BioPromise?

Biotechnology, Sustainable Development and Canada's Future Economy

EXECUTIVE REPORT TO CBAC
(Canadian Biotechnology Advisory Committee)

from the BSDE Expert Working Party

September 2006

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This publication is also available in alternative formats on request. Contact the Chair of the Expert Working Party, Dr. Arthur Hanson, at the address below:

Dr. Arthur Hanson
Chair, Expert Working Party
2650 Dorset Road
Oak Bay, BC V8R 3N1
Email: ajhanson@mts.net

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Biotechnology, Sustainable Development and Canada's Future Economy (BSDE) Expert Working Party

Chair: Dr. Arthur J. Hanson, O.C.

Dr. Peter G. Brown, McGill University
Dr. Ann Dale, Royal Roads University
Dr. Don Dewees, University of Toronto
Prof. Linda Lusby, L.L.B., Acadia University
Dr. David Punter, University of Manitoba
Dr. Robert Slater, Carleton University
Dr. Stuart Lee, Canadian Biotechnology Secretariat

This Expert Working Party was formed in 2005 to perform in-depth, independent research and analysis for the Canadian Biotechnology Advisory Committee (CBAC) on the topic of biotechnology, sustainable development and Canada's future economy. In so doing, it commissioned several small research projects, performed a significant literature review, and drew heavily on the expertise of Working Party members.

The specific charge to the BSDE Working Party was to:

- Identify opportunities for, and challenges posed by, new biotechnology applications in the future development of the Canadian economy in all relevant sectors, and appropriate regulatory approaches these new applications may require.
- Identify, to the extent possible, those areas where new applications of biotechnology can contribute to achieving sustainable development goals both domestically and internationally.
- Identify policy initiatives within and across all branches of government that will encourage further development of biotechnology applications in areas most likely to contribute to achieving sustainable development objectives, including investment and incentive policies.
- Develop a sustainable development framework for applications of biotechnology.

The BSDE Expert Working Party's opinions and findings are reported to CBAC but are not necessarily those of CBAC.

The technical BSDE report is attached to this Executive Report as a CD-ROM. It is also accessible online at www.cbac-cccb.ca. Contact info@cbac-cccb.ca for individual background research papers.

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Biotechnology, Sustainable Development and Canada's Future Economy

Just Imagine... in 2020...

A Canadian society where:

A flourishing rural economy supplies one-quarter of Canada's fuel, chemical and synthetic product needs from renewable biomass sources...

A 50 percent reduction occurs in the use of harmful chemicals that accumulate in the environment and in peoples' bodies...

A successful national strategy of "biowaste to bioproduct" is implemented in cities and rural communities across the country, based on the conversion of commercial food wastes, household compostable wastes, manure, aquaculture, agriculture and forest residues into biofuels and feedstocks for use in newer, cleaner chemical processes that reduce fossil fuel consumption...

A well-established and successful eco-efficiency effort exists within Canadian industries—partly based on the use of enzymes to prevent pollution and reduce material and energy use by three or four percent each year per unit of manufactured product...

An end occurs to contaminated industrial, mining and other "brownfield" sites, assisted by new biological remediation techniques for cleaning up past messes and treating current operations...

An effective national network is in place for monitoring the health of local ecosystems, relying not only on inexpensive biosensor monitoring tools, but also on the commitment and involvement of local communities and citizen groups...

A concerted effort by Canadian researchers, non-governmental organizations (NGOs), businesses, and government officials leads to new vaccines, crop varieties and environmental technologies needed to meet the Millennium Development Goals[1] for global sustainable development—including biological control for human, fish, plant and livestock diseases; drought-resistant crop varieties; and advanced water pollution control for communities and industry.

[1] Eight goals agreed by all countries and international development institutes to meet key needs of the world's poorest people by 2015. www.un.org/millenniumgoals/

These actions are driven by a growing realization of the magnitude of environmental and development challenges Canada and the world face. Our society embraces rigorous principles to reduce and eliminate environmental damage, and to improve quality of life.

Biotechnology is a major contributor to each of these seven imagined 2020 outcomes—a means to achieve important sustainable development goals of environmental quality, new economic opportunities and improved quality of life for Canadians and people elsewhere. But these new biotechnology applications are quite different from innovations such as the early genetically engineered crop introductions of the 1990s. These new applications are far more integrated into the mainstream of industrial and community activities and decisions. Most are multiple-step initiatives, where biotechnology and other innovations are introduced at various stages. Some stages involve genetically engineered organisms, others do not. Many applications, such as industrial enzymes, operate in closed environments, or, as in the case of genetically engineered vaccines, are unlikely to affect the natural environment.

We pause at this point in our scenario to introduce this report.

This study[2] has been prepared by an Expert Working Party that reports to the Canadian Biotechnology Advisory Committee (CBAC). It is the first comprehensive effort undertaken in Canada to examine biotechnology in relation to sustainable development. We have maintained an impartial, analytical view about this relationship and its implications for decision-makers. This Executive Report is directed to Canadian decision-makers in the federal government, provincial governments and local communities, and to senior business and civil society representatives.

When it comes to the introduction and acceptance of new technologies, 2020 seems to be just around the corner. However, to solve problems related to sustainable development, the next few decades are critical. Canada has a backlog of environmental problems such as brownfield reclamation, and must improve the eco-efficiency of industries. At the same time, Canada faces critical economic situations in rural areas and, globally, prospects of failing to meet important goals related to climate change, biodiversity protection and international development.

The scenario, as introduced above, is only one among many possible outcomes. Reality may prove to be quite different, depending on decisions taken over the next several years. What we highlight in our report are the opportunities and steps that need to be taken if Canada and Canadians decide to embrace biotechnology as an important means to address sustainable development issues.

Why single out biotechnology, given the range of possible means and technologies to address key sustainable development issues? Biotechnology is a maturing technology for which numerous environmental and sustainable development applications have been suggested.[3] In general, there is recognition that without a commitment

[2] BSDE Expert Working Party, 2006. *BioPromise? Biotechnology, Sustainable Development and Canada's Future Economy.* Report to the Canadian Biotechnology Advisory Committee.

[3] See, for example: I. Serageldin and G.J. Persley (eds.), 2003. *Biotechnology and Sustainable Development: Voices of the South and the North*. CABI Publishing, Oxford. p. 318; J. de la Mothe and J. Niosi (eds.), 2000. *The Economics and Social Dynamics of Biotechnology*. Kluwer Academic Publishers. Norwell, Mass. p. 281; OECD, 2002. *Biotechnology for Clean Industrial Products and Processes: Towards Industrial Sustainability*. OECD. Paris p. 194; OECD, 2004. *Biomass and Agriculture: Sustainability, Markets and Policies.* Environment and Sustainable Development 1:13; United Nations, 2003. *Impact of New Biotechnologies, with Particular Attention to Sustainable Development, including Food Security, Health and Economic Productivity.* Report of the Secretary-General; A. Sasson, 2005. *Industrial and Environmental Biotechnology: Achievements, Prospects, and Perceptions.* Institute for Advanced Studies, United Nations University, Yokohama, Japan. p. 23.

to new sustainability technologies and other forms of innovation, we are unlikely to achieve longer-term societal goals. Organizations such as Sustainable Development Technology Canada (SDTC) and Canada's International Institute for Sustainable Development (IISD) have embraced the need to champion innovation if societies are to live sustainably.

Why consider all seven outcomes noted in the scenario? These seven outcomes address environmental and development problems that Canada[4] has identified to be of major significance for our future well-being, including greenhouse gas reduction, diversification from our reliance on hydrocarbons for energy and materials, reduction in levels of persistent pollutants, environmental restoration of contaminated areas, need for improved municipal and industrial waste utilization, maintenance of ecological integrity, biodiversity and ecosystem function, and the Millennium Development Goals.

SUSTAINABLE DEVELOPMENT (SD) *Improving the quality of human life while living within the capacity of local and global ecosystems, with more equitable sharing of economic and social benefits among today's rich and poor, and without compromising the ability of future generations to meet their needs. (Adapted from definitions of the World Conservation Strategy and the World Commission of Environment and Development. The Principles and Values section of this report lays out our criteria for moving towards sustainable development goals.)*

BIOTECHNOLOGY *The application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services. (Organisation for Economic Co-operation and Development [OECD] definition.)*

And what commitments should accompany technology innovation of the sort described? To reach the sustainable development outcomes of our scenario requires a tremendous commitment on the part of Canadians. As individual citizens and consumers, and through our organizations, we need to make informed, responsible choices about problem-solving, including the role of new technologies.

Business, communities and governments would need to act more quickly and effectively on investment decisions, new regulatory applications and capacity building.

But the lesson of technology innovation is that success is less than predictable. Therefore, whatever Canada's future holds, Canadians will need to take an ***adaptive approach*** in which continuous learning and application of new knowledge are central to managing processes of change. In addition to the major efforts of R&D, investment and commercialization that will be required in the years ahead, we will need to (1) recognize the role of values-driven decision-making; (2) strengthen our system of governance for addressing innovation in problem-solving; (3) establish new metrics, standards, and develop the information needed to monitor progress; and (4) build public dialogue around desirable outcomes and how we might achieve them.

These points cover some important matters to be considered in more depth later. Now back to our scenario.

[4] Information is widely available, for example on the following websites: Environment Canada's Green Lane www.ec.gc.ca/envhome, The National Round Table on the Environment and Economy www.nrtee-trnee.ca, and the International Institute for Sustainable Development www.iisd.org.

Building an Adaptive Relationship between Biotechnology and Sustainable Development...

Well before 2020, most Canadians accepted that biotechnology could help Canada and the world attain sustainable development goals. Some important conditions made this acceptance possible. Canada's "innovation for sustainability and productivity" policy, first implemented between 2007 and 2010, can take major credit for this acceptance.

Central to this policy has been the gradual implementation of a federal approach that:

- Enables research and commercialization of sustainability initiatives, including timely licensing and regulatory decisions;
- Commits to a values-based approach to technology development, explicitly addressing moral- and values-based choices involved in innovation technologies;
- Establishes an information and monitoring system to detect baseline and post-introduction changes in the environment, biodiversity and key social indicators;
- Implements a sustainability assessment framework that applies to emerging technologies and is used to assess new products, projects and policies;
- Integrates the information and the framework to support:
  - Decision-making at all levels of government in an adaptive management paradigm;
  - Development of fiscal instruments and R&D policy to ensure that economic signals support sustainable development goals;
- Supports ongoing citizen and multi-stakeholder deliberative dialogue on important issues; and
- Leverages "innovation for sustainable development" as an important international policy tool for both human and ecosystem health.

This policy is well supported by provincial governments, each with specific biotechnology and sustainable development programs related to their own needs and environmental conditions.

Just Imagine in 2020...
Four Big Trends

The following four trends helped the transition involving biotechnology and sustainable development:

- Cellulosic ethanol production leading to biorefineries.
- Canada's stringent approach towards eco-efficiency and persistent chemical contaminants.
- Community and industry-led initiatives for seeking value-added uses of wastes and contaminated sites.
- Greater integration of science and technology applications into international development problem-solving.

