Not enough GREEN in Canada's BIOPRODUCT INDUSTRY

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Executive summary

Canada has the essential ingredients to create a profitable bioproduct industry – abundant sources of biomass, a strong industrial sector and the scientific capabilities needed for bioproduct research and development. With the growing concern over the environment, and the impetus to transition from an oil-based economy to one based on sustainable alternatives, one would expect strong growth in the Canadian bioproduct industry.

Our analysis of the 2009 and earlier Statistics Canada bioproduct development surveys reveals the exact opposite. The bioproduct industry in Canada has contracted. The number of firms involved in the bioproducts industry companies dropped from 239 in 2006 to 208 in 2009, and the number of employees involved in bioproducts, total bioproduct revenue and the value of exports fell during the 2003-2009 period.

The most widely used inputs were agricultural and forestry biomass. Small to medium size firms predominantly used agricultural biomass, while large firms sourced biomass mainly from forestry. Total bioproduct revenue of $1.33 billion in 2009 was dominated by one product – ethanol – with over 68% of bioproduct industry revenue coming from ethanol, and 63% of the ethanol revenue in Ontario. Firms also experienced almost $1-billion in cost savings from using bioproducts internally; 63% was captured in B.C., presumably mainly by large firms using forestry biomass.

Over 80% of Canada's bioproduct industry was composed of small companies, for whom developing and producing bioproducts was a primary focus. In contrast, the large firms involved in the industry undertook bioproduct activity as a secondary activity, making up only 1.3% of total firm revenue. For these firms, the main benefits may come from cost savings resulting from using bioproducts in internal operations.

The industry is early in its life cycle and continues to develop new products and processes for converting biomass into industrial products. R&D expenditure was hit particularly hard in the financial crisis of 2009 dropping to 52% of the previous year's spending. With limited financial and human resources, Canadian bioproduct firms relied heavily on external resources, accessing knowledge, expertise and R&D capabilities through a combination of contracting and collaborations with other firms in Canada and abroad, and from universities and government labs. The industry remained challenged by access to capital, regulation and most recently the cost of acquiring biomass.

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Overview

Canada has many of the elements needed to build a thriving bioproduct industry – significant sources of both agricultural and forestry biomass, strong research capabilities, a skilled workforce and an industrial sector looking for ways to make their products more sustainable. However, when it comes to developing a globally competitive biofuel and bioproduct industry, Canada appears to be falling behind. Our analysis of the Statistics Canada's 2009 Bioproduct Production and Development Survey[2] and the results of previous surveys from 2003 and 2006 found that Canada's bioproduct industry continues to contract and is heavily weighted toward one product - ethanol. This paper examines the state of the Canadian bioproduct industry in 2009 and some of the changes which have taken place between 2003 and 2009.

In 2009, an estimated 208 bioproduct firms[3,4] were 'conducting bioproduct research and development *without* sales of bioproducts' or 'in production *with* sales' (Bioproducts Production and Development Survey 2009, p.3). Survey respondents included any firm involved in the development or production of industrial and consumer products from biomass with the exclusion of food, feed and medicines. This includes products such as biofuels, plastics, chemicals, bioenergy and non-conventional fibres. Biomass is defined as 'renewable biological materials' - from forestry, agriculture, marine and aquaculture source; by-products from processing (agricultural, forestry, food/feed); or recycled bio-materials and waste materials (Bioproducts Production and Development Survey 2009, p. 2).

Industry Statistics & Structure

The number of firms involved in bioproducts decreased by more than 13% between 2006 and 2009, from 239 firms to an estimated 208. The industry underwent a significant structural change in the 2003 to 2006 period, with many large and medium sized firms exiting the bioproduct industry (Table 1). Firm size was defined by employment. Small firms employed fewer than 50 employees; medium firms 50- 149 and large firms had 150 or more employees. In 2009, the number of large firms recovered slightly, however medium-sized firm numbers continued to decline. Small firms continue to dominate the bioproduct industry in number of firms, making up 81% of industry numbers in 2009.

