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Biofuels and Biorefinery Development in Canada: The Question of Sustainability

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I will provide an overview of what's going on in Canada with respect to biofuels and then focus on the question of sustainability, drawing on my work in the strategic planning area of the biobased economy and on presentations and data from colleagues in Natural Resources Canada, Agriculture and Agrifood Canada, Environment Canada and Industry Canada. We are approaching this issue through an interdepartmental committee.

My key messages are:

- The sustainable development (SD) challenge—especially on the environmental side—is large. If biofuels are developed carefully and deliberately, they can be the foundation for a more sustainable future.
- The Canadian context is different from that of the United States. Danny Le Roy covered this and I will elaborate on it. How biomass will be utilized in Canada represents a major shift requiring many adaptations.
- There are economic, environmental and social aspect to SD. Although we consider these aspects when we support projects and make investments, we are missing an opportunity to really design bio to provide solutions for a more sustainable future. We need to start by assessing the impacts of our first-generation investments, and then design accordingly.

From the environmental perspective, the global human population is not living sustainably. Our ecological "overshoot" occurred in the 1980s and the human ecological footprint is now 25% beyond that threshold, and rising. Meeting the challenge will require dramatic changes—substantially beyond incremental improvements—in design and efficiency. We must re-examine not only how we produce but how we consume and dispose of goods. If properly designed and carefully integrated with the petroleum-based economy, the use of biomass and biotechnologies can contribute to a more sustainable future.

However, not all products from biomass are sustainable. Different bioproducts have different benefits, and the entire life cycle—including mode of usage and end-of-life—should be examined.

Agricultural biotechnology holds the promise of providing new feedstocks for energy production and other industrial products. Industrial biotechnology can be applied to both biobased and non-bio feedstocks, supplying processes that are less energy or chemically intensive.

A European review of life-cycle assessments of nine categories of bioproducts showed a range of benefits in terms of CO_2 reduction *vis-à-vis* their petroleum-based counterparts. There were differences between products, and wide variations within some product categories. Some products, such as biopolymers, even showed a negative CO_2 benefit, depending on how they are disposed of (Fig. 1).

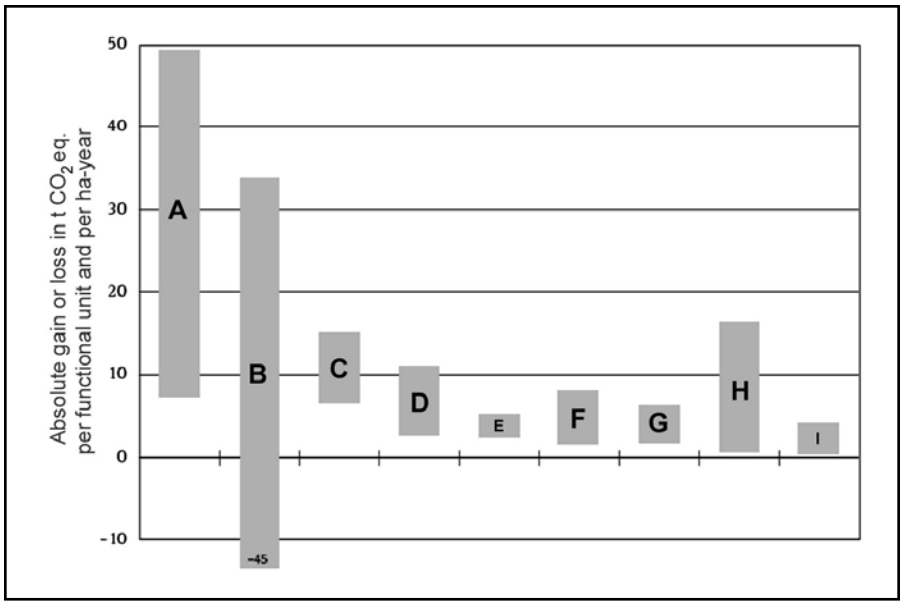

Figure 1. Impact of bioproducts on CO_2 emissions versus petroleum-derived equivalent (ADEME, 2004). A=agrimaterials; B=biopolymers; C=agricultural biomass (bio-energy); D=forest biomass (bio-energy); E=ether alcohols (biofuels); F=ester oils (biofuels); G=hydraulic oils and lubricants; H=surfactants; I=solvents.