Sustainable Cellulosic Ethanol Production Leading to Biorefineries

In 2006, a new government mandate to use biofuel sparked private investment and public interest in sustainable biotechnology applications. Federal and provincial incentives for biofuel production virtually assured the short-term profitability of new plants. Investors jumped on the bandwagon. People accepted the new fuel mixes. Farmers and biofuel investors benefited from the new subsidized biofuel market and higher prices of farm commodities arising from competition between food and fuel uses of crops.

In Canada, the use of ethanol/gasoline blends surpassed federal and provincial expectations. But with the eventual removal of tariff barriers and subsidies for biofuels, domestic corn and grain-based ethanol production dwindled, as suppliers found it cheaper to import biofuels from eco-certified international producers. However, Canada's cellulosic ethanol producers, who used agricultural and forestry waste as feedstock, stayed in business. Canada had an early leadership role in developing cellulosic ethanol technology, which, when evaluated against the new sustainable development assessment framework, was predicted to be significantly more environmentally sound and useful.

By 2012, the superior environmental performance of cellulosic ethanol production was confirmed through new environmental monitoring programs, and firms were able to offset their production costs with increased carbon credits not available to corn- or grain-based ethanol producers. Licensing royalties provided another income stream. Especially important was a strategic partnership between a leading Canadian business and a European firm; the two companies were able to protect key intellectual property rights for a plant design and process that was

Natural Resources Canada, Canadian Forest Service

to become the world standard. Cellulosic ethanol brought greater attention to the practical value of new biorefineries capable of reducing dependence on fossil fuel and of producing new products out of residues and wastes.

By 2012, warmer winters left forests throughout Canada vulnerable to insect outbreaks. The urgent need to process large volumes of dead wood led to new investment in wood and pulp processing mills as integrated biorefineries, capable of producing energy, ethanol, and a host of speciality chemicals as well as more traditional forest products. This new investment directly benefited several communities threatened by loss of their mainstay industry.

With the price of oil remaining high in 2010–2020 and decision-makers using sustainable development assessment frameworks to inform fiscal priorities, it became both economically and environmentally desirable to generate as many specialty chemicals from biological feedstock as possible. Forestry, of course, is not the only source of biomass for further refinement, and in the agricultural sector, biorefineries process oilseeds into plastic replacements, lubricants and biodiesel; animal waste into energy, fertilizer and feed; and plant residues into ethanol and related byproducts. Sustainable use has been achieved by giving first priority to waste and ecologically sustainable use of residual materials as a source for biorefinery feedstocks.

Biorefineries are scale-appropriate, taking into account transportation costs of raw materials, the need to provide local jobs and opportunities for local investors and farmer cooperatives, but also economies of scale. Thus, many are located in rural areas, contributing directly to the economies of smaller communities. Others are being set up on a large scale to provide for the engineering complexity and cost-effectiveness of creating products that substitute for petroleum-based chemicals and plastics. Cities also participate in this bio-economy, as systems for collecting organic waste from municipalities are established, which then feed plants that convert the waste into gaseous form—a rich source of many of the building blocks for useful chemicals.

By 2020, biorefineries are an integral component of agribusiness and the forest industry, and have stimulated a booming business converting organic wastes of many types, ranging from household compost to wood and straw, old tires, and wastes from food processing. The impact of this mass diversion of organic material on soil quality and biodiversity is closely monitored, with the results published on the Internet

A biorefinery is an industrial plant that takes biological material as its input, transforms the material into mixtures of valuable chemicals and then separates and purifies them, yielding multiple valuable products and often a large amount of energy as a byproduct, with minimum waste and pollution.

(See www.biorefineryworkshop.com for a comprehensive overview of biorefineries.)

and integrated into yearly reports that form the basis for sustainable land-use decision-making by local councils. So far, the data have been very useful in aiding communities to choose appropriate crop rotations and to guide them in determining how much biomass to leave on the ground. Data are also showing the real reductions in pollution, energy use and greenhouse gas emissions achieved by using biomass, whenever possible, instead of petroleum-based feedstocks for industrial use. Biorefineries have started Canada on a gradual, long-term transition from a fossil fuel- to a carbohydrate-based economy.

Canada's Stringent Approach towards Eco-efficiency and Persistent Chemical Contaminants

Fortunately, Canada's decades-long struggle to reduce persistent chemicals in the environment has given our nation environmental advantages that frequently tip the balance of trade in our favour. Monitoring has demonstrated significant human and ecosystem health advantages.

New industrial processes that eliminate the use of chemical solvents provide a double eco-efficiency bonus of pollution prevention and improved energy efficiency. Stimulus for developing the enzymes, catalysts and eco-industrial networks necessary for more eco-efficient production was provided by changes to the *Canada Environmental Protection Act* (CEPA) and other legislation, starting in 2008. These changes were spurred by two earlier realizations: that progress for control of persistent chemical contaminants was too slow, and that a substantial number of the chemicals introduced into use within Canada in the last half of the 20th century still required additional environmental and health assessments.

Damage to forests and crops under stress from climate change promoted further development of genetically engineered (GE) biological control products to address pest and disease problems. By 2015 these products significantly reduced Canada's use of persistent chemicals. In some instances, GE biological control products are being coupled with GE crops to enhance disease resistance. However, Canada is still considered a cautious acceptor of GE crops, especially for tree and aquaculture products, by comparison to some other parts of the world.

ECO-EFFICIENCY *"Doing more with less" through reduction of energy and material use in industrial production, and, at various stages in a product's life cycle, putting materials and energy considered waste or unusable to use.*

These changes in industrial and natural resource practices within Canada are reflective of developments taking place internationally. By 2010–2015, Canada's ability to compete in the international marketplace is governed by many sustainability certification processes. Some have standing under international trade agreements. Sustainability certification is very important for retailers in many markets, based on perceived consumer preferences. For example, under the international "eco biotech" labelling scheme, products that contribute to sustainable development through a 20% or greater reduction in energy, greenhouse gas or pollution load are able to differentiate themselves with special labels. This "eco biotech" label has been endorsed by influential environmental groups worldwide, and products with this branding enjoy special status in the marketplace.

Agriculture continues to be served by biotechnology. Through the use of advanced bioinformatics and environmental sensors, crops are being developed that are better matches for the variety of agricultural eco-systems in Canada. And there is a need for new varieties, as climate change creates conditions unfavourable for traditional crop varieties. Segregation of virtually all crops and chain of custody certification are standard practices demanded by both consumer markets and by the degree of specialization on the part of farmers. Specific eco-efficiency standards have been worked out for both farm production and for various types of agro-product processing.

The debate about genetic modification has become more sophisticated in the face of increasing subtlety and complexity of modern breeding techniques, such as marker-assisted selection,[5] and is now much more focused on case-by-case assessments of types of innovative crops against sustainability goals. Environmental monitoring has shown that the new varieties are actually reducing the chemical input load on the environment, or the need for water. Those that did not perform, or that were shown to be injurious to the environment, were identified and removed from the market.

A renewed Canadian agricultural innovation strategy that emphasizes the production of high-value crops and sustainability favours the use of biotechnology as an enabling means. And Canadian farmers, making more money through high-value speciality crops, can afford to leave more marginal land untilled. In partnership with governments and conservation organizations, the number of "conservation covenants" has grown remarkably, especially after 2010. In the prairie provinces, several endangered species have been re-introduced to this restored natural habitat.

Community and Industry-led Initiatives for Seeking Value-added Uses of Wastes and Contaminated Sites

Pressures on industries and communities to address waste issues and invest in ecological restoration were already present at the turn of the new century. But by 2012 to 2015, when it became apparent that even advanced standard sanitary engineering and remediation methods were not entirely effective, attention turned to newly emerging biotechnology approaches. These included bioremediation techniques for removing heavy metals, and multi-source biorefineries capable of handling a wide variety of organic materials that would otherwise find their way into landfills—including tires, compostable wastes, and various debris such as wood and plastic window frames.

[5] Use of genetic markers whose location is known, for selection of a characteristic, trait, or disease-associated gene whose effect is known but whose location is not. This type of work is made possible through recent advances in genomics and bioinformatics.

Many trial efforts were underway during the first decade of the 21st century, but these technologies really came into their own during the second decade, once the kinks were worked out, the economics became more favourable, and reasonable rules were established for implementing these waste and remediation efforts. For example, use of GE plants capable of absorbing heavy metals from contaminated sites required special disposal rules and regulations to ensure that they would not escape beyond the site. While multi-source biorefineries were a proven technology by 2006, it was 2010 before they became economically viable, and 2015 before they replaced aging composting facilities in cities such as Halifax and Edmonton.

Greater Integration of Science and Technology Innovations into International Development Problem-solving

Started in 2007, ongoing dialogue among environmental NGOs, representatives of all levels of government, Genome Canada and other researchers, and industry representatives helped to identify specific niche areas of innovation in agriculture—such as plant-based vaccines—that diverse stakeholders could rally around. This proved to be an excellent strategy, because concerted action was necessary to forge multiple new business, regulatory and other relationships along the new value chains that arose in the switch from food crops to non-food products.

This dialogue also plays an important role in brokering agreement on the distribution of types of crops grown in a region or province; with the increasing use of plant platforms for energy and for industrial and fine chemical use, there is a need to ensure sufficient supply of food and feed crops. By 2020, this had become a major consideration.

Biotechnology has given Canada additional opportunity to build on its international reputation as an "honest broker" and supporter of environmental agreements. By sharing its management and governance innovations—adaptive management, dialogue, sustainability assessment, regulatory systems—with developing nations, it helps them to develop capacity to achieve their Millennium Development Goals for alleviating key concerns around disease, poverty, hunger, clean water, and environmental sustainability.

By taking leadership in international forums such as the UN, World Intellectual Property Organization (WIPO) and the World Trade Organization (WTO), Canada is contributing to the creation of systems that reconcile the need to explore and develop biological

Image courtesy of the CSIR

In 2003, Petrus Vaalbooi of the South African San Council shows the Minister of Science and Technology of South Africa, Dr. Ben Ngubane, how Hoodia is cleaned. Later that day a benefit-sharing agreement was signed between the Council for Scientific and Industrial Research (CSIR) and the South African San Council, which was witnessed by Minister Ngubane.

resources with the fair and equitable sharing of benefits derived from them. This leadership role allows Canada to participate in public-private partnerships, spearheading such initiatives as the provision of heat-tolerant edible vaccines to millions of people in areas without refrigeration. This involvement also strengthens Canada's position within international research consortia that lead to accelerated discoveries for meeting the needs of people in developing nations as well as within Canada.

Of note is an international network of centres of excellence for marine biotechnology. There have been numerous strategic alliances and spin-off companies arising from research performed by Canadian network members. These are rapidly developing into a burgeoning domestic marine health products industry that is based on extracting valuable compounds from aquaculture and fish-processing waste, as well as taking advantage of genetically engineered (GE) marine species grown in closed culture for valuable medical compounds.