[2] The Bioproducts Development Survey was commissioned by Agriculture and Agri-Food Canada and conducted by the Business Special Surveys and Technology Statistics Division (BSSTSD) of Statistics Canada

[3] "In order to palliate for non-response, an adjustment factor for weighting was applied to the homogeneous response groups created from the sector of activity. This adjustment factor is used as a final weight to produce estimates."(Statistics Canada, 2011)

[4] Statistics Canada Bioproducts Surveys cover bioproduct activity of Canadian firms. Firms with multiple establishments were asked to complete a separate questionnaire for each establishment engaged in bioproducts production or development in Canada. Authors acknowledge this could result in double counting at the firm level for a small fraction of the sample.

Table 1: Selected Canadian bioproduct industry statistics by year

	2003	2006	2009
Number of firms	232	239	208
Percent of firm population			
Small firms	66%	84%	81%
Medium firms	17%	8%	7%
Large firms	17%	8%	13%
Revenue from bioproducts	$3,129,455	$1,758,309	$1,333,503
% of total firm revenue	26.3%	23.5%	9.0%
Total bioproduct R&D spending	$96,327,000	$84,329,000	$64,580,000

Source: Statistics Canada Bioproduct Development Surveys 2003, 2006 and 2009

Geography

In 2009, Ontario and the Prairie provinces ranked highest based on number of firms (Figure 1) and correspondingly by firm bioproduct gross revenue (BGR). Taken together, Ontario and the Prairies accounted for 79% of the industry total gross revenue. Also, note that a shift in the location of firms producing bioproducts is evident from Figure 1, with the number of firms in Ontario increasing, while the number in British Columbia and Quebec dropped.

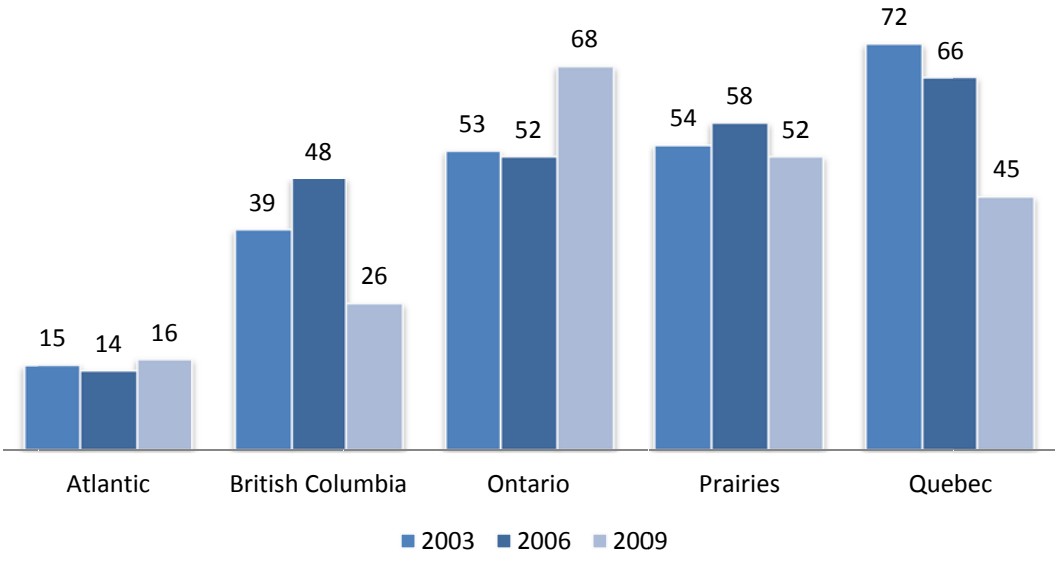


Figure 1: Number of firms by region and year
Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Biomass

Agricultural biomass was the primary biomass source for 44% of firms in 2009 (Figure 2). Although the questions changed between the surveys, there appears to be an overall trend to greater use of agricultural biomass.

