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Identifying successful business models, strategies and policies for promoting the Canadian Bioeconomy

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Issue

Major fluctuations in the price of oil combined with the climate change debate have strengthened public interest in the use of biomass as industrial feedstock. There has been a dramatic surge in the use of bio-based resources for fuels and energy generation, primarily as a result of government policy and supporting funding. The worldwide surge in biofuels has many concerned that the focus is too limited. There are other uses for biomass which can generate both economic and environmental benefits. Bio-based chemicals can provide Canada's chemical industry with an alternative input to oil and a new range of products which may improve the competitiveness and environmental footprint of both the chemical industry and the companies using bio-based chemicals and the bioproducts they produce.

Bio-based chemicals offer opportunities for biomass suppliers, chemical companies and their customers on several dimensions (Figure 1). The research found that bio-based chemical chains were typically composed of 'traditional' technology firms, with a single bio-focused firm which acted as the link between biomass production and traditional economy firms. This entry point offers unique opportunity for biomass providers to act as dominant players in capturing and retaining value for their outputs while still providing cost-competitive feedstock for conversion. The outputs of bio-based chemical companies typically act as intermediates and feed into a wide range of traditional chemistries used by chemical firms, processors and their manufacturing customers (Figure 1). This research observed that bio-based firms and technologies can induce a bio-shift in a supply chain with little adjustment required in the rest of the chain. This was due in large part to demands by processors and manufacturers that new materials must integrate with existing

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machinery and processes. The limited impact on later stage firms highlights the importance of existing chemical value chains and clusters and the bio-based industry's need to leverage the strengths, resources and infrastructure of today's chemical industry. Strategies that focus on joint development will help convert big chemical industry players into bio-based leaders while securing a market for start-up companies and ideas for future technology generations – similar in some ways to the biotechnology industry's relationship with pharmaceutical companies today.

Policy Implications and Conclusions

Research findings reveal opportunities at multiple levels of value chains for farming, forestry, chemical, and manufacturing sectors to supply global markets with sustainable alternatives to oil based products (BioProducts Canada, Ontario BioAuto Council, FP Innovation, Sustainable Chemistry Alliance, CRIBE). The case-based analysis provided insight into the state of the industry globally and provincially, from which the researchers drew the following observations and policy recommendations:

i. **Bio-based chemicals need to be a priority**: the bioeconomy has been a focus of many federal and provincial government departments and agencies and yet little in the way of policies and programs – outside of biofuels – is in place to support bio-based chemicals. The bio-based chemical industry – and its interface with industrial biotechnology - holds great opportunity for the agricultural and forestry sectors as well as the struggling chemical and manufacturing sectors in Ontario. The current estimate of the worldwide market for bio-based chemicals ranges from USD $164-$240 billion (IB-IGT, 2009, ICIS, 2010). While Canada has made large scale investments in the biofuels sector - the result of which could be a viable processing foundation for the creation of a bio-based chemical sector– few policies exist to encourage the growth of bio-based chemicals. Significant changes in market creation, product innovation and profit – as well as environmental stewardship – can be realized without huge public sector investments.