As part of Canada's contribution to the international network, in 2008 a marine biodiversity and biotechnology centre was established. This centre has a number of "public good" functions. It is the North Atlantic node for the use of biotechnology to monitor and conserve marine biodiversity, especially those species affected by fishing, where genomic techniques are used to identify sub-populations that may be at risk. It also serves to monitor marine bioprospecting off Canada's shores, and regularly documents new industrial and medical uses associated with genetic material taken from the life of vents, arctic habitats and other extreme ocean environments. A unique non-profit centre, "Goods from the Sea" was started in 2010 to ensure the equitable distribution of the benefits of marine biotechnology. Special licensing practises have been devised to ensure that useful innovations discovered through the network's research are made available to those who need them at affordable costs.

Just Imagine… 2020… An Outcome?

Can we create a future where a national *innovation system* supports the invention, commercialization and market acceptance of new technologies for achieving sustainable development? Augmented by a *regulatory system* that ensures the safety and health of the environment and Canadian citizens? And supported by an excellent *system of knowledge generation and communication* that serves civil society, government and business? Where these three interlocked systems are *guided by values, ethics and principles* that steer their functioning towards environmental and human sustainable development outcomes? If we are successful, there should be renewed confidence in our national ability to act for the public good—and to be seen as doing so.

Could *Just Imagine… 2020…* become a reality that contributes to Canada's sustainability, productivity and competitiveness?

Other Biotechnology and Sustainable Development Scenarios

We believe that *Just Imagine… 2020…* is attainable. In fact, through Canada's investments in scientific R&D at Canadian universities and research centres such as the National Research Council (NRC) and the International Development Research Centre (IDRC), and through provincial innovation centres and the private sector, we have starting points for each of the outcomes mentioned. Each imagined event is based on pathways of endeavour that already exist. Yet, make no mistake: achieving these outcomes will take concerted effort on the part of several sectors, public acceptance, and strategic use of political energies. The effort should be well worth it.

However, *Just Imagine… 2020…* is only one of many possible scenarios that could be considered.[6] Some might be much more pessimistic about possibilities and timelines. Others might emphasize the competitive advantages of other nations in relation to levels of investment, size of markets, etc. And, of course, it would be possible to construct a "muddling through" scenario, where Canada fails to adopt new technologies due to various barriers and an inability to foster key drivers such as strengthened calls for a clean environment. Some might be bolder, speaking to Canada's "natural advantage" of a large land and biomass potential.

Biotechnology scenarios feature prominently in several international initiatives. The Organisation for Economic Co-operation (OECD) has examined the role of biotechnology in agriculture, medical, environmental and industrial applications, leading the OECD Secretary General in 2002 to prepare an article[7] entitled *Biotechnology: The Next Wave of Innovation Technologies for Sustainable Development.* The OECD has now embarked on a new project: *The Bioeconomy to 2030: Designing a Policy Agenda.* The core of this project[8] is to develop a "no-regrets" form of policy-making for the biosciences, so decisions can be made without foreclosing on future opportunities and options. The OECD study will rely on scenario development rather than forecasting, since technology futures are "inherently unpredictable."

In 2000, the World Business Council for Sustainable Development (WBCSD)[9] introduced three biotechnology scenarios at a global level, each dealing with a different driver: fear of innovation, consumer choice, and opportunity to shape outcomes. The third, called *Biotrust*, is based on building trust among stakeholders while taking into account eight areas of concern: transparency, ongoing stakeholder involvement, ground rules for risk-benefit analysis, a global system of safety standards, inclusion of developing nations in the benefits of biotechnology, data protection, guidelines for patenting and licensing, and responsibility for external costs and other liability issues.

We reflect on these hypothetical examinations because they lend insight into the kinds of issues we must consider now if we are to understand and shape science and technology applications for future use. Throughout this report, we will place emphasis on adaptive planning and management, which requires both public dialogue and trust-building. We live in an age where change is constant and surprises are common. An adaptive approach encourages mutual learning processes, where all parties openly acknowledge that innovations are indeed experimental, with implications and impacts being revealed only gradually.

[6] The series of Foresight exercises conducted through NRC and the Office of the Science Advisor offer considerable insight into outcomes, including bioproducts. See www.nrc-cnrc.gc.ca/aboutus/ren/nrc-foresight-sum_e.html and J. E. Smith. *S&T Foresight: Provocateur for Innovation Policy?* www.proact.2006.fi/chapter_images/298_ref_a10_jack_smith.pdf

[7] In Serageldin and Persley, 2003.

[8] OECD, 2006. Scoping Paper. International Futures Programme. www.oecd.org

[9] WBCSD, 2000. *Biotechnology Scenarios: 2000-2050: Using the Future to Explore the Present.* Geneva. p. 60. www.wbcsd.org

BSDE—A New Relationship between Biotechnology, Sustainable Development and the Economy

The overarching message of this BSDE report is that biotechnology could help Canada and the world attain sustainable development goals while enhancing Canada's overall economy. A strong sustainable development-oriented biotechnology sector could reduce Canada's ecological footprint, reduce toxic substances, support clean air and water goals, and perhaps play a role in relation to climate change, while positioning Canada and its people to take full advantage of new knowledge and skills available in coming years.

Decisions made over the next several years will shape outcomes from 2010 to 2020. The Working Party's recommendations cover the most significant choices we believe should be made soon to ensure an optimal long-term relationship between biotechnology and sustainable development. Canada can then take advantage of this relationship to shape its future economy.

To achieve optimum impact, biotechnology should be applied within a strengthened policy and legislative framework. If poorly implemented, biotechnology initiatives could exacerbate existing problems—or create new ones. The result would be a lack of public confidence that could spill across a number of areas of technology introduction. For that reason, we examine BSDE from the perspectives of opportunity, community and ecosystem health, potential economic advantages, monitoring and assessment needs, public learning and dialogue, Canadian and international interests, and governance concerns. These are key building blocks for a strong relationship between biotechnology and sustainable development.

Enhancing and maintaining public goods and public trust are key for sustainable development and for biotechnology applications. We must ensure a high level of accountability relative to both. Hence, there is a central role for government as trustee, which brings with it a number of obligations. Most fundamentally, we must ensure that innovative technology applications ultimately protect and enhance the "common good" derived from essential elements of nature, including matters related to access to and benefits from genetic material, safeguarding biodiversity, sustainable use of the biomass that maintains soil fertility, and the integrity of ecosystems. This is a tall order, requiring use of our most credible agencies for accountability, particularly the Auditor General of Canada and the associated office of the Commissioner for Environment and Sustainable Development (CESD).

Principles and Values

While there has been much discussion about principles and values surrounding biotechnology in Canada, most has been based on medical and food applications. Efforts to create a robust, broadly accepted environment and development approach have been limited. Certainly, the existing Canadian Biotechnology Strategy (CBS)[10] is deficient in this regard, although the overall vision of the CBS[11] is consistent with our own sustainable development approach.

When working with an all-encompassing topic such as sustainable development, it is important to be as clear as possible about the desired outcomes and the process for obtaining them. Below, we present two sets of principles, one detailing the desired ends we are working towards, and the other outlining the means by which we work toward our desired ends. Together they summarize the values that guide

[10] 1998 Canadian Biotechnology Strategy. www.biostrategy.gc.ca

[11] The CBS vision is "to enhance the quality of life of Canadians in terms of health, safety, the environment and social and economic development by positioning Canada as a responsible world leader in biotechnology." www.biostrategy.gc.ca

our vision of and recommendations for sustainable development in the context of biotechnology.

The first set of four principles, adapted from *The Natural Step*, establishes ***rigorous conditions*** that should stimulate a more rapid transition away from unsustainable natural resource and environmental use.[12] We have deliberately chosen principles that industry and community leaders in many countries endorse—because they aim high, intending to create transformative change towards sustainability. Example applications of each principle are noted in italicized text.

Desired Sustainable Development Outcomes

- Reduce and eventually eliminate activities that cause the systematic increase of substances from the earth's crust (e.g. petroleum products, heavy metals) within ecosystems at the earth's surface. *Substitute renewable for non-renewable sources of materials and energy.*
- Reduce and eventually eliminate activities that result in the systematic increase of synthetic molecules (e.g. nuclides, persistent organic pollutants) that cannot be broken down and reintegrated into natural systems. *Make safe, biodegradable products wherever possible.*
- Reduce and eventually eliminate activities that result in the degradation of essential eco-system functions (e.g. soil degradation, water pollution) and biodiversity (e.g. unsustainable harvesting, invasive species). *Protect ecological goods and services while respecting nature and biological diversity.*
- Develop societal structures and practices that ensure that basic human needs (including determinants of social and emotional health) are met worldwide. *Work cooperatively to meet the Millennium Development Goals.*

We adopted the second set of five principles from the Queensland, Australia, *Code of Ethical Practices for Biotechnology*, a widely quoted source.[13] These principles are helpful to guide ***due process*** for achieving outcomes.

Sustainable Development: Principles for Process

- Integrity: having honesty and respect for the truth.
- Beneficence and non-maleficence: achieving the greatest possible good while doing the least possible harm.
- Respect for persons: treating patients, clients, research subjects and consumers as autonomous agents having freedom of choice, dignity and human rights.
- Justice: recognizing wider community interests beyond the interests of the individual, organization or corporation; providing redress for the vulnerable; and promoting equitable access to resources.
- Respect for the law and system of government: complying with relevant laws and standards; fostering public participation and transparency in decision-making; and demonstrating accountability for actions and use of resources.

[12] Adapted from Robert, K.H. et al., 2002. *Strategic Sustainable Development – Selection, Design and Synergies of Applied Tools.* J. of Cleaner Production, (10): pp. 197–214; see also K.H. Robert, 2002. *The Natural Step Story.* New Society Publishers, Gabriola, B.C. p. 288 and www.naturalstep.ca

[13] See *Code of Ethical Practice for Biotechnology in Queensland*. www.sdi.qld.gov.au/dsdweb/v3/guis/templates/content/gui_cue_menu.cfm?id=7145; also, see Evlyn Fortier and Marc Saner, 2004. *Is the Queensland Code for Biotechnology a Good Model for Canada? A Preliminary Analysis.* Institute of Governance, Ottawa. p. 44.

KEY FINDING #1

The principles of Canada's existing biotechnology strategy do not provide sufficient operational guidance for sustainable development or direct enough support toward specified goals in this area.

RECOMMENDATION #1

The Government of Canada should develop a biotechnology strategy that contains explicit values and ethical principles driving the assessment and uptake of new opportunities, implementation of adaptive management integrating ecology and the economy, and the development of a global outlook for meeting Canada's sustainable development goals.

Adaptive Management

We encourage the use of adaptive management[14] because development of biotechnology for sustainable development will be neither fully predictable nor ordered. Surprises are to be expected. An adaptive management approach to a new technology gives us a means of dealing with issues that otherwise may be too complex, interwoven, and dynamic to assess with conventional risk-avoidance approaches. It allows us to move forward while providing the information needed for risk identification and risk management. Specifically, adaptive management requires "a transparent and open-minded process of social choice" in which policies and novel programs are treated explicitly as experiments, with opportunities for social learning and subsequent adjustment of practices.[15] Adaptive management is reasonably established as an approach for environmental issues and sustainable development, although still not common practice.