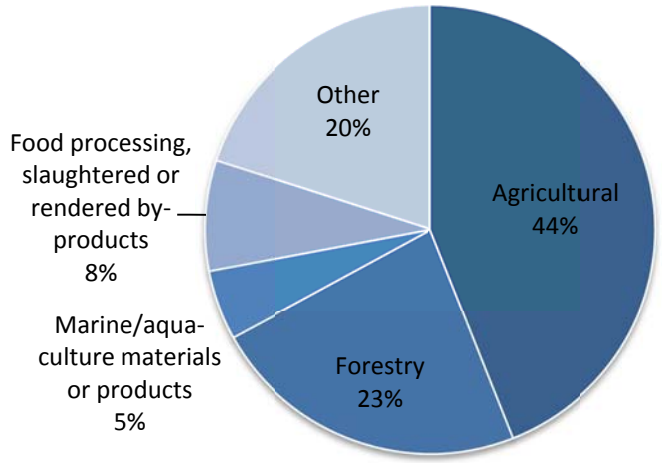
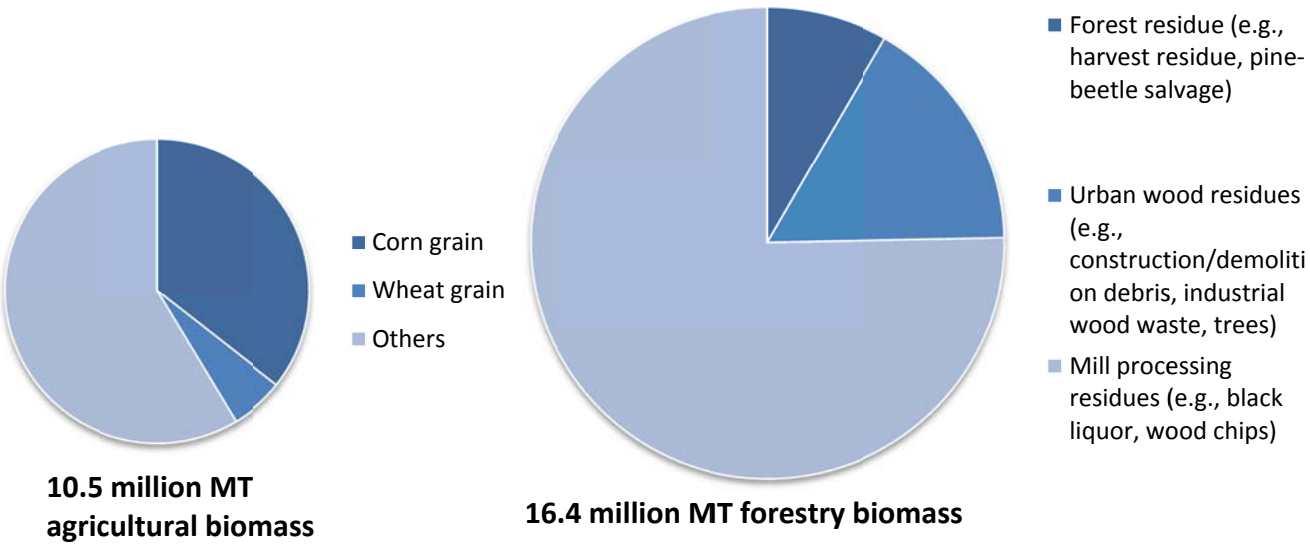


Figure 2: Percentage of firms by primary biomass source, 2009
Source: Statistics Canada Bioproduct Development Survey 2009

There are significant regional differences in biomass sourcing. In Atlantic Canada, British Columbia and Quebec more firms used forestry biomass. In Ontario and the Prairies agricultural biomass was used by most firms.

Although fewer firms used forestry biomass, they used more, an estimated 16.44 million metric tonnes compared to 10.6 million metric tonnes of agricultural biomass (Figure 3). Seventy-five percent of forestry biomass was mill processing residue (black liquor, wood chips) with another 8% from forestry residue. Corn grain accounted for almost 36% of agricultural biomass.



Note: other data suppressed
Figure 3: Breakdown of biomass by source and weight, Canada 2009
Source: Statistics Canada Bioproduct Development Survey 2009

Industry Performance

Financials

The significant declines in bioproduct revenue, exports and R&D present a disconcerting counter-point to the general perception that Canada is moving rapidly toward a new bioeconomy. Although total revenue for firms involved in bioproducts increased over the 2003-2009 period, revenue from bioproducts decreased by roughly two-thirds in 2008 and then recovered somewhat in 2009 (Table 2). Bioproduct exports also plummeted, both in real dollars and as a percentage of bioproduct revenue. The rise in the Canadian dollar relative to the U.S. dollar is likely a significant factor in the fall in exports. Another mounting concern is the steep rise in biomass input costs and its impact on gross margins[5] (Tables 2 and 3).

