An Energy Systems Perspective on the Emerging Bioeconomy

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Biological Systems: Managing Global Climate for over 500 M yrs

How can we use biological systems to address anthropogenic climate change?

Albedo

High = cooling

- Infra-red long wave radiation (low heating)
- Reflected shortwave radiation

Low = warming

- Infra-red long wave radiation (more heating)
- Reflected shortwave radiation

GHG management

- CH$_4$
- CO$_2$
- N$_2$O

(Absorbs long wave radiation)

C held in Dead Biomass

- Coal
- Oil
- Nat’l Gas

Ocean biology

- Clouds
- Snow

Vegetation

- Vegetation (esp conifers)
- Deserts
Canada’s Green Advantage

A 1% increase in above ground biomass:
- Could offset \(~20\) yrs fossil C emissions or
- Provide energy equal to \(~13\) yrs of current primary demand.

CO\(_2\) (N\(_2\)O & CH\(_4\))

Sun

C sink

Photo-synthesis

Metabolism, Fire, Harvest & Decay

Human-induced Emissions

Reduce (N\(_2\)O & CH\(_4\))

Biosphere C Stocks

Bio-based energy, chemicals and materials

Fossil Fuels

Carbon Cycle

REDUCE Landfill & Agriculture Emissions

REMOVE CO\(_2\) to biosphere

REPLACE fossil fuels with biomass
Obama renews commitment to CC action
Melting arctic & severe weather
Fossil fuel recovery & pipeline projects lack ‘Public License’
Interest in Cdn energy strategy & systems level approaches
High cost for CCS ($150+/tCO$_2$)

Forest & Agric'l C Sinks seen as central to Canada meeting its Kyoto commitment
Plans for Emission Trading
Many R,D&D initiatives funded
KYOTO Protocol


What do Canadian energy systems look like?
What is the current role for bioenergy/biofuels?

Change in Fed. Gov't CC policies
Forest fires & Mtn Pine Beetle make Canada's forests a C source
Concerns about validity / verification of offset projects
Focus on geol. CCS research & deployment

Canada Abandons Kyoto Protocol

Interest in Cdn energy strategy & systems level approaches
Obama renews commitment to CC action
Melting arctic & severe weather
Fossil fuel recovery & pipeline projects lack ‘Public License’
High cost for CCS ($150+/tCO$_2$)
NOTE:

- Net export = 51% of 1° energy supply
- Biomass = 2.7% of 1° energy supply
Biomass: • 5.7% of domestic primary energy supply (693 PJ/yr) • Equivalent to ~39 Mt dry biomass/yr
Domestic GHG emissions (Mt CO₂e/yr)

Delivered Services

Energy Losses

Energy Demand: 336

Service Demand

Non energy uses

Mobility

Residences

Supply Chain

Buildings

Industry (not energy ind.)

Energy Supply for Domestic Use

Domestic GHG emissions

1° Energy

Supply for Domestic Use

Oil

Nat'l Gas

Coal

Uranium

Hydro

Bio

= Total GHG Emissions:
~800 Mt CO₂e/yr

To address climate change, Cdn GHG emissions must be reduced by 520 to 640 Mt CO₂e/yr by mid century.
Message #1:

Go big or go home.

We have a 500+ Mt/yr GHG problem…

…”solutions” that are less than 1Mt/yr are not climate change solutions.
Message #2:

We have the bio-resource potential
Potential for Bioenergy

Approx. equal to all 1° energy used domestically in Canada

Estimate for biomass potential for energy

Current Forestry & Agriculture Production (165 Mt/yr)

At 130 Mt(dry)/yr, bioenergy could provide:
✓ 2000 PJ/yr (~1M boe/d)
✓ Reduce GHG by ~130 Mt CO₂e/yr

How much?

Bioenergy Potential - Mt(dry) biomass/yr

- Aggressive
- Conservative
- MSW

Biomass Crops
- Silviculture/Forest Mgmt
- Pest/Disease Residue
- Fire Residue
- Unused AAC
- Forest Harvest Residues
- Mill Residues
- Crop Residues

Agriculture
- Corn
- Hay
- Wheat
- Que
- BC

Forestry

Existing bioenergy (~5.5% Ttl energy)
Agricultural carbon sinks:

- Low-tillage agriculture,
- Crops that build soil C
- Biochar into soils.

30+ Mt/yr

Forest carbon sinks

- Through improved mgmt and new technologies
- New tree genotypes
- Pest / disease control

70+ Mt/yr

Biosphere emission reductions

From:
- Crop & animal production,
- Landfill sites,
- Managed aquatic systems.

40 Mt/yr

Message #3:

We need to enhance the value of our bio-resources.
The Price of Energy

2008-13 Energy Price ($/GJ)

- Oil: $60-100/boe
- Gas: $3-$7/GJ
- Coal: $0.50-3.50/GJ
- Wood/Straw: $50-200/dry t
- Corn: $100-300/dry t
- Electricity: $50-100/MWh
- Gasoline: $0.60-1.00/L
- Diesel: $0.50-3.50/GJ
- Biodiesel: $50-100/MWh
- Ethanol: $60-100/MWh

Also Consider...

- The efficiency and cost of converting feedstocks to energy commodity;
- The quality / ease of use of the energy commodity;
- The life cycle ‘carbon benefit’ of the bioresource
  - Depends on carbon price
  - Typically <$3/GJ benefit

Strategies for enhancing the Bio-resource value?
Strategies for Enhancing the Bio-Resource Value.

1. Price on Carbon

2. Regulation
   - e.g. fuel standards

3. Enhance the Value Chain:
   Examples:
   - Biomass waste to energy or C sinks
   - Water treatment + C sink / energy resource
   - ??

Produced Water Containing Organics
- oil sands *in situ* production
- oil sands mining (tailings)
- tight oil / gas fracking water

From Kimetu et al. 2013
4. Partner rather than Compete

✓ The existing energy industry has the resources, scale of operations and the need for cleaner technologies.

✓ Rather than working to take market share away from the industry, find ways to help the industry reduce their C, water or biodiversity footprint.

✓ The energy industry will pay more for GHG solutions that are “inside their fence” than for “offsets” to meet regulatory requirements.
Message #4:
Plan for Unintended Consequences
A common problem in the energy sector, given the scale of the industry and its expanding geographical distribution.

We need to learn from the past mistakes of other industry sectors, and get in front of problems before they undermine the public license to operate.

For the Emerging Bioeconomy:

1. Food Price / Availability
2. Water
3. Land use / Biodiversity
4. Albedo
5. Byproduct streams

Investors and regulators need to foresee possible problems and address them early.
Summary of Key Messages

1. Go big or go home.
2. We have the bio-resource potential.
3. We need to enhance the value of our bio-resources.
4. Plan for unintended consequences.

Thank you