We believe it to be an essential approach for the future—a means to build confidence in technology innovation, and a means to learn from "small surprises" in order to improve safety and maximize sustainable development benefits. Thus, adaptive management figures prominently in all parts of our report. However, because it is not an approach widely used by those engaged in innovation technology introductions, there is a need for capacity building on how adaptive management can be applied in a systematic fashion.

Timelines and Barriers

What kind of timelines are we expecting for the mainstreaming of BSDE? The timeline table on the next page is based on extensive review of current initiatives and projections worldwide. It shows biotechnology innovations from 1995 to date, along with our outlook for 2007 to 2020. In reality, timelines will depend on regulatory and investment decisions, and on public and consumer acceptance of products. Nevertheless, we will likely possess the necessary scientific and technological knowledge for each category within the timeframes noted. We envisage that by 2012, BSDE will have become a mainstream technological and economic activity.

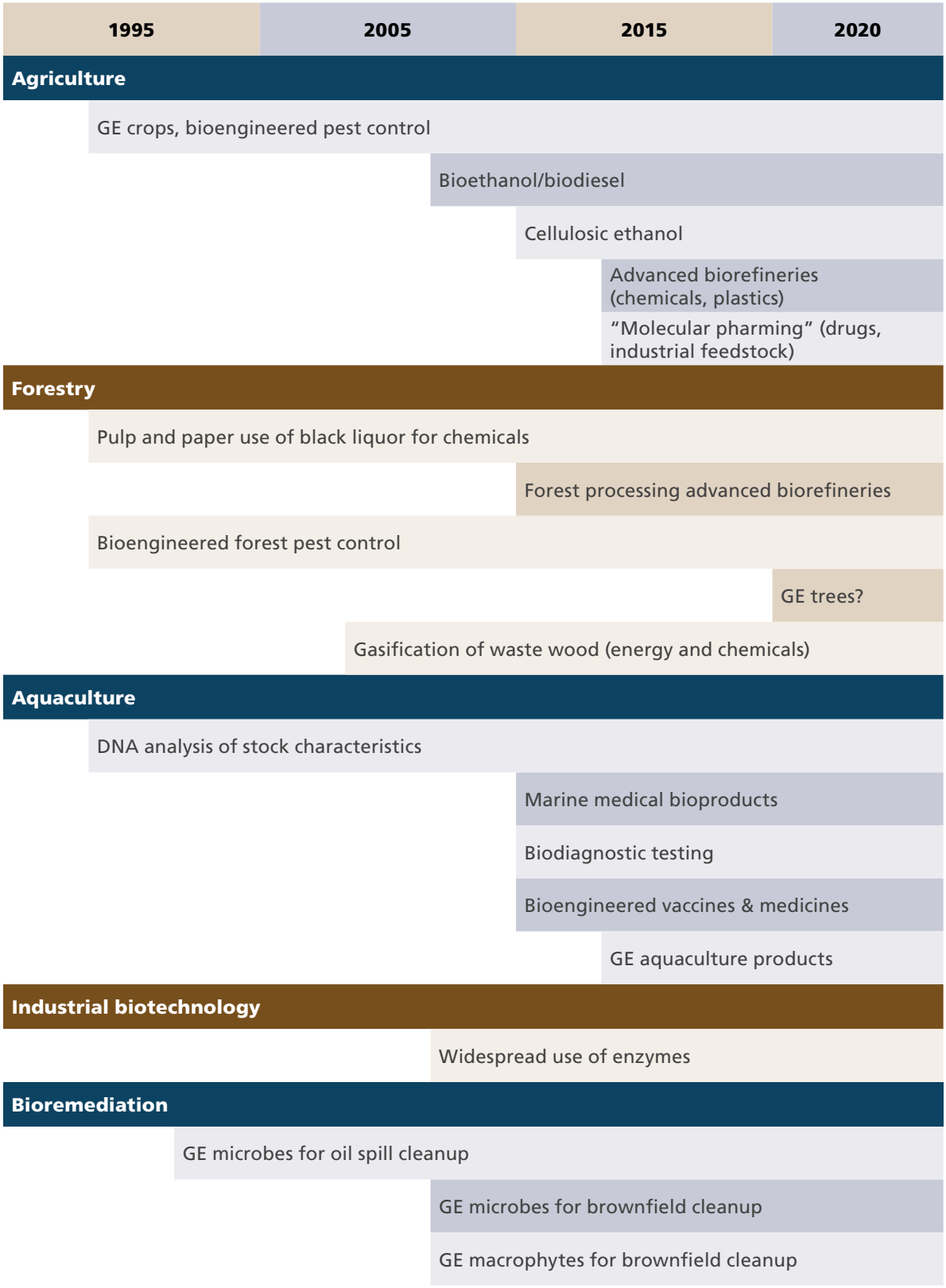
We place considerable emphasis in this Executive Report on bioproducts and biorefineries, since these are likely to be most significant in terms of policy decisions, and in terms of need for new assessment processes. Industrial use of enzymes will proceed at rates determined by industrial R&D and re-tooling of industrial processes. Bioremediation, while in use for activities such as oil spill cleanup may be introduced rather slowly, as specific techniques are developed.

Canada has considerable research capital for BSDE—through government-sponsored

[14] Adaptive management is "a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs." B.C. Ministry of Forests and Range, Forest Practices Branch.

[15] Kai Lee, 2003. *Adaptive Management in the Canadian Nuclear Waste Program.* Background paper commissioned for the Nuclear Waste Management Organization. p. 10. www.nwmo.ca

Timeline for Canadian BSDE Applications



organizations such as the Canada Foundation for Innovation (CFI), the NRC and National Science and Engineering Research Council of Canada (NSERC), federal departments, various provincial research councils, and private-sector companies. Useful dialogue and action—especially for bioproducts—fostered by Industry Canada, BIOTECanada and other associations, is taking place among key players.

Yet resulting commercialization rates in each area are still low. Sustainable Development Technology Canada (SDTC) is a helpful addition for initiatives that are at a crucial pre-commercialization stage. However, most SDTC efforts are currently focused on climate change. Some companies wishing to establish industrial biotechnology operations in Canada are frustrated by decision times and regulatory uncertainties.

There is a very concerted effort underway to develop the biofuel sector both in Canada and other regions and countries through the use of generous subsidies and various incentives.[16] This approach, coming at a time of collapse of World Trade Organization (WTO) talks to reduce agri-cultural subsidies could be seen as a harbinger of a whole new round of rural support mechanisms, with the added twist of seeking to link these initiatives to fuel security and to environmental benefits. These "first-generation biofuel" investments have the potential to lock countries into choices and longer-term financial and environmental costs that are not desirable. These issues need to be considered carefully.[17]

We believe that biofuels can be useful for Canada and others as an important entry point to the broader industrial transformation favouring bioproducts.[18] However, both immediately and for the long run, it is sensible to encourage technologies that utilize, at a sustainable level, residues and wastes. This strategy would place emphasis on accelerating production efficiency and achieving well-defined environmental benefits. In particular, it would require a focus on commercially successful cellulosic ethanol and lignocellulose from wood and crop residues. It is a strategy that would stimulate use of currently available materials such as commercially collected food wastes, livestock wastes and municipal wastes. This approach will require further R&D

[16] The most comprehensive support packages are those proposed by the Canadian Renewable Fuels Association in their 25 July 2006 *Canadian Renewable Fuels Strategy*, which calls for changes to tax credits for ethanol and biodiesel production, accelerated depreciation, initial support for a commodity production incentive during start-up and, for smaller producers, an additional tax credit for a portion of their production. In addition, it is proposed that matching funds on a dollar-to-dollar basis be provided to increase participation by farmers (up to $75,000 per producer, with a limit of $20 million per ethanol project and $10 million per biodiesel project). The emphasis in these proposals is on conventional food crops including grain, corn and canola, although use of waste materials such as cellulosic ethanol is not excluded. The purpose of these incentives is to create an industry that could be competitive with subsidized US first-generation biofuels. www.greenfuels.org

[17] See speech by Stavros Dimas, EU Commission Member, 7 June 2006 to Goethe Institute. Brussels. *A Sustainable Bio-fuels Policy for the European Union;* also, The Worldwatch Institute, June 2006 review of biofuels; Alexander E. Farrell, Richard J. Plevin, Brian T. Turner, Andrew D. Jones, Michael O'Hare, Daniel M. Kammen, 2005. *Ethanol Can Contribute to Energy and Environmental Goals.* Science, 311: pp. 506-508.

[18] A.M. Walburger, D. LeRoy, K.K. Kaushik, K.K. Klein, March 2006. *Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and the United States*. Biocap Canada Foundation.

investment and support to move from pilot-stage plants to large-scale, integrated commercial biorefinery facilities capable of providing a range of products.[19] Other countries with defined mandates (e.g. US goal to support mainstreaming cellulosic ethanol over the coming six years) and incentives (e.g. Ireland's use of carbon credits that could be applied to an integrated biorefinery) may provide a better investor environment that will lure away businesses started in Canada.

Pulp and paper mills already are strategically important as proto-biorefineries. They produce chemicals from wastes, along with a significant amount of energy for use in their processing and for sale to others. This would appear to be an area of advantage for Canada and also an urgent matter. Yet, with the exception of a few companies such as Tembec, which is producing high-quality cellulosic products, food-grade ethanol, a range of lignin by-products and other chemical products at its Temiscaming site, Canadian mill owners are not embarking on an integrated biorefinery approach. With new investment and engineering re-design, it has been suggested that very significant new revenue streams could be established.[20] Major technical breakthroughs may well take place in European or US rather than Canadian operations. The double-barrelled barrier of recent low revenues in pulp and paper and limited investment presents a dilemma, since biotechnology innovation could help reduce costs over the long run, while providing value-added chemical and additional energy product streams.

Other cases of uncertainty in Canada could be cited, including the slow progress of dealing with urban organic and food wastes, manure from feedlots, and the scaling-up of cellulosic ethanol from agricultural residues by Iogen Corporation. Much will depend upon whether the current provincial and federal

http://commons.wikimedia.org/wiki/Image:Temiscaming_Quebec.JPG

commitment to biofuels broadens into a more general shift to bioproducts, as suggested in *Just Imagine… 2020…* . Clearly, there will be a need to attract multinational companies now just beginning to develop biorefineries that will produce platform chemicals for various synthetic products.

At the moment, with the exception of biofuel efforts, there is no dedicated federal program effort to ensure that biorefineries do indeed emerge as part of Canada's future industrial fabric. Practical barriers include the need for further R&D effort, stable investment funding, a transition to new bio-based engineering and plant management capacity, an integrated approach to regulatory decisions, and, very likely, improved federal-provincial coordination for creating attractive development situations. There will be a period of perhaps 5 to 10 years when many, perhaps most, biorefineries are unlikely to be profitable. Other nations face the same challenges. The US, China and countries in Europe are investing through public and private funding.