The drop in bioproduct research and development spending is a concern, given the early stage of the industry. However, in addition to the $50-million spent internally on bioproduct research in 2009, firms also contracted out $9.4-million and spent $14.4-million on biomass research. Spending on biomass increased significantly between 2006 and 2009, possibly due to the large increase in biomass costs, or to greater interest in bioenergy.

Table 2: Key revenue and R&D summary statistics 2003, 2006 and 2009

	2003	2005	2006	2008	2009
	$ thousands				
Canada					
Total firm revenue (all sources)	11,914,662	7,081,904	7,486,339	19,685,698	14,898,795
Revenue from bioproducts	3,129,455	1,697,799	1,758,309	1,047,418	1,333,503
Bioproduct/total revenue	26.3%	24.0%	23.5%	5.3%	9.0%
Revenue from bioproduct exports	1,491,626	828,455	632,606	187,976	438,667
Percentage of revenue from exports	47.7%	48.8%	36.0%	17.9%	32.9%
Total cost of biomass inputs	-	319,886	343,373	1,731,080	1,852,135
Revenue from bioproducts minus cost of biomass inputs	-	1,377,913	1,414,936	(683,662)	(518,632)
Total R&D spending	242,371	241,227	242,299	305,924	127,389

[5] Defined as revenue from bioproducts minus biomass input costs

R&D spending on bioproduct development	96,327	88,091	81,329	49,934	50,152
R&D spending on biomass development	-	5,236	3,000	14,540	14,428
Bioproducts R&D spending contracted out	10,295	3,761	6,014	13,497	9,438
Total bioproduct and biomass R&D expenditure	106,622	97,088	90,343	77,971	74,018
Total firms	232		239		208
Bioproduct revenue per firm	13,489		7,357		6,411
Bioproduct revenue per bioproduct employee	399		442		442
R&D per firm	415		353		310
R&D as a % of revenue	2.03%	3.41%	3.24%	1.55%	0.86%

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

In 2009 bioproduct revenue made up only 9.0% of the total revenue of firms involved in bioproducts, down from 26.3% in 2003. This is due to the combined effect of the decline in bioproduct revenue and the recent increase in larger firms involved in the industry with their large streams of other revenue.

Strong distinctions in revenue can be seen across firm size (Table 3). In 2009, small and medium firms reported similar percentages of revenue from bioproducts at 58.5% and 60.1% respectively. For large firms, bioproducts appear to be a sideline to their main business activities, with bioproduct revenue making up just 1.3% of total firm revenue.

Some firms use the bioproducts that they produce internally rather than marketing them to other firms. In 2009, a new question asked firms whether they used the bioproducts they produced in their internal operations, and the magnitude of cost savings resulting from that use. Only 39 firms (16 large firms and 23 small) reported using bioproducts internally; 5 in British Columbia, 14 in Ontario and 11 in Quebec. The estimated savings were $981-million, with $614 million estimated savings by BC firms, $204 million by Ontario companies and other data suppressed. It is likely that most, if not all, of the five BC firms were large forestry firms.

Firms were asked the cost of their biomass in 2009 and the difference between bioproduct gross revenue and cost of biomass suggests an industry struggling with profitability (Table 3). The cost savings from internal bioproduct use represent significant economic benefits that are not accounted for in revenue from the sale of bioproducts and may be a critical factor in bioproduct profitability.

Table 3: Bioproduct revenue and cost of biomass by firm size (Canada)

	Small firms *'000*	*% of total firm revenue*	*Medium firms* *'000*	*% of total firm revenue*	*Large firms* *'000*	*% of total firm revenue*
Bioproduct Gross Revenue	$523,157	58.5%	$635,619	60.1%	$174,728	1.3%
Total cost of biomass input	$800,528		$607,708		$443,827	
Difference	($277,371)		$27,911		($269,099)	

Source: Statistics Canada Bioproduct Development Survey 2009

The negative margins exhibited in Tables 2 and 3 are unique to the latest survey results. The 2006 survey (which reported numbers from 2005 and 2006) revealed an industry with healthy margins due, in large part, to significantly lower biomass input costs (Table 2). The 500% increase in biomass input cost from 2006 to 2008 had a significant impact on industry profitability. Unfortunately, results on biomass use and cost from the three surveys are not directly comparable due to differences in the questions[6]. It is possible to speculate a trend toward greater use of agricultural biomass. Yet, as was reported in the biomass section, while fewer companies used forestry biomass, they used more of it compared to agricultural biomass. However, it is not possible to determine changes in the amount of each used over the time period. Agricultural input costs (cost of production), such as machinery fuels, pesticides, fertilizers, all increased significantly since 2004 (AAFC, 2009) putting upward pressure on the cost of biomass. Rising global commodity prices have also challenged the industry.