Canada has a long history of natural-resource-based industry, with established infrastructure and much know-how. However, new business models are required, and the need for these industries to reinvent themselves is a significant driver for the development of Canada's biobased economy. Unlike the United States, energy security is not a driver. Canada is a net energy exporter. In general, there are long distances between feedstock sources and manufacturing facilities, and Canada's industry structure is mainly comprised of small-to-medium-sized enterprises.

A significant change is underway in terms of biomass utilization. Traditionally, it has been used to produce food, feed and wood fiber. Unutilized residues from forestry and agriculture operations and urban communities, along with some crop production are now being converted into bioenergy and biofuels. This is occurring at a relatively rapid pace, albeit on a smaller scale than in the United States. We are seeing new interest in small-scale bio-energy- and biofuel-production plants. We are exporting biomass feedstocks—in particular wood pellets and canola seed and oil for biofuels and bio-energy production in other countries—and are developing new bioproducts, including diverse co-products, and biorefineries.

Canada must work out how best to use biomass feedstocks and various biotechnologies and how to integrate them with existing resources and industry.

Sustainable Development

Sustainable development was defined in the 1987 Bruntland Report as development that *meets present needs without compromising the ability of future generations to meet their own needs*. We consider environmental, economic and social dimensions in our decisions and we track these indicators. Canada lacks a national SD plan, in contrast with countries in the European Union, for example. And, with the development of our oil sands, we are even shying away from the concept of sustainability. Therefore, although we are making progress towards SD, we have yet to adopt a concerted top-down approach. A bottom-up approach to SD is taking shape and we see some good things happening with respect to forest and agricultural production. Sustainable forest management became a critical issue in the 1990s as a result of a boycott of Canadian pulp and paper products, and sustainable agriculture is developing albeit at different paces within different provinces. At the municipal and regional levels, we see growing interest in sustainability planning; more and more communities are looking at development through a sustainability lens, which is encouraging. Large corporations and utilities have been triple-bottom-line reporting as in the United States and two provinces have adopted SD legislation.

Also, there's been significant advancement in the world of SD research. Many new tools are available and we have criteria for sustainable biomass production. Many have referred to the "perfect storm." Certainly many factors appear to be coming into alignment. The time is good for biobased industries to be developing as part of the movement to a more sustainable future.

Path to Sustainability

Canada's official reasons for supporting biofuel development are to lower air emissions, to reduce greenhouse gasses and to provide economic opportunities for farmers. Like other countries, the challenge of decreasing transportation emissions is significant compared with those from industrial plants; biofuels promise to be part of the solution. Unofficial reasons include the fact that we are in pre-election mode and the current government has had strong rural support.

Nevertheless, we believe we are on the right path—finding new uses for our renewable resources, including residues. Residue use is an important driver for both forestry

and livestock production, providing significant environmental and economic benefits. In summary, we have large volumes of biomass and great opportunities for new biobased industries that contribute to clean new economic development.

Federally funded projects are judged in terms of economic, environmental and social criteria. The Canadian Environmental Act mandates public consultation, but this is directed towards meeting current standards versus making the stretch to targets necessary for sustainability.

We have some large questions still to answer relating to the collective impacts of our biodevelopment, the impacts on other sectors, and whether to produce ethanol or other products from our land base. Other questions include:

- Which feedstocks should be chosen to go beyond the proposed 5% renewable content?
- What will be the impacts on land use, nitrogen applied, biodiversity and soil quality?
- Which conversion technology should be chosen—thermochemical or biochemical?
- Which high-value co-products should be focused on—which chemicals?
- Which fuels should be produced—butanol, Fischer-Tropsch, H_2, *etc*.?
- Given US investment in lignocellulosic ethanol, should Canada adapt this technology or focus on others and other products?

The most frequently raised questions with regard to the sustainability of first-generation biofuels are:

- Economic
  - Future prices: ethanol, oil
  - Feedstock supply and cost? (Ontario is importing corn.)
  - Energy costs?
  - High-value co-products needed to break even?
  - Increased farmer income?
  - How many jobs?
  - Impacts on livestock sector?
- Environmental (re: production, manufacturing, infrastructure development, use)
  - Energy balance (net energy)?
  - Competition for water? Land?
  - Impacts on water? And soil?
  - Biodiversity impacts?
  - GHG impact? (N balance as important as C balance?)• Social (including human health)
  - Developing and retaining expertise?

