

U.S. - CANADA
CLEAN ENERGY DIALOGUE



US Canada Clean Energy Partnerships in Bioenergy

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Trade in Energy

- Canada supplies the US with more energy, with greater security and reliability, than any other country in the world. This is true in all energy commodity areas and it is true in this state.
- Our energy infrastructure-including oil and gas pipeline networks and electricity grids-is highly integrated
- Our energy partnership, based on our open market energy policies and energy trade relationship underpinned by NAFTA, has served both of our countries well.

Canada, biofuels and biomaterials

- The addressable market for bio-based products is \$8.3 trillion, representing the current global trade in fuels, chemicals, food, fiber and materials, and it is expected to double by 2050, representing an increase in energy intensity and food consumption in developing nations, combined with a 40 percent global population gain.

- Since global trade is highly robust, Canada's potential share is limited only by its feedstocks and the feasibility of technology.
- As the second largest nation in terms of land mass, the potential is very strong-and though Canada represents roughly 3 percent of global energy usage, it's participation in the biobased economy could be much higher. 6 percent of global trade is not all inconceivable, or \$150 billion in current dollars.

- Because technology can move and the feedstocks cannot (or not very far for cost and transportation reasons), feedstocks can represent up to 70 percent of bio-based products, in order to have a robust domestic production and an export trade, the key is to develop feedstocks.
- Nations that have significant feedstock resources can develop technology internal – as in the case of the US and China – or develop through partnerships and licensing, as in the case of India and Brazil.

Feedstocks

- Feedstocks fall into four categories of opportunity:
 - First generation: They have a value of \$700-\$1000 per tonne because of their value in food and feed markets.
 - Dedicated land-based “energy crops”: These generally have a value of \$60 per tonne.
 - Residues: Waste materials including animal, solid municipal waste, yard waste, etc. with a value of nominal or even negative costs (“tipping fees”).
 - Aquatic species: Such as micro algae. At present time, production costs for these feedstocks (at their pre-commercial production volumes) are between \$2000 and \$6000 per tonne.

Value of Feedstocks

- Feedstocks change in value not so much by feedstock but by category of purpose, and the success of the processing technology in transforming them into higher value products or combinations of products.
- Feedstocks for power markets are worth (unsubsidized, or outside of mandates) around \$40 per tonne. The global power markets have a value of roughly \$2 trillion.

- Feedstocks for feed markets can be distiller grains and can be work from \$100 - \$1000 per tonne range, depending on the amount of protein.
- Liquid Fuels are currently valued at \$500-\$800 per tonne range, depending on the BTU content of the liquid fuel produced and the demand for gasoline, diesel, ethanol and biodiesel. The global fuel market is roughly \$2.5 trillion in value.
- Chemicals made from biomass have a value in the range of \$500-\$800 per tonne and the global chemical markets are roughly \$250 billion in value.

Canada is very competitive in:

- Wheat
- Corn (maize)
- Canola
- Wood biomass
- Municipal residue
- Animal residue
- Forest residue
- Agricultural residue
- Fish and waste and oils
- Industrial residue (e.g. flue gas, brewers waste, pulp waste)

Canada can competitive in:

- Camelina
- Switchgrass
- Miscanthus
- Microalgae (seaweed)

Examples of Processing Technologies

- Just as there are multiple feedstock platforms, there are multiple processing technologies that unlock the value of the underlying feedstocks, by breaking up and recombining biomass into higher-value materials.
- Traditional grain fermentation
- Oilseed crushing and trans-esterification
- Cellulosic
- Consolidated bioprocessing
- Pelletization and torrefaction
- Gasification and catalytic processing
- Gasification and gas fermentation
- Slow or fast pyrolysis
- Aquatic species oil extraction and harvesting
- Cellulosic sugars

Canadian Technologies of Interest

- Iogen – Cellulosic saccharification and fermentation
- Mascoma Canada – Consolidated bioprocessing
- Lignol – Cellulosic saccharification and fermentation of wood biomass
- Comet Biorefining – Cellulosic sugar culturing
- Dynamotive – Slow or fast pyrolysis
- Enerkem – Gasification and catalytic processing of municipal solid waste.