[19] The largest facility is a $200 million biorefinery investment by Cargill (originally with Dow Chemical) to produce polylactide polymers from corn, and from this stock, biodegradable plastics. www.natureworksllc.com

[20] G. Cosset, D. Raymond and B. Thorp, 2005. *The Integrated Forest Products Biorefinery.* www.biorefineryworkshop.com; P. Gunther, 2005. *Capturing Canada's Natural Advantage.* Workshop Report. Alberta Research Council, Paprican, Canadian Forest Innovation Council. www.arc.ab.ca; Paul Stuart, June 2006. *The Forest Biorefinery. Survival strategy for Canada's Pulp and Paper Sector?* Pulp & Paper Canada.

KEY FINDING #2

Canada is not moving quickly enough to set conditions in place that are attractive to bio-refinery investors. Integrated biorefineries, designed to yield a range of outputs for synthesis into products and energy, promise new revenue streams, cleaner air and water, and the reduction of dependence on fossil fuels. This matter requires urgent attention, as other nations are already supporting new developments. Various barriers to the trade and transport of biomass products must be removed, and, very likely, transition support from government will be required.

RECOMMENDATION #2

The Government of Canada, in order to give Canada a comparative advantage, should enable the establishment of advanced biorefineries capable of using either agri-cultural, forest, food or municipal wastes and residues. This should be done through arrangements with provincial governments and the private sector that do not impose ongoing costs on Canadian taxpayers.

Addressing Community Health, Economic and Ecological Needs

The prolonged, often bitterly divisive debates over GE food crops presented concerns about one aspect of biotechnology where direct benefits to the public were hard to discern. Yet some GE crops have been accepted by many farmers, since they raise net incomes and reduce the need for pesticides and ploughing. Where benefits are clear, for example, with certain life-saving medications, or where risks are not perceived to be great, for example, in the use of GE enzymes in the industrial production of cloth for blue jeans, public acceptance appears to be high. In years ahead, new questions will arise, for example, about the environmental and local benefits of crops for biofuel production. We can anticipate neither all the key debates, nor their outcomes.

But communities—rural and urban, large and small—have a very legitimate stake in the future of BSDE. Their interests are informed by perceived benefits—primarily the health of individuals and quality of life of the community, ongoing and new economic opportunities, and the health of ecosystems and the environment. Local stock-taking will also measure biotechnology benefits from the perspective of consumer choice, and access and benefits sharing. Major centres already feature "bio-based" clusters, largely centred around medicine and food R&D. Smaller initiatives include the Ottawa Valley-based

eco-industrial Bioproducts Business Network, centred in part around byproduct synergy—optimizing waste and energy use.[21]

BSDE and Rural Economies

An immediate concern is the role bioproducts and biorefineries can play in the economy of rural areas, especially those suffering through low crop prices, the effects of various livestock diseases, and problems in other sectors such as forestry, pulp and paper, and marine fisheries and aquaculture. We commissioned the Conference Board of Canada to examine potential economic benefits for rural communities that might arise through biotechnology applications. Analysis of rural area biotechnology applications (see table) shows possible impacts arising from new biotechnology value chains in three rural sectors. The findings reveal a substantial number of potential environmental and economic benefits.

Overall, however, the Conference Board findings, based on application of their innovation framework,[22] suggest that biotechnology applications for rural resource use are far from being an economic panacea. Their analysis suggests that biorefineries have the potential to be anchor facilities in rural communities. Biorefineries could bring some new, high-value jobs to rural communities, including support operations such as transportation and logistics. Moreover, biorefineries will produce many different outputs that can in turn be transformed into products and services.

However, the economic viability of rural biorefineries remains speculative. Challenges include developing workable financial and institutional arrangements such as farmer-led cooperatives in which shares would be purchased, obliging the delivery of set amounts of raw material. Big biorefineries will enjoy the same advantages of scale as do large petroleum refineries, and are therefore likely to be located near urban centres. On the other hand, transport cost of "wet" crops and wastes gives an advantage to at least some level of processing to be done locally in rural communities. Such processing would certainly include smaller ethanol and local operations that produce intermediate-stage chemicals that might feed larger biorefineries producing plastics or other final products. Other materials, such as manure from feedlots or intensive animal husbandry operations, and waste from rural food-processing operations could be handled by smaller-scale rural biorefineries.

The initial opportunity to test the Conference Board's conclusions will come over the next several years as biofuel production becomes established in various Canadian rural locations. However, this will be in a situation where a considerable subsidy is provided. In the US, with conventionally produced, highly subsidized bioethanol, large integrated operators have had a clear advantage.

Ensyn Rapid Thermal Processing Commercial Plant

[21] www.ontariobioproducts.com/regional-networks/eastern.aspx

[22] The Conference Board of Canada, 2005. *Assessing Biotechnology as a 21st Century Technology Platform for Canada* provides a description of their innovation framework. The study on rural implications of BSDE will be published by the Conference Board.

Analysis of Biotechnology Issues for Rural Areas

	Agriculture	Forestry	Marine Aquaculture
Inputs	A range of crops including corn, wheat and others such as biopharmaceuticals, possibly some agroforestry; Crop residues, wastes from food processing, slaughterhouses; Solid and liquid manure from livestock.	Biotechnology applications assist in the bleaching of wood pulp; Residues and wastes from mill operations transformed into more valuable uses.	Biotechnology applications applied to improve reproduction, reduce spread of disease and improve feed conversion; Fish-processing plant waste.
Production	Some crops will need heightened containment procedures; Mix of non-GE and GE crops; More efficient use of water, better crop rotations and cultivation, reduced use of biocides.	Major supply likely to be wood waste; Pulp and pulp mill waste effluent; Little or no use of GE tree crops but fast-growing poplar plantations likely.	Greater range of organisms produced including unicellular organisms, algae and seaweeds, finfish and shellfish; Transgenic organisms, if approved, need containment, perhaps land-based facilities; Improved feed conversion, pest and disease control; High-value health and well-being products.
Processing	Variety of biorefinery types in use including smaller, intermediate and large refineries, with much greater efficiency than now; Cellulosic and thermal processes permit much greater use of wastes; Location competitively determined by transportation costs, processing type, local organizational factors, but with significant incentives or other factors still in play.	Existing and new pulp mills become biorefinery sites; Biorefineries extract lignin used for production of ethanol, and refine and collect valuable resins and other molecules; Self-fueled, with energy surplus.	Production and byproducts are processed into biofuels, animal feed, chemicals and health products through biorefineries and other forms of processing.

Analysis of Biotechnology Issues for Rural Areas (continued)

	Agriculture	Forestry	Marine Aquaculture
Customers	New customers in new supply chains, but price competitiveness with fossil fuels and chemicals still a problem; International marketplace for commodity and specialized products is major concern for Canadian producers.	Companies requiring chemicals and feedstocks such as resins for glues, foods and health products; Companies seeking biofuel sources.	Customers include agricultural farmers, health and beauty product companies, beer manufacturers, others; Aquaculturists seeking vaccines, medicines, biodiagnostics; Fish vendors, consumers.
Impact	Increased farmer and rural community income through higher overall return from crops and sale of residues, high-value pharmaceutical or other specialized crops; Reduced environmental impact (e.g. reduced pesticides, animal waste disposal); Moderate reduction in Green House Gas (GHG) (carbon dioxide and methane); Concerns may develop over competition for land use, biodiversity, soil quality and water use.	Added income streams for pulp and paper mills, making them more competitive and preserving rural jobs in resource towns; Reduced environmental impact from pulp and paper operations and ecologically sustainable use of residues; Moderate reduction in GHG (carbon dioxide); Value-added to wood residues, including from forests damaged by climate change.	Improved incremental revenues for producers and economic improvements for rural locations with biorefineries or other processing; Improved predictability of revenue resulting from effective management of fish reproduction and disease control; Better environmental control and reduction in wastes; Ongoing concerns over containment and other issues related to genetic mixing, species introduction, spread of disease to wild stock, allocation of space for aquaculture.

Our concern is that the mandated move towards biofuels in Canada and other OECD countries has the potential to become a new form of rural agricultural subsidy in rich nations, and that, while price supports and tax breaks may be provided in the name of environmental protection, they may be neither cost-effective nor helpful in stimulating the best longer-term technology. We do not believe it is in Canada's longer-term interests for farming communities to link their future to new subsidy programs.

We also believe that agricultural commodity prices may rise as a consequence of the rapid

move towards biofuels taking place in many countries. Concern is already being voiced internationally about competition between fuel use and food use. It makes sense for Canada to concentrate its efforts on the use of wastes and residues in a sustainable fashion, and not to engage in highly subsidized efforts to grow dedicated biofuel crops where others may have a comparative advantage. Growing canola for biodiesel may be one such case.

Furthermore, tariffs that would, in effect, restrict ***sustainably produced*** biofuels from entry into the Canadian market would be unreasonable. Current Canadian tariffs, while lower than others such as Australia, do represent a barrier for ethanol-exporting nations such as Brazil. The US, as it ramps up its domestic production, may well seek a foothold for ethanol markets in Canada duty-free under the North American Free Trade Agreement (NAFTA). Only limited direction has so far been provided in the WTO on the subject of biofuels. They are appearing on lists related to environmental protection and undoubtedly, there will be challenges to tariffs.

KEY FINDING #3

Governments are establishing precedents in economic policy that could work against both economic efficiency and the internalization of environmental costs for both present and future applications of bioproducts. In the case of biofuels, the stimulus of subsidies, excise tax removal and other incentives may provide short-term rural economic activity. This approach, especially if entrenched around first-generation solutions such as ethanol production from grain, may delay introduction of more effective second-generation solutions such as ethanol from cellulose. Canada and other countries have set up trade barriers by keeping tariffs on biofuel imports.

RECOMMENDATION #3

The Government of Canada should ensure that positive fiscal policies (R&D funding policy, tax structure, etc.) are linked to positive sustainable development outcomes. Direct government intervention should be recognized to be temporary funding only and involve careful monitoring. The Government of Canada should promote participation in development of eco-labelling and sustainable development certification schemes for bioproducts, and remove import tariffs on sustainably produced biofuels and other bioproducts.

Ecosystem Monitoring

Clearly, some of the most significant bioproduct concerns will be those associated with the introduction of GE organisms into the natural environment, along with concerns about the effects of more intensive use of ecosystems. If the full range of introductions described in the *Just Imagine… 2020…* scenario were to take place, it would mean the presence of drought- or insect-resistant GE plant crops, faster-growing trees, and perhaps aquacultured marine or freshwater crops, plus a variety of plants and microbes used for cleaning up mining tailings, brownfield sites, etc. As well, plants with GE medicinal properties (e.g. insulin-producing) and vaccines can be anticipated. Increased use of biomass that previously had been left to contribute to soil fertility poses questions and possibly ecological risks. Canadians have not fully debated the merits of these introductions. Nor is there currently a well-developed framework for appropriate ecological assessment, or post-introduction environmental monitoring of novel organisms.

While some of the necessary regulatory elements are in place, the system is currently piecemeal. The biotechnology regulatory framework distributes responsibility between four departments and

agencies,[23] each with its own culture and methods of defining terms such as "precaution." There is weak coordination among departments to aid in the determination of how to assess products that do not fall in any one department's regulatory mandate, but are shared among them. As new innovations are developed, the system is vulnerable to ***rising expectations*** on the part of proponents, and ***rising doubts*** on the part of those skeptical about new technological interventions.