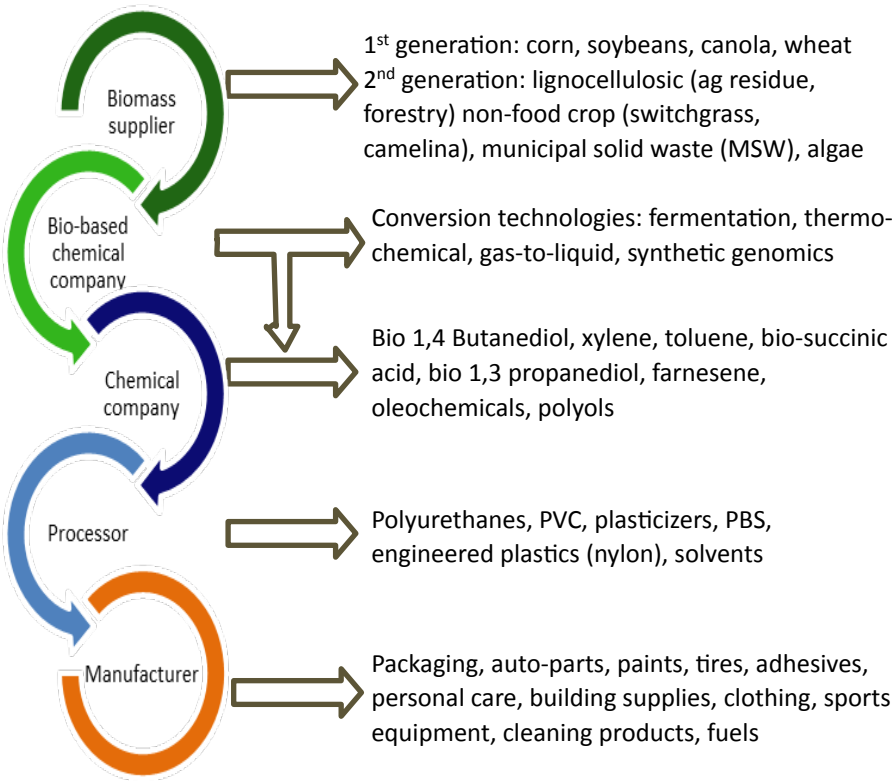


Figure 1. Bio-based chemical value chain with examples of level inputs, technologies or outputs

ii. **Companies innovate:** This research showed a role for university and public sector research but clearly illustrated that companies innovate – '*the creation and marketing of the new*' – not universities (Kline and Rosenberg, 1986). Three of the four technologies examined originated, either entirely or in part, in a university or government lab. Further research, development, demonstration and ultimately commercialization took place in all four chains within private sector companies. Two of the

chains entered into an exclusive license for the technology and had little or no on-going relationship with the originators of the technologies. In one chain, based on university-led R&D, the commercializing company did maintain a direct relationship with the university.

A strong policy push toward commercialization has led many universities and research organizations to shift their research focus away from primary research to later-stage development in hopes of meeting the mounting program requirements for commercialization. By in large, bioeconomy research funding to date has focused on public-private-partnerships in which public research organizations have controlled research direction. By turning to academia and public research organizations to commercialize research, government programs have ignored the commercialization role of industry while placing unrealistic goals on public research entities. Innovation and invention are distinct activities and public policy must recognize commercialization requires industry to lead and that the roles of public research organizations and public funding should be to support.

iii. **Focus new investment on close to the source infrastructure:** There is a staggering amount of research taking place around the world focused on bio-based chemicals. While research can flow easily from one centre to another, demonstration and scaled-production require local footprints and supply networks. The research revealed a gap in funding for investments in infrastructure to support the conversion of biomass into novel molecules and chemicals for further processing. These early links in the bio-based value chains are essential to capturing value in a region and creating the nucleus of activity needed to draw further investment and activity.

iv. **New foundation for old industry:** The research found that the four chains were composed predominantly of traditional technology firms, with a single bio-focused firm which acted as the link between biomass production and traditional economy firms. The outputs of the bio-based chemical companies acted as intermediates and feed directly into the production processes of a range of chemical firms, inducing a bio-shift to the chains with little adjustment needed in the rest of the chain. Public investments in bio-based chemical processing can stimulate a major shift in chemical value chains with limited infrastructure investment needed in the rest of the chain and could potentially aid in the recovery of the Canadian chemical industry.

v. **Financing for companies**: Companies moving into bio-based chemical production are faced with the daunting task of sourcing investments from a market that is still recovering from the downturn of 2009. They are also hindered by the age of the industry and the lack of knowledge within the finance community about bio-based chemistry and industrial biotechnology. Three of the four chains identified financing as a significant challenge to commercialization; with two of the three highlighting capital expansion financing as the critical need. An early and positive signal to the industry would be to broaden the scope of existing funding programs to ensure bio-based chemicals are captured within the range of eligible technologies and products.

Background and Literature Review

The rapid growth in bio-based products will continue in the near future, spurred concerns over oil supply and pricing and for greater environmental sustainability. As a result bio-based products, including chemicals and materials, have moved higher on the strategic agendas of many industrial value chains. While the landscape of active players consists primarily of smaller new technology companies, an increasing number of large

multinational firms are showing an interest in bio-based technologies and products (King, 2010).

