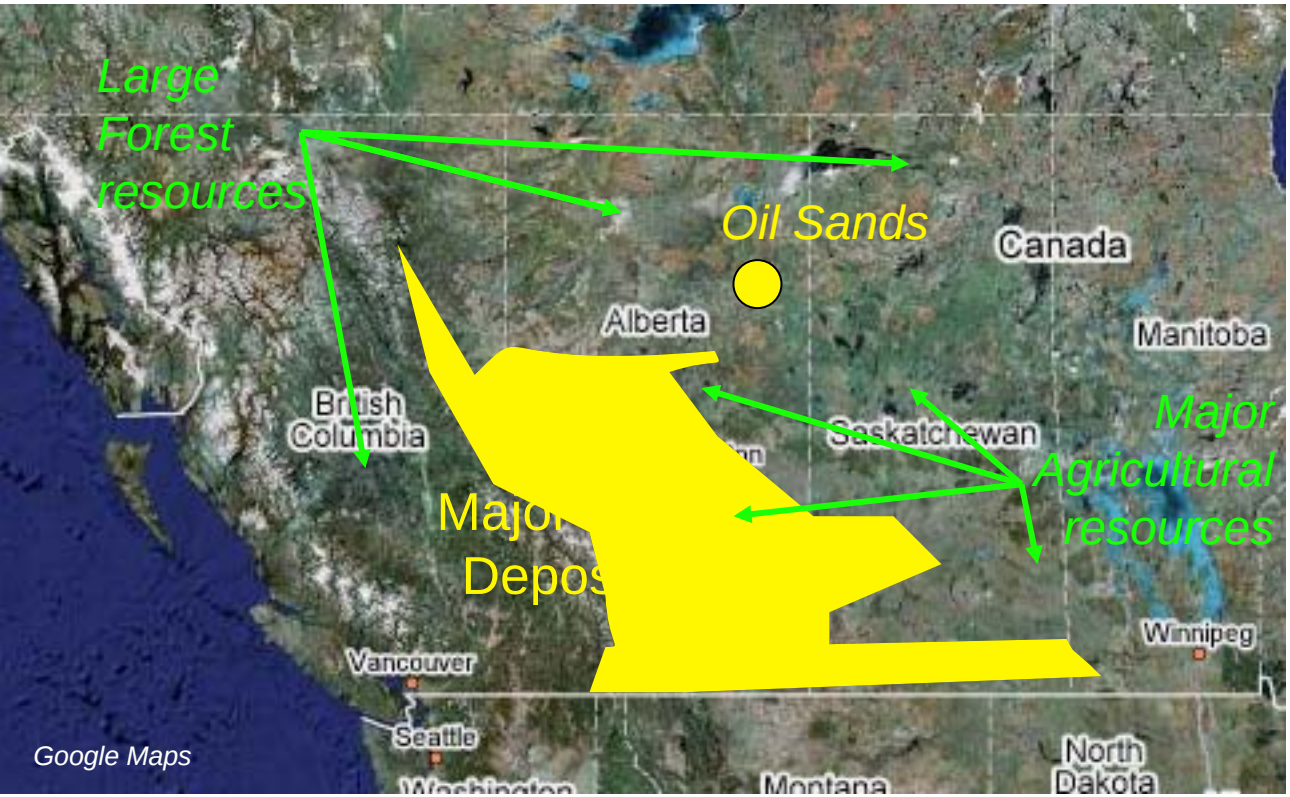
↓

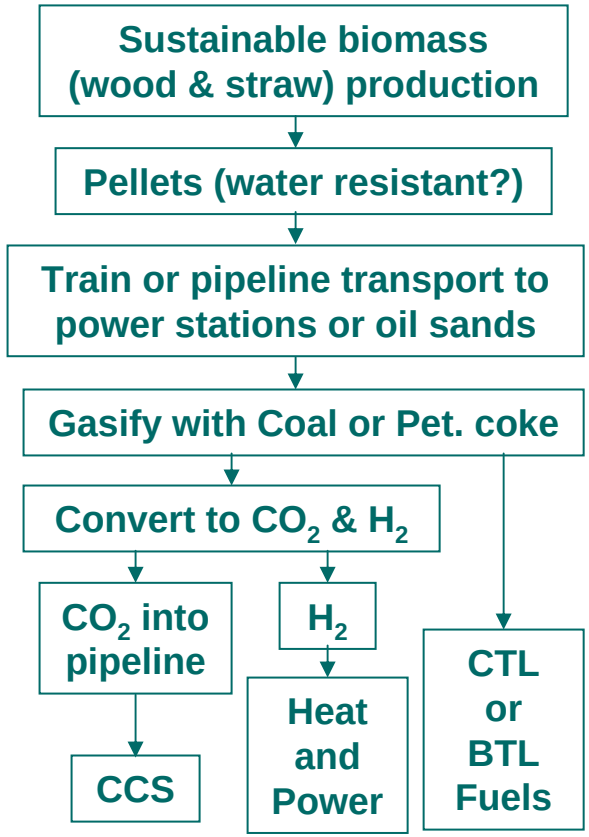
NA distribution

About 15% of Canada is within 100 km of a NG pipeline. Sustainable biomass production could provide bio-SNG equivalent to 50% or more of current NG demand in Canada.