Information and knowledge must be the cornerstone of an adaptive management approach to biotechnology development. Those who make decisions about the introduction of biotechnology products or processes must possess the best possible understanding of the associated potential benefits and risks. One key area is long-term environmental health, especially in relation to potential impacts at the ecosystem level. Rigorous ecosystem monitoring is needed to understand anticipated, unanticipated and cumulative effects across various scales and locations. An example is the ability to determine acceptable levels for the ***sustainable*** harvest of biomass residues from agricultural, forestry and marine environments. A detailed, regionally-based national inventory of these wastes and residues is needed now, but it is a number of years away from being completed, as funding allocations have been limited.

The federal government has not yet implemented its long-awaited research strategy on the *Ecosystem Effects of Novel Living Organisms* (EENLO).[24] EENLO should not only include new, more in-depth research, but also link with other ecosystem monitoring activities operating at local, provincial, national or international levels. It will be necessary to build an international comparative knowledge base on ecosystem effects of various biotechnology introductions.

KEY FINDING #4

No systematic ecosystem-scale monitoring regimes exist nationally to direct the development, deployment and regulation of biotechnologies in government decision-making. The monitoring systems that do exist are not integrated enough to answer ecosystem-level questions. The links between existing data sources and decision-makers are frequently informal, tenuous or non-existent. An integrated information generation and communication system is required for the assessment of environmental sustainability. Implementation of the federal Ecosystems Effects of Novel Living Organisms (EENLO) program has been stalled.

[23] Environment Canada, Department of Fisheries and Oceans, Health Canada, and Canadian Food Inspection Agency.
[24] See www.ec.gc.ca/scitech/default.asp?lang=En&n=18BE230D-1. Seven areas of research are proposed under EENLO.

RECOMMENDATION #4

The Government of Canada should implement an ecosystem monitoring and information program to provide sufficient and robust information on the ecosystem effects of new activities related to biotechnology. A dedicated effort is required that would integrate this program with existing ecosystem health initiatives and include the implementation of EENLO. The monitoring strategy should provide for transparent, timely and scientifically credible development of regulations, and for testing of important ecological hypotheses concerning innovative technologies.

BSDE Assessment Framework

A considerable element of precaution is embedded within Canada's current environmental and health regulatory systems. But overall, they present neither a streamlined nor a particularly transparent system of assessment for BSDE applications. Assessments do not consistently cover all stages of product development. Nor are they integrated into a sustainable development framework. Environmental assessment should function to integrate these elements within an overall decision-making context that would include social and economic factors. But this ideal is far from being achieved, although its value is noted by the Canadian Environmental Assessment Agency and others.[25]

While many appropriate tools are available, such as life cycle and economic benefit/cost analysis, they are not currently being applied in a consistent way to measure impacts such as effects of bioproduct production on biodiversity or to determine the most cost-effective approaches to meet sustainability objectives. This is partly the result of the newness of applications. But there are more fundamental problems.

The *Canadian Environmental Assessment Act* (CEEA) does not provide for integrated sustainable development assessment. And, while a new technology, such as GE canola or the use of bioethanol as a transportation fuel, may be introduced across the country, it does not trigger a major environmental assessment. The scarcity of good baseline ecosystem and other relevant information continues to be a problem, as mentioned earlier. Under the federal government's *Biotechnology Regulatory Framework,* the assessment of ***products*** of biotechnology is delegated to units of government such as the Canadian Food Inspection Agency (CFIA), whose environmental assessments are considered to fulfill the requirements of the *Canada Environmental Protection Act* (CEPA). These assessments are based on small-scale, relatively short-term experimental and field trial data, and do not have the statistical power and scope to be predictive over large-scale introductions.

[25] The CEAA is struggling with this problem at both conceptual and practical levels. See www.ceaa-acee.gc.ca/017/0004/001/index_e.htm and R. Gibson, 2002. *Specification of Sustainability-based Environmental Assessment Decision Criteria and Implications for Determining "Significance" in Environmental Assessment,* CEAA R&D monograph; B. Dalal-Clayton and B. Sadler. *Sustainability Appraisal: A Review of International Experience and Practice.* www.iied.org/Gov/spa/docs.html

Overall, assessment of innovative technologies is a patchwork effort that requires further reform to meet future requirements of biotechnology, nanotechnology and possibly other technologies. We believe an integrated assessment approach is desirable, based on economic, social and environmental aspects, taking into account our guiding principles. The accompanying text box describes the elements for a sustainable development framework that could be applied for innovation technologies. How it might be applied is addressed in our technical report. We are mindful of the need to: (1) use a principles-based approach to assessment; (2) make the best possible use of the array of available tools; (3) ensure the assessment covers a full lifecycle approach for products, and the full development cycle from R&D to commercial stage; (4) include deliberative dialogue with stakeholders as part of the process; and (5) establish appropriate timelines that do not unnecessarily hinder development.

Elements of a BSDE Assessment Framework

- Initital screening procedures applied to identify those initiatives that require more extensive review.
- Integrated impact assessment methods appropriate for biotechnology, based on value chains (for example, starting with raw materials, biorefinery operations, including intermediate and final products, disposal or transformation of products after use, and of waste materials associated with their production and use).
- Reliable benefit/cost and benefit/risk calculations tailored to specific circumstances.
- Thorough assessment of impacts of regulatory and economic instruments such as tax breaks, tariffs, accelerated depreciation, incentives, subsidies, etc.
- In-depth research, especially at the ecosystem level, to set baselines and establish effects using standardized methodologies devised under EENLO.
- Regular monitoring of impacts and audits to ensure compliance with sustainable development principles, as well as to detect and allow for mitigation of long-term and cumulative effects.
- Appropriate application of dialogue tools and scenarios designed for their learning value, and for inputs to adaptive planning and management.

This assessment framework could be applied initially within the context of existing laws and regulations, notably the *Canadian Environmental Assessment Act* and the *Canadian Environmental Protection Act*. Based on initial experience, further refinements could be implemented as

necessary, possibly including amendments to these acts and others. The framework should be robust enough to use in both strategic policy as well as implementation assessments.

KEY FINDING #5

No integrated framework exists in Canada to assess how well specific applications of biotechnology could meet objectives that combine environmental, economic and social concerns. Unless a comprehensive framework is developed, it will be difficult to reach good decisions on which applications are likely to be most effective. Existing assessments are not guaranteed to cover all significant stages of development or a product's full life cycle. Current assessment studies, for example on bioproducts, do not adequately assess potential social, economic and environmental impacts. The problem will worsen as the volume of proposed initiatives increases and becomes more diverse.

RECOMMENDATION #5

The Government of Canada should develop, by extending the use of existing tools and assessment processes, a sustainable development assessment framework to:

- *guide the formation and implementation of policy towards sustainable development goals and principles;*
- *screen applications for new products and services; and*
- *assess products at all stages of their development and life cycle.*

The assessment will support, not replace, existing health, safety and environmental reviews and could be introduced in a progressive fashion.

Public Learning and Dialogue

Consumers, communities and civil society institutions have powerful roles in determining the acceptability of various innovations. Therefore, we believe a need exists for robust learning and dialogue approaches. We seek dialogue that will be broadly accessible, meet adaptive planning and management needs, and, of course, help to steer the course of BSDE.

Within Canada, some of the conditions for a healthy dialogue on biotechnology and sustainable development are definitely present. Not only the government, but also a wide range of organizations are researching, discussing and distributing opinions, including the Federation of Canadian Municipalities, rural community and farm producer organizations, NGOs such as Pollution Probe and the Canadian Institute for Environmental Law and Policy (CIELAP),[26] faith groups, and universities with biotechnology interests. The abundance of information and the number of active organizations can provide a strong foundation for people to engage in productive dialogue.

However, we must find less costly and time-consuming tools and approaches than the usual consultation meetings, polling and adversarial dialogue and action associated with some debates. And we need to move well beyond the conveyor-belt approach of one-way information flow on Canada's BioPortal[27] and other government websites, useful as these are for information dissemination. We need to establish ***deliberative dialogue***, especially with and among younger people who will be exposed to many technological choices over the coming years. We must also create processes to help people make technology choices. These choices will be values-driven, but ultimately made on the basis of

[26] See Pollution Probe and BIOCAP, *Primer on Bioproducts.* p. 69; and Susan Holtz, 2006. *Innovation Technologies and Sustainability.* CIELAP. p. 28.
[27] The *BioPortal* is the Government of Canada's single-window information source, from government sources, about biotechnology. www.biotech.gc.ca

perceived benefits and risks. Such dialogue could be grounded on the principles identified in this report concerning the substance of sustainable development, or on governance and applications for specific biotechnology topics.

We define deliberative dialogue as that which facilitates productive information exchange, articulation and dissemination of knowledge through diverse, ongoing forums, in order to increase civic literacy on complex, critical public policy issues.[28] This dialogue is designed to enable people from diverse sectors, academic disciplines, and civil society to engage in trans-disciplinary discussion, which we believe is fundamental to faster take-up and adoption of innovative sustainable community development. Sometimes, deliberative dialogue involves conversational interactions among parties, that is, where different parties respond to one another's claims and critiques, as well as put forth their own perspectives and arguments. This process is unique and based on Canadian experiences with multi-stakeholder and open-ended deliberative processes.

Deliberative dialogue depends on sponsoring organizations (e.g. governments, public broadcasters, universities) to establish and maintain a neutral, safe space and accurate, clear background information for a prolonged, exploratory discussion. This permits trust-building and supports adaptive learning as new levels of understanding are reached.

Canada has pioneered the development of communication tools that could be suited to this

ongoing interaction. Royal Roads University's "*e-Dialogues®*" tool provides an Internet-based platform for large numbers of participants to discuss sustainable development issues with experts. The "*Dialogue Tool*" developed for the Canadian Biotechnology Advisory Committee (CBAC) also provides a unique approach to discuss potentially divisive topics.[29] And social science research performed by Canadian universities[30] provides an understanding of the social uses of knowledge to ensure that public participation has a meaningful impact.

Political support is needed to encourage meaningful, long-term citizen engagement on the introduction and sustainable development use of biotechnology and other new technologies.

[28] A. Dale, 2005. A perspective on the evolution of e-Dialogues concerning interdisciplinary research on sustainable development in Canada. *Ecology and Society* 10(1): 37. www.ecologyandsociety.org/vol10/iss1/art37/

[29] This tool helps to identify a "spectrum of acceptability" for various biotechnology applications. It was created through a stakeholder group working in cooperation with CBAC. While specifically developed to address issues related to GM food, the tool could be used to assess any type of bioproduct, as well as some health and industrial applications. www.cbac-cccb.ca/epic/internet/incbac-cccb.nsf/en/ah00344e.html

[30] Examples are UBC research by M. Burgess and P. Danielson on how Canadians use different sources of information to navigate their way through issues where there are competing claims about health, environment, social or economic factors. (www.genomebc.ca/research_tech/research_projects/ethics/building_ge3ls.htm), and University of Calgary research on how to strengthen the role of public participation and dialogue in governance and regulation of biotechnology. (www.ucalgary/%7Eeinsiede/current.htm#gels)

KEY FINDING #6

The fate of a new technology is frequently determined by its broad acceptability to society both within Canada and globally. At the moment there are no Canadian forums for sustained, deliberative dialogue about the relationship between biotechnology and sustainable development. Deliberative dialogue to facilitate the exchange of information and points of view is an important means to build trust and understanding among relevant stakeholders. This makes it critical for both market acceptance and adaptive management of innovative products. Canada is fortunate in having a number of the preconditions for such dialogue already in place, and also some "Made in Canada" dialogue tools well-suited to the task.