The negative margins can also be an indication of the early stage of the industry. It is not uncommon for start-up companies – or, in some cases, a start-up industry – to run negative cash flows, with substantial burn rates, for many years.

Top products

When ranked according to number of firms involved in developing and/or producing particular products, bioenergy was the top category in Canada in 2009 followed closely by biodiesel (Figure 4). However, when it comes to bioproduct gross revenue (BGR), ethanol was the overwhelming leader, contributing 68.2% of bioproduct industry revenue (Figure 5). Ethanol revenue comes from small and medium sized firms. The remaining bioproduct industry revenue is derived primarily from *other organic chemicals*, *bioenergy* and *polymers* (Table 4).

[6] The 2009 survey was the only survey to ask respondents for the quantity and cost of biomass inputs. Earlier versions asked respondents to indicate type of biomass and to allocate percentage of biomass used to each of the given biomass types without asking for quantity or cost of biomass.

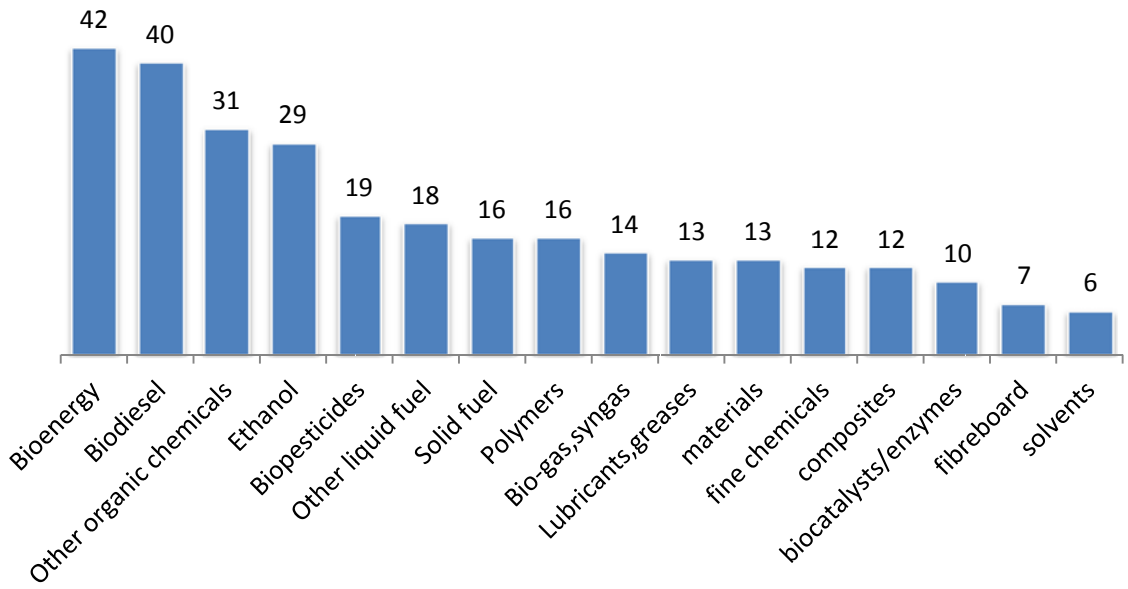


Figure 4: Number of firms by bioproduct type, 2009
Source: Statistics Canada Bioproduct Development Survey 2009