The chemical industry, in particular, offers great potential for bio-based alternatives. In 2009, global chemical industry sales (excluding pharmaceuticals) were valued at about US$2.61 trillion. Industrialized countries accounted for 56% of world production, but the main growth centres of chemicals sales and production were in emerging markets, especially Asia (ICCA Review 2009-2010). Canada's chemical industry was valued at $34.7-billion (excluding pharmaceuticals) in 2010 by Statistics Canada, with Ontario's chemical industry accounting for around 45% of the Canadian total (MEDT). The Chemistry Industry Association of Canada (CIAC) has expressed concerns over the competitiveness of Ontario's chemical manufacturing sector as the bulk of new investment is occurring elsewhere and manufacturing plants – buyers of chemicals – are closing (CIAC 2010). Revenue potential for *biorefinery*-based chemicals is estimated at US$ 10-15-billion by 2020 and the larger bio-based chemical segment is projected to represent 8% of global chemical sales by 2012 (King, 2010, ICIS, 2010).

National mandates and policies focused on biofuel and bioenergy production have been major factors contributing to the growth of those industries. Bio-based chemicals and materials generally do not benefit from policy support beyond a handful of research grants. The notable exception is in the United States where commercialization efforts by companies have received sizable grants and government-backed loans from the Department of Energy for work in bio-based chemicals. Canadian investments into bio-chemicals and materials have generally been focused on research or commercialization from public sector research entities and partnerships. Similar to Canada, EU programs support an increasing share of bio-based materials in chemical production but no related subsidies or mandates exist in the chemical industry (King, 2010).