RECOMMENDATION #6

The Government of Canada, working cooperatively with others, should initiate and maintain long-term deliberative dialogue with citizens and stakeholders on biotechnology and sustainable development. This dialogue should take place using cost-effective electronic exchanges, and should emphasize dialogue with younger people. Learning and dialogue efforts should be designed to yield measurable results linked to adaptive planning and management.

BSDE and International Cooperation

We conclude that Canada should strengthen its participation in international cooperation for biotechnology and sustainable development—for Canada's own good, and to support global sustainable development objectives including the Millennium Development Objectives. International development organizations have acted on the merits of biotechnology, primarily in relation to health and food issues, intellectual property rights, and access and benefits sharing.[31] Others, including a number of international environmental NGOs have fiercely debated subjects such as GM trees, rules for biosafety, and "terminator" genes, among many topics.

The subject area will become more complex as other natural resource, environmental and industrial biotechnologies are added. Meanwhile, biotechnology gaps are building between biotechnology-sophisticated countries like China and India, and most nations in Africa, and poorer nations in other parts of the world. There is growing interest in the potential role of Africa as a supplier of biodiesel and other biofuels to Europe.[32] Undoubtedly, there will be debate about whether this can be done sustainably, producing local benefits while safeguarding soil fertility and biodiversity, and within the limits of available water. And, as will be discussed below, there are major public health, clean water, and food security issues where biotechnology is likely to play a more central role in Africa and in other developing regions.

Knowledge Networks

Canada and Canadian organizations should engage in various international knowledge networks and initiatives concerning key aspects of biotechnology and sustainable development. While this is already occurring through organizations such as the OECD and the Food and Agriculture Organization (FAO) of the United Nations,

[31] See the FAO Statement on Biotechnology www.fao.org/biotech/stat.asp, extensive biosafety and other discussions related to the Framework Convention on Biological Diversity www.jiwlp.com/contents/biosafety_resources_net.html and www.biodiv.org; UNCTAD, 2004. *The Biotechnology Promise*. p. 129. stdev.unctad.org/docs/biotech.pdf; International Food Policy Research Institute (IFPRI) Program for Biosafety Systems and other topics www.ifpri.org/themes/biotech/biotech.htm; UNESCO Biotechnology Action Council www.portal.unesco.org/sc_nat/ev.php?URL_ID=2494&URL_DO=DO_TOPIC&URL_SECTION=201&reload=1062152397.

[32] See www.biopact.com.

our view is that strategic participation is needed on a broader basis with European and other North American research groups, and with emerging biotechnology leaders among developing countries such as China, India and Brazil.

To serve Canada's national interests adequately, Canada should take a leadership role and initiate a biotechnology and sustainable development knowledge network explicitly designed to address practical issues such as trade certification and procedures for sustainable development assessment, and that covers new areas such as biofuels and other emerging environment and sustainable development technologies where biotechnology has a role. Canada has strong motives to do so, since BSDE matters will find a place in international trade and multilateral environmental agreement negotiations. Canada must also develop necessary knowledge for BSDE in the most cost-effective and timely way. Often, this will be through joint efforts at an international level, involving public and private sector interests.

KEY FINDING #7

Canada can meet important domestic BSDE knowledge needs in a more timely, cost-effective fashion by leading or participating in international research and development on biotechnology and sustainable development. This engagement, which can be implemented through Canadian universities, and various research organizations, will also promote international appreciation for Canadian views and approaches.

RECOMMENDATION #7

Establish one or more Canadian university centres of excellence on biotechnology and sustainable development, with a requirement for strong international research linkages. To ensure relevance, funding could be delivered by Canada's research agencies in cooperation with relevant federal and provincial government departments and private sector support.

International Development Cooperation

The second major need is for Canada and Canadians to contribute towards a responsible approach for biotechnology and sustainable development applications in developing nations and at an international level. Such engagement is particularly important to meet the UN Millennium Development Goals, for future economic initiatives such as biofuel plantations and processing that could have major ecological implications, and for future international trade or multilateral environmental negotiations.

One new area for developing nations is access and benefits sharing (ABS) mechanisms to ensure the fair and equitable sharing of the benefits of biotechnology between the provider of the genetic "raw material" and those that develop such materials into useful innovations. Use of various policy instruments or approaches, such as

private-public partnerships, reduction or elimination of tariffs, open source Intellectual Property (IP) agreements, patent pools, strategic licensing approaches, farmers' rights, research partnerships, and benefit-sharing agreements may balance some of the perceived local negative effects of intellectual property rights. This is an area where Canada has many shared interests with developing nations, and also a vested interest in having robust, globally acceptable arrangements in place.

While Canada has internalized sustainable development within its international development strategy, no comprehensive policy for biotechnology applications exists within the Canadian International Development Agency (CIDA). And only a limited understanding appears to exist within CIDA for the roles innovation technologies could play in international development. There are various pressures on CIDA to be cautious engaging in this area, especially concerning food production.[33]

Canada's International Development Research Centre (IDRC) has initiated a promising new program on Innovation, Policy and Science that will link Canadian expertise in technologies with developing country researchers.[34] This program will be driven strongly by the interests and needs of developing nations for poverty alleviation. IDRC, taking on a role of non-partisan broker, has held a number of dialogue sessions in developing countries on the role of biotechnology and other emerging technologies.

Canada has some distinct advantages vis-à-vis biotechnology and sustainable development that could benefit developing nations. These include our promotion of value-added agricultural innovation; our expertise in vaccines and disease prevention for humans, livestock and fish; our environmental technology capabilities; and our fledgling efforts to establish new lines of bioproducts. Also of considerable interest to some developing nations is our domestic regulatory system and domestically applied experience with international agreements. These are matters of interest for others in relation to their capacity building needs and also in how we approach negotiation and subsequent implementation of international agreements.

KEY FINDING #8

Canada underutilizes the international development potential of biotechnology. The immediate challenge of meeting the UN Millennium Development Goals presents broad entry points for BSDE. A new challenge facing developing nations is sustainable biofuel production for domestic use and export. The views and needs of individual developing nations should drive their development goals. Canada can play an important role by sharing its science and technology capacity and its experience with regulatory frameworks.

[33] See, for example, The Working Group on Canada's Policy with Regard to Agricultural Biotechnology and Developing Countries. "The Working Group is made up of international development organizations, farmers groups, and other civil society organizations including: Canadian Organic Growers, ETC Group, Inter Pares, National Farmers Union, Social Justice Committee, The United Church of Canada, Union Paysanne, and USC Canada." www.interpares.ca/en/publications/pdf/no_more_silver_bullets.pdf

[34] www.idrc.ca/en/ev-90465-201-1-DO_TOPIC.html

RECOMMENDATION #8

The Government of Canada should build policy and capacity in CIDA and other Canadian institutions to address BSDE opportunities and needs of poorer nations. This should be done in a way that promotes equitable distribution of the benefits of biotechnology, especially in the international arena and for poorer developing nations.

Governance

A good governance system will build understanding and trust among key players in both public and private sectors, create space for informed dialogue, and lead to solid decisions and choices that can be implemented in a timely manner with adequate monitoring. Canada has made some progress—but at a slow pace—towards these desirable outcomes through its 1998 Canadian Biotechnology Strategy (CBS). The Strategy is a shared endeavour that builds on the efforts of a number of departments and agencies, which retain implementation responsibility for individual initiatives.

The purpose and proposed outcome of the CBS is "to ensure that biotechnology continues to enhance Canadians' quality of life in terms of health, safety, environment and social and economic development."[35] Further, the CBS should position Canada as a world leader in biotechnology. Thus, the aspirations of this Strategy are well in line with those we have identified. We therefore propose strengthening existing institutions and governance mechanisms rather than inventing new ones in a field that is already extraordinarily complex and prone to polarized views.

Governance for biotechnology (and also for sustainable development) presents the classical need for horizontal initiatives. In addition, there is a need for integrated effort related both to policies and to outcomes. Overall, the CBS was set up to be catalytic, keep files moving, and provide funding for special initiatives. It is quite complex,[36] reflecting the need for leadership, coordination and integration, for independent advice (via CBAC) to ministers and officials, and to have a communications role internally across government, with stakeholders, and with the public. There are several biotechnology coordinating committees to guide the overall process and provide strategic direction (Ministerial and Deputy Minister levels) and technical-level guidance (Directors General). In between is the Biotechnology Assistant Deputy Ministers' Coordinating Committee (BACC). BACC operates at a level with considerable accountability for outcomes and with a degree of both strategic/political and technical capacity, recognizing the dual role of Assistant Deputy Ministers in government. The small Canadian Biotechnology Secretariat (CBSec) works in a coordinating—not directive—role.

The Auditor General's 2005 review concluded that "Overall, the Canadian Biotechnology Strategy has not functioned as planned. It was designed for leadership from the top, which was not provided; however, management and working-levels did provide some coordination."

We believe that having a well-functioning coordinating and integrating body will be needed even more in the future. This body should have the capacity and operational ability to enable deliberative dialogue, to ensure that adequate statistical, monitoring and scientific knowledge is being produced and used in assessments, to draw integrative understandings relevant to policies and implementation performance from the plethora of studies and experimental initiatives funded through the CBS and other sources, and,

[35] See www.tbs-sct.gc.ca/rma/eppi-ibdrp/hrdb-rhbd/cbs-scb/description_e.asp and www.biostrategy.gc.ca.

[36] An overview of governance structure and performance of the CBS is provided in Chapter 4 of the November 2005 Report of the Auditor General of Canada. www.oag-bvg.gc.ca/domino/reports.nsf/html/20051104ce.html#ch4hd4a

of course, to be accorded a high level of visibility inside and outside of government.

The CBS should operate in an adaptive planning and management fashion. Through its existing structure and mandate, it has the elements necessary to commission necessary experimental and interdisciplinary analysis, to consider the results and recommend corrections through progressively higher bureaucratic, and ultimately, political channels, and to initiate broadly-based public and stakeholder dialogue. These are key ingredients for adaptive planning and management.

Ongoing adjustments will be required as new demands arise, especially late in the current decade when many new BSDE applications emerge. This argues against developing a centralized or highly structured system of governance. Instead, a flexible approach is desired—where partnerships and arrangements can be tailored to correspond to new knowledge and changing priorities. This also is consistent with the approach of adaptive planning and management that we advocate.