Hacatoglu, McLellan, Layzell, unpublished

Example 2: Biomass for Oil Sands Extraction and Upgrading



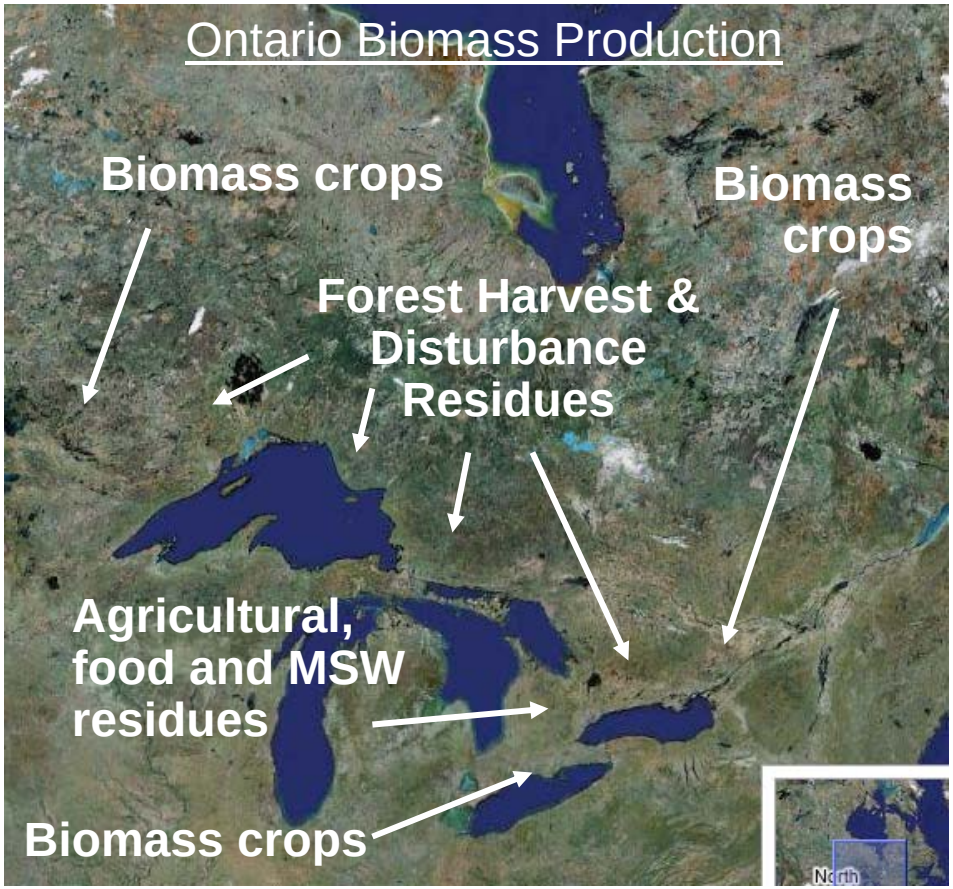


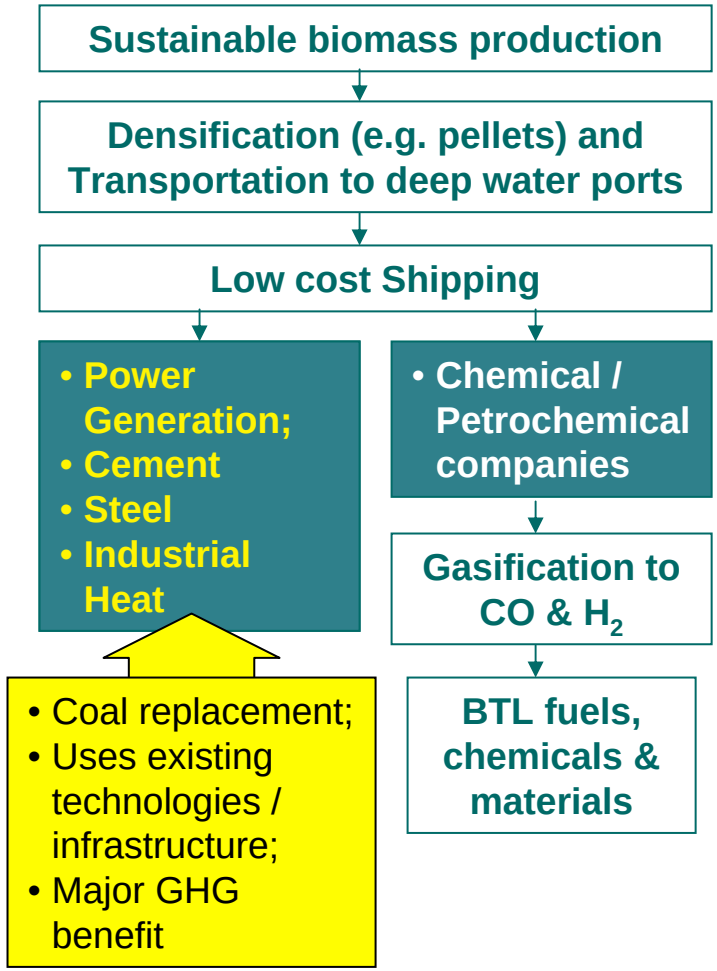
Current oil sands production (1M boe/day) demands ~8 Bm^3 CH_4/yr, which could be replaced by about 15 Mt biomass/yr

Wood and Straw Pellets

Could pellets made with this process be pipelined like a coal slurry?

Example 3: The Great Lakes / St. Lawrence as a Bioenergy Corridor





Ontario Alternative Energy Incentives ($/GJ):

Bioethanol: $7-8/GJth *Wind Power: $15/GJ^{e}*

Biodiesel: $6/GJth *Solar Power $104/GJ^{e}*

A solid biofuel incentive of ~$4 / GJ would create a vibrant market and generate >3X the GHG benefit of bioethanol.

Conclusions

1. Canada has vast biological resources that could be used to address climate change / energy priorities;
2. Solid biofuels replacing coal gives the best climate benefit;
3. Gasification / BtL of bulk biomass is likely to be a key route for ‘second-generation’ liquid biofuels;
4. Research is needed to develop and assess **transformative, yet sustainable bioeconomy systems**, including new crops, large scale conversion technologies; bioenergy (& biodiversity) corridors.