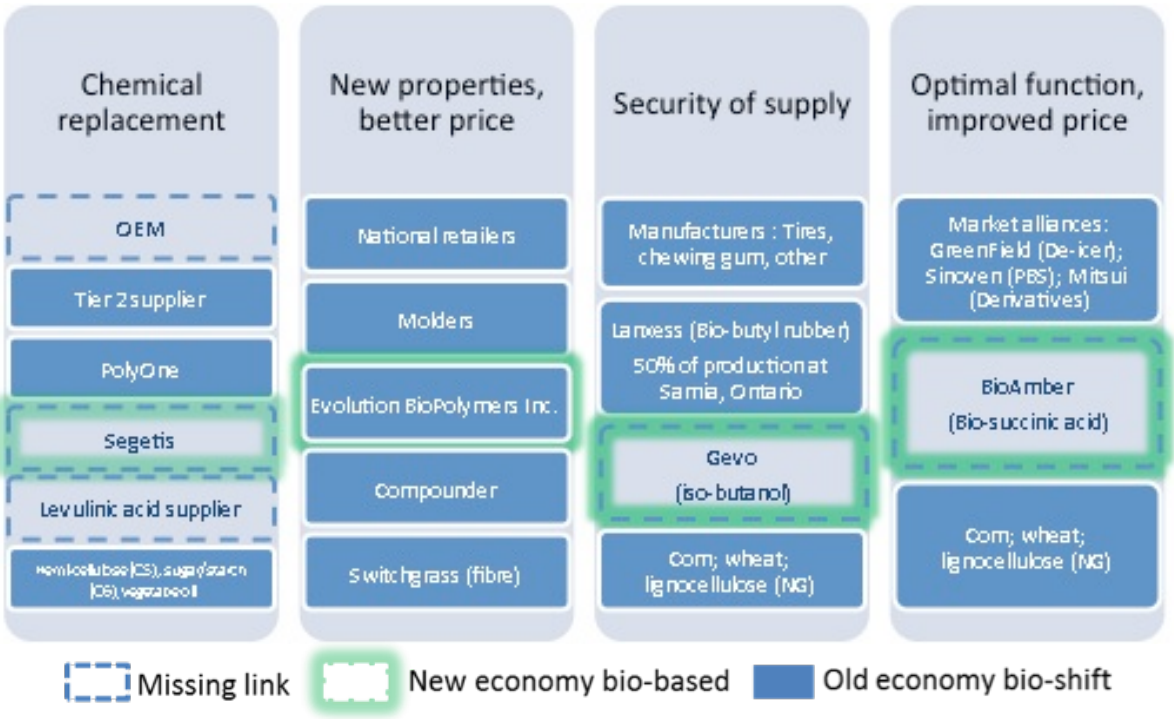
Analysis and Results

This research studied four Ontario value chains developing or using new bio-based products (Figure 2). Three chains involve new to the industry bio-based chemicals and the fourth involves biofibre composite material. The case-based research identified the different roles and focus for firms in these chains, the motivations for the companies involved and the challenges they face in moving from oil-based products to bio-based alternatives. The research found that there were gaps in most bio-based chemical chains which were often filled by foreign companies or foreign products. The research also found that these chains were typically composed of predominantly traditional technology firms, with a single bio-focused firm who acted as the link between biomass production and traditional economy firms. Partnerships, both commercial and R&D focused, also played a major role in the incorporation of bioproducts into chemical value chains. Policy implications of these findings are also discussed.

Background data for the case studies was collected using publicly available data including company websites, government and industry association websites and third-party data. In some cases more detailed information on the companies and their value chains was collected through semi-structured interviews with selected industry participants holding senior management positions or higher.

Role and Focus

The growing body of research and publications that discuss bio-based chemicals illustrate the many different areas of science and technology that overlap to create a highly complex and heterogeneous industry (Chotani (2000), Gibson, (2010), Lorenz (2002)). This complexity is reflected in the value chains studied. For ease of discussion and illustration the authors have depicted only part of each value chain in Figure 2. The reader should not misinterpret the simplicity of the diagram to be a complete representation of the value chains, their outputs or their connections to multiple industrial sectors and customers.



NG: Next Generation

Figure 2. Bio-based chemical value chains

The four chains studied all introduced new technology and in some cases new molecules to their respective industrial sector (s). Firm focus varied depending on the level within the chain. Bio-based chemical firms are focused on building a new-to-industry idea into a successful business and securing first-to-market advantages; chemical firms focused on oil replacement for cost, assurance of supply and environmental impact and chemical consumers sought out the chains in response to customer demand for sustainable products. In two of the four cases the chains delivered the same product providing for simple substitution, while in the other two chains the bio-based substitute introduced new, more desirable properties into the end products.

Motivation and Challenges

In all four chains *suppliers* of biomass and bio-based chemicals, and *buyers* of the bioproducts shared a common motivation in promoting or accessing new properties specific to the bio-alternatives. Buyers in two of the chains were also motivated to a lesser degree by security of supply and end-consumer demand respectively. Suppliers of bio-based chemicals all noted unique value propositions for their bio-alternatives and price strategies as motivators to enter the chains. Biomass suppliers in general have noted diversification of markets and business risk management as motivating factors.

Challenges were also specific to levels in the chain. The challenges faced by three of the four bio-convertors – links between biomass suppliers and processors/manufacturers – noted financing to be a significant challenge. This financing was needed to develop processing capacity to feed into the chemical value chains. While financing was noted by other links in the chains, the nature of the financing was distinct. A later stage processor noted the internal battle over resources to be a challenge rather than the risk-financing required for scaled production needed by the earlier bio-conversion firms.

Gaps Analysis

The research found that there were gaps in most bio-based

chemical chains that were often filled by foreign companies or foreign products (Figure 2, Table 1). This observation and potential trend raises concern over the impact of these value chains within Canada. Missing links were typically foundational – or close to the source – and hold the greatest potential for value retention, capture and spin-off. The gaps in the chain highlight the young state of the bioeconomy as typically they involved the new, disruptive technologies needed to convert biomass into value-added chemical. Given the early stage of this industrial sector these gaps are anticipated but the lack of domestic options to either fill these gaps with Canadian-originated or Canadian-recruited technologies is a concern. Interviews revealed active campaigns to fill these voids but no clear mechanism to assist in foreign direct investment or to align the scattered R&D efforts taking place across the country.