There may be a need to broaden membership within the CBS. For example, the interests related to international development are not well represented. The subject matters of bioterrorism and biosecurity are becoming key concerns within many countries, including Canada, and are related to stewardship matters in various ways. These are topics not currently covered, nor are some relevant agencies represented on the various committees.

The CBS should function as a centrepiece of the federal effort for BSDE. But, of course, it is not the only element. In addition to the responsibilities of departments and agencies, the federal government also has a central coordination role, facilitating federal-provincial relationships. The provinces play important regulatory and enabling roles in their governance of innovation, environment and development. We see opportunities for federal-provincial cooperation to reduce inter-provincial trade barriers concerning bioproducts, to harmonize standards on use of biomass and on environmental assessment of biotechnologies, to harmonize taxes and incentives, to develop a national ecosystem monitoring system, and to develop biotechnologies related to sectors such as marine and forest products. We also hope for a high level of accountability for results, including the possibility of dedicated effort concerning BSDE by the Commissioner on Environment and Sustainability (CESD).

A renewed governance regime should reinforce three pillars supporting the primary objective of promoting biotechnology in sustainable development. First, the federal government must take a strong, effective and ongoing leadership role. Second, all sectors of society must be engaged. Third, we must promote the development of knowledge, including sound science-based information, to support societal decision-making. This goes beyond government decisions, and includes such matters as Canadians' behaviour and views on sustainable consumption and investment decisions.

An effective BSDE governance regime can build on complementary private sector initiatives. At some point, for example, segments of the

biotechnology industry may be sufficiently cohesive and mature to develop a non-legislated performance system along the lines of chemical producers' "Responsible Care™" program. The "Stewardship*first*™" program run by CropLife represents one such starting point related to biotechnology.[37] Similarly, industry segments may be able to draw upon or develop quality management standards like ISO 14001, which not only improve credibility, but also enhance the public's trust in private sector risk management. The biofuel area presents an important immediate opportunity, with both domestic and international trade implications.

The Government of Canada has the ability and the obligation to address biotechnology and sustainable development issues on behalf of the country. A facilitating, enabling, catalyzing form of leadership is needed, which pulls stakeholders together so they can play important governance roles and promote biotechnology for sustainable development.

KEY FINDING #9

Canadians (and our international partners and neighbours) must be able to trust biotechnology decisions made by the regulatory structure established to protect and promote public health and safety. They must also be able to trust mechanisms for monitoring and assessing information about immediate and cumulative impacts of biotechnology applications. A systematic approach to information and knowledge generation, developed with the "long haul" in mind is needed. Like the post-market surveillance performed on new pharmaceutical products, this information should be integrated into the overall process of approving innovative products or processes into the environment.

BSDE governance can draw upon existing organizations and governance mechanisms where there is a capacity to address changing needs, and to accommodate partnerships and new arrangements

RECOMMENDATION #9

The following three objectives should be promoted by the Government of Canada for BSDE governance.

1. *Provide strong federal leadership.*

   Ministers and deputy ministers will continue to define political goals, set strategic directions, establish priorities, allocate resources and create the context within which the government machinery will operate. The Biotechnology Assistant Deputy Ministers' Coordinating Committee (BACC) is the level at which important political and technical understanding can be integrated to shape policies and outcomes in an adaptive fashion. There are three key roles that BACC should play in promoting biotechnology:

   - *Align biotechnology policies, regulations and incentives so that biotechnology contributes to the government's agenda and priorities related to sustainable development.*
   - *Ensure that national leadership institutions, such as parliamentary standing committees and Canadian councils of ministers, are provided with the information and analysis about biotechnology and sustainable development that they need to make decisions.*
   - *Make certain that the federal government delivers on its responsibilities in an exemplary manner.*

[37] www.croplife.ca/foodforthought/crop_protection_canada/crop_protection_canada_01.php

2. Engage all sectors of society.

Within the next twenty-four months, priority should be given to getting BSDE on the agenda of environment, forestry, fisheries, energy and agriculture ministerial councils representing the different levels of government. As well, there must be a greater degree of engagement with sectoral interests, including the substantial number of large corporations, small- and medium-sized enterprises (SMEs), industry associations, environmental NGOs, aboriginal groups, and others with a stake in BSDE.

3. Promote informed decision-making.

In support of environment, health and safety, the governance regime must emphasize monitoring, assessing and adjusting to information in order to identify both short-term effects and longer-term cumulative impacts of new technologies and biotechnology applications. This information is essential for developing regulations, making robust assessments, and evaluating the effectiveness of decisions.

In support of policy development, transparency and accountability, BACC or an independent third party should prepare a series of annual reports for public distribution. These should deal with a different facet of biotechnology and sustainable development each year: research, regulatory regimes, commercialization success and competitiveness, international and domestic policy agendas, and public attitudes towards the achievements of biotechnology in reaching sustainable development objectives.

Conclusion—Our Vision and Action on Recommendations

As we look ahead 10 or 15 years, we hope to see a culture in which sustainable development is accepted as a lodestar of decision-making across all sectors of society. A solid and growing wealth of information about techniques to create a sustainable environment will be widely available. And the emerging field of biotechnology will be recognized as an important contributor to sustainable development in a host of ways. Biotechnology will be a key factor in providing citizens and government decision-makers with the "environmental space" they require to enhance well-being in a time where rapid adjustments to changing environmental and social pressures may be required.

Both ordinary citizens and government decision-makers will be aware of, and comfortable with, biotechnology's contributions and its continuing potential to benefit society. "Success stories" will be well known and consumers will be able to identify desirable new products or technologies made possible by biotechnology. Biotechnology problems and risks will be understood, contained, or addressed through precautionary action. By this time, the potential of biotechnology to contribute to productivity and competitiveness will be recognized and Canadians will benefit from the transformations it affords.

To facilitate this culture, a number of highly collaborative and cooperative relationships will be in place. National and international governments will have links and networks dealing with biotechnology and sustainable development. These will have the capacity to take information about new technologies and convert it into proposals for new investment strategies and support for research, development and commercialization. Strong arrangements within governments will exist to deal with

cross-cutting issues (such as those posed by some biotechnology applications), and civil servants will be rewarded for their ability to foster collaborative relationships.

Governments will also work with non-governmental organizations, aboriginal groups, research institutions, academia, and other sectors of society to explore issues, establish programs, and build trust. The ability to be flexible and adaptive when dealing with new technologies will be seen as a strength, not as a sign of indecision. Greater value will be attached to benefits, both commercial and social, that will accrue years into the future. Governments will actively use and explore the potential of the various instruments at their command to promote biotechnology goals and optimize benefits, while reducing risks.

Our understanding of cumulative impacts and longer-term effects resulting from decisions made in the early years of the 21st century will have expanded. Ideally, new analytical approaches will have been developed, including an improved capacity for dynamic risk assessment. Information will be available to allow for independent assessment of the effects of government action. Governments will transparently evaluate the cumulative effects of their actions and the combined effects of multiple policy instruments. There will be institutions in place, some real and some virtual, to allow information and discussion to flow among all sectors of society.

Dialogue and learning will increase, along with trust in societal institutions and their programs and decisions. Citizens will be more knowledgeable about sustainable development in general, and there will be mechanisms for civil discourse and discussion on means to achieve a world where future generations would have the resources and opportunities to explore their own potential without being constrained by the over-consumption decisions of their forebearers.

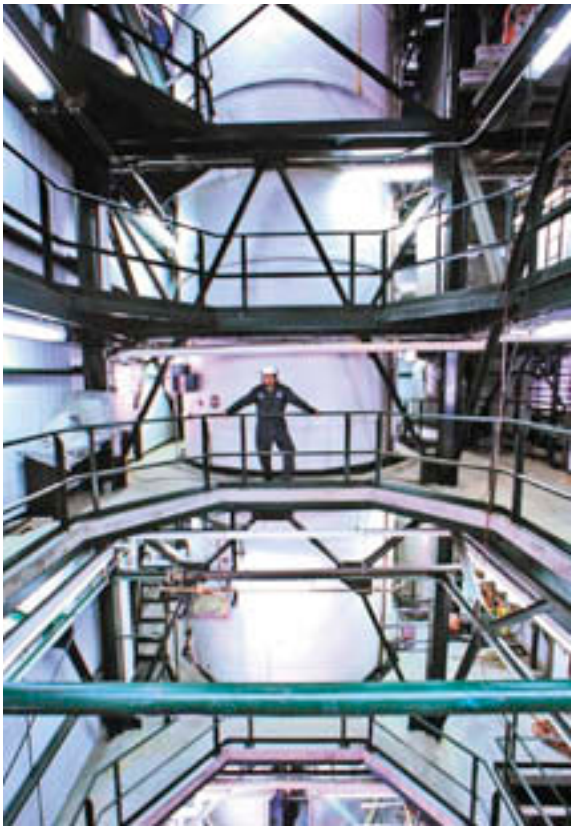


Image courtesy of Iogen Corporation, Ottawa, ON, Canada

BSDE will have a "profile" in the discourse and institutions of government. For example, there will be references to biotechnology and sustainable development in budgets and Speeches from the Throne. Parliamentary and legislative committees will, from time to time, examine sustainability issues relating to biotechnology, and their activities will play a key role in promoting public awareness of issues and stimulating discussion. Government departments and agencies will consider issues of sustainable development routinely in the assessment of new policy proposals, and will consider the implications of using a range of policy instruments to achieve objectives of sustainable development through biotechnology. The federal government will be active in international forums dealing with biotechnology and sustainable development issues, and Canada will have the reputation and capacity to take the international lead on important issues, such as harmonized regulation.

Biotechnology industries will come to recognize their common needs and will work together to build credibility with their customers and the general public, as well as build their reputation with regulators. Industry, possibly with the encouragement and cooperation of governments, will have developed self-regulatory approaches to raise levels of compliance. Industry codes of conduct will be in place and an industry-driven co-regulation program (along the lines of Responsible Care™) will be maturing.

This vision may seem overly optimistic or demanding. But we believe that our nine recommendations, if acted on immediately, will be important first steps toward creating a productive, safe and long-term relationship between biotechnology and sustainable development for Canada's future economy. Our first recommendation covers Canada's need to ***take a strategic approach to BSDE***—not piecemeal. Our second recommendation is that Canada should ***focus on implementation of advanced technologies*** if we are to properly seize new bioproduct and biorefinery opportunities—that some call "Canada's natural advantage." The next three recommendations address the need to ***recognize the interlocked nature of environment and economy***. Canada needs to get the market signals right for biofuels and other novel products by avoiding long-term distortions, and to monitor ecological change well. And, there should be a gradual move to an integrated sustainable development assessment approach which, properly implemented, need not become burdensome. Our sixth recommendation is to ***engage citizens and stakeholders in deliberative dialogue*** in a manner that has not happened up to this point. We believe Canada should ***take a strong international cooperation role for BSDE***. We need to participate more in international knowledge networks, and to strengthen biotechnology and sustainable development internationally and with developing nations. These points are covered in recommendations seven and eight. Most importantly, Canada needs to ***strengthen governance for adaptive management of BSDE***. We believe this can be done mainly through making existing governance mechanisms work better, the subject of our final recommendation.