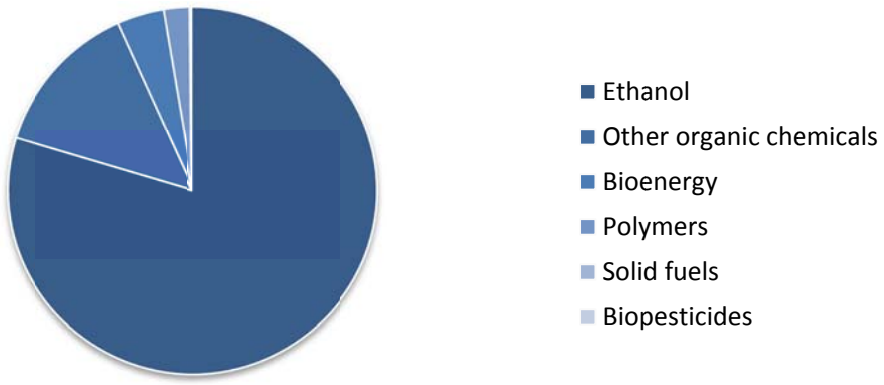


Figure 5: Top bioproducts by bioproduct gross revenue
Source: Statistics Canada Bioproduct Development Survey 2009

Table 4: Top bioproducts by Bioproduct Gross Revenue (BGR)

Type of bioproduct	Number of firms	Number of firms with product in market	Bioproduct gross revenue (BGR) (2009) '000	Percent total industry revenue	Number of firms by firm size	Bioproduct gross revenue (2009) '000
Ethanol	29	20	$909 530	68.2	Small 11	$314 503
					Med 10	$595 027
Other organic chemicals	31	20	$155 497	11.7	Small 15	
Bioenergy	42	21	$46 643	3.5	Small 9	
					Large 12	
Polymers	16	10	$28 166	2.1	Small 8	
					Large [2]	
Bio-pesticides	19	18	$1 052	0.08	Small 18	
Others	~218	~132	$159 112	11.9		

Note: other data suppressed due to confidentiality

Source: Statistics Canada Bioproduct Development Survey 2009

Ten medium-sized firms accounted for over 65% of ethanol revenue or 45% of total bioproduct industry revenue highlighting the weight of this single bioproduct in Canada's industry (Table 4).

Firm size and performance

The industry continues to be comprised of primarily small firms (Figure 7) although the number of large firms has rebounded somewhat since 2006.

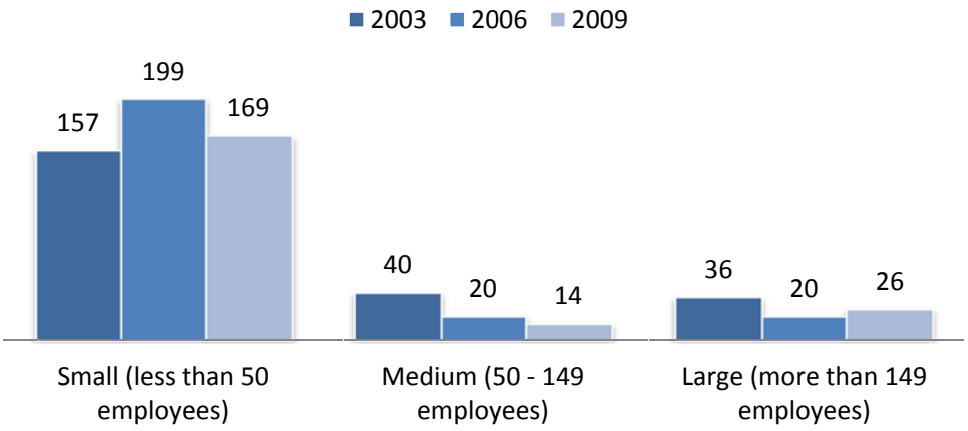


Figure 6: Number of firms by firm size (Canada)

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

In 2009, key differences were evident across firm sizes (Table 5). While small firms dominated the industry landscape in terms of numbers, medium-sized firms generated larger bioproduct gross revenue. The stark contrast between the importance of bioproducts for small and medium firms and the minor role they play in large firms is evident in the differences in bioproducts as a percentage of total firm revenue. However, the benefits for large firms may come primarily from internal use of bioproducts, something that is a minor factor for smaller firms.

Top industry sectors for small firms were biodiesel, bioenergy, ethanol and bio-pesticides. Medium firms were largely working in ethanol (71% by number of firms and 93% by revenue), while the majority of large firms were engaged in bioenergy production, possibly for internal use.

Small and medium firms primarily used agricultural biomass – in fact medium firms sourced only agricultural biomass. The majority of large firms used forestry biomass.