Partnerships

Partnerships played a pivotal role in all four chains (Table 1). Partnerships were both R&D and market-focused in all four chains. Strategic and technical alliances or joint developments were observed in three of the four chains. Joint development projects helped larger chemical companies enter the bio-based market and assisted start-up companies in gaining access to resources, strengths and much needed infrastructure in the existing chemical industry. R&D partnerships tended to focus on next generation technologies in three of the four chains; with all noting lignocellulosic feedstock as a focus.

The importance of foreign partnerships, at least early in the process, was highlighted in three of the four chains, as firms reached out around the world for products, ideas and expertise. The challenge for policy makers is to attract these companies to invest in Canadian operations and feed into the Canadian chemical and manufacturing industries.

Role of Policy

Policy played a variable role in the four chains (Table 1). Regulations in the U.S., Canada and the EU created market demand for alternatives to some traditional chemicals. A leading example was phthalate or plasticizer replacements. One of the chains targeted this industry sector and may benefit from this line of policy reform. National mandates and regulations of bio-based fuels had an indirect impact on one company in of the four chains. Like many bio-based chemical firms, biofuels were a possible co-product of their conversion technology. Market demand for jet fuel in the U.S. helped to diversify the product offerings of this firm and created a volume play for its portfolio. Finally, two of the four chains provided examples of government funding programs acting to enable development partnerships and advance scientific discovery closer to commercialization.

Concluding Remarks

Canada is in an enviable position with forest and agricultural lands that yield an abundance of biomass, the skilled labour and education systems to support innovation and growth of a new economy. What is missing is a vision and plan for how to best use these natural assets to the nation's advantage. This lack of vision leaves Canada vulnerable to others who can move quickly to buy up natural resources and turn them into value-added commodities and products that Canadians will purchase as foreign-made goods.

Many voices are proclaiming Canada to be a superpower in the global bio-economy and yet Canada has no comprehensive policy; no real plan for how to strategically employ biomass resources, and no clear understanding how the industry might evolve beyond renewable fuels to reap the broader economic advantages of bio-based chemicals. In the absence of all of the above Canada's bioproduct industry is floundering – at least according to the most recent Statistics Canada Bioproduct Development Survey. Results show the bioproduct industry contracting with the number of companies, employment, investment in R&D and revenues all falling significantly in 2009 (Sparling et. al, 2011). Bio-based chemicals represent roughly 10% of the industry and contributed approximately $155-million or

Table 1. Summary of anchor technology/company for each of the value chains

	Origin of technology	Stage of development	Financing	Partnerships R&D	Partnerships other	Production site	Gap	Policy impacts
1	Individual	Commercial production (several million pounds)	Venture Capital (VC)		Joint development	U.S.	Expansion capital	Regulations on plasticizers creating market pull
2	University – shared patent?	Early stage Commercial	In-house; provincial R&D grants	University-led with emphasis on development	Feedstock supply	Ontario	Marketing	Provincial funding for PPP
3	Government lab – exclusively licensed	Early stage commercial production (3,000 MT); larger scale planned at 30,000-50,000 MT	VC; joint-venture	2nd generation technology & feedstock Technical alliance (B2B)	Distribution to Asia; Acquisition for value-add; Joint development, Exclusive licensing	France; Second location planned for Sarnia, Ontario	Expansion capital	DOE funding at inception
4	University – exclusively licensed	Demonstration scale; Commercial production estimated at 18 MGPY in Q1 2012	VC, IPO	Technical alliance for 2nd generation (B2B)	Heads of Agreement, Letters of Intent for future supply	U.S.	Scaled production	Fuel regulations in US creating market for jet fuel offering

12% of the industry's total revenue. This could be expanded dramatically in the future. In comparison ethanol companies make up 10% of the industry and contributed 68% of the total industry revenue.

Policies that address the voids outlined in this paper and in particular secure missing infrastructure – namely new bio-conversion technologies – will make Canada competitive with other jurisdictions offering a wide range of support and incentives. Policies that provide financial support in the way of government-backed loans or grants are needed but must include non-biofuel technologies and be feedstock agnostic. Biases towards first-generation technologies commonly based on corn, soybeans or canola may be holding back Canadian firms and encouraging investments in other locations. Finally, policies that recognize private industry as the economic driver of this industry will be foster the creativity, genius and profit needed to solidify Canada's role as a bio-economy leader.

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