- Noise, odor, truck traffic associated with industrial development?
- Residual antibiotics in meat (*i.e.* animals fed DDGS)?
- Health impacts of combustion of biofuels?

Economics of Biofuels

We are assessing the impacts of our first-generation investment, with several departments examining various angles. Scientists at Agriculture Canada are doing economic modeling work using the CRAM model—the regional, economic and agricultural production model. They are looking at effects of biofuel production on agricultural sub-sectors in terms of farm income and regional distribution. The international perspective is being appraised using the AGLINK model. At the projected feedstock price, the model indicated that the minimum oil prices for profitability were US$55 for ethanol and US$65 for biodiesel, and below these government incentives would be needed. Also, it was found that to a large extent policies outside of the country have a much bigger impact than what occurs internally.

Greenhouse-Gas Emissions

The GHG impacts (reductions) attributed to biofuels are significant but not large. Although we've been selling this as a way of mitigating climate change, the impact is small. Environment Canada has reviewed biofuel-lifecycle data from around the world and available environmental information. Energy consumption and CO_2 emissions are best understood, but there are many gaps with respect to other environmental parameters. As more plants are built and more data become available, a comprehensive picture will emerge of all of the benefits and impacts.

Natural Resources Canada has used the GHGenius model to examine the lifecycle of GHG emissions, showing that E10 from various feedstocks results in reductions in CO_2 emissions of 4.1% to 6.3%—small but significant.

Shared Vision of Sustainability

Sustainable development has to be planned and designed. Biofuels production represents a route for developing infrastructure and demand, although it is not the ultimate goal for Canada. It is important to communicate that completing a checklist of "environmental, economic and social" parameters does not mean a project is sustainable. We have to educate the public that there's a difference between this checklist and taking action for sustainability. We need to do much better than baseline, much better than the gasoline-equivalent or business-as-usual comparison if we are to achieve SD. In our work, we recommend that developers of new bioprojects create a shared vision of sustainability and describe specifically how the use of biomass and/or biotechnology will contribute to this vision.

The design for SD must be flexible to avoid becoming locked into a given technology. In terms of targets, it will likely take time for groups to agree on what numbers to aim for. The following principles [referred to as the *The Natural Step* system conditions

(http://www.naturalstep.ca/system-conditions.html)] can be used to define a proposed project's contributions to the development of a sustainable future by helping to reduce or eliminate:

- ongoing build-up of substances taken from the earth's crust,
- ongoing build-up of substances produced by society,
- ongoing degradation of natural systems by physical means, and
- undermining the ability of people to meet their needs.

I am involved in several SD-related activities including an initiative in Alberta starting in June 2007, in which stakeholders will be invited to develop a shared vision for a large triticale biorefinery initiative, which hopefully will lead to a superior design. Also planned is an international forum on applied sustainable development hosted by the Université de Sherbrooke in Sherbrooke, Québec. And we will release the third edition of the *Sustainability Assessment Framework and Tool* (SAFT) guide (Five Winds International, 2006), a qualitative assessment framework for biobased systems.

Dramatic changes in how we do things will be needed. Renewable biomass and new technologies are part of the solution. We need to figure out how to develop this biobased economy where it makes sense and where it makes sense for Canada, which may differ from rationales for other countries. The real economic, environmental and social impacts of first-generation biofuel investments should be evaluated before moving ahead "too fast in the fog." We need to elucidate the attributes of a sustainable bio-economy for Canada, and build with that end in mind.

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MARIA WELLISCH graduated from McGill University in chemical engineering (1984) with a minor in environmental studies. She has spent over 20 years in environmental planning and lifecycle-management work for natural resource-based companies in Canada, originally for the forest-products industry and more recently in the development of new bioproducts and bioprocesses.

Ms. Wellisch joined Canada's public service in 2002, and is currently on secondment with the National Research Council as advisor for Bioresources Conversion and Sustainable Development. Her current work centers on strategic sustainable development of the new biobased economy, exploring the use of various sustainability planning and assessment tools in the evaluation and design of various bio-pathways.