Table 5: Summary industry sectors, revenue and biomass source by firm size 2009

	Small firms	**Medium firms**	**Large firms**
Number of firms	169	14	26
Bioproduct Gross Revenue (BGR)	$523-M	$636-M	$175-M
Top industry sectors (by no. of firms, all stages of development)	Biodiesel, bioenergy, ethanol, biopesticides	Ethanol, solid fuels, other organic chemicals	More than half in bioenergy, none producing ethanol
Leading industry sector by BGR	Ethanol (60%)	Ethanol (93.6%)	Undisclosed
Primary biomass source	Majority using agricultural biomass	Agricultural biomass (100%)	Majority using forestry biomass
Percentage of firms producing for internal use	13.6%	0	61.5%
BGR as percent of total firm revenue	58.5%	60.1%	1.3%

Source: Statistics Canada Bioproduct Development Survey 2009

Product pipelines

Many bioproduct firms undertake activities along the commercialization continuum from basic research and development through proof of concept testing, to production and commercialization. Survey results from 2003 and 2006 show that small firms were by far the most active at all stages of development (Figure 7) reinforcing the importance of small firms in initiating bioproduct innovation. The same dynamic can be seen in pharmaceutical biotechnology or “red” biotechnology where small companies develop new products through the early stages of commercialization, generating ideas, patents and technology which are bought, licensed or acquired by larger firms (Pisano, 2002).

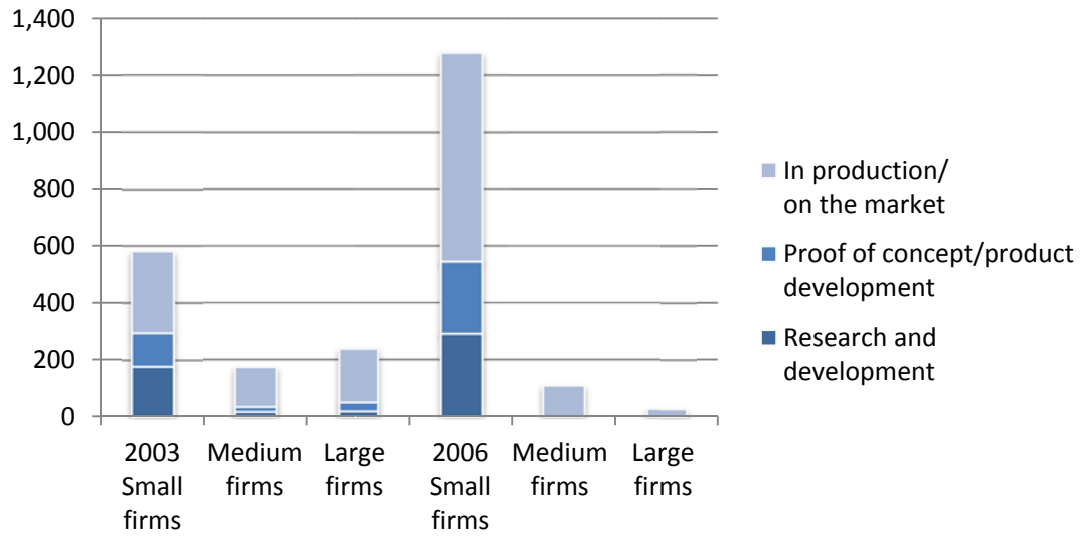


Figure 7: Number of bioproducts at each stage of development, by firm size and year (Canada)
Note: data unavailable for 2009
Source: Statistics Canada Bioproduct Development Survey 2003, 2006

For the 2009 survey, product development data was available only at the level of each individual bioproduct (Figure 8). Results indicate the *ethanol* sector had the lowest percentage of firms with products in R&D, possibly indicating the relative maturity of the ethanol industry compared to other bioproduct. *Polymers* ranked highest with 75% of polymer firms having products in the R&D phase. *Biopesticides* showed a very strong 'in market' percentage at 95% and an equally strong R&D pipeline with 74% of biopesticides firms having products in the R&D phase. Of the selected sectors *bioenergy* firms had the lowest percentage of firms 'in market' at only 50%. Bioenergy firms were more focused at the proof of concept phase (69%) and R&D (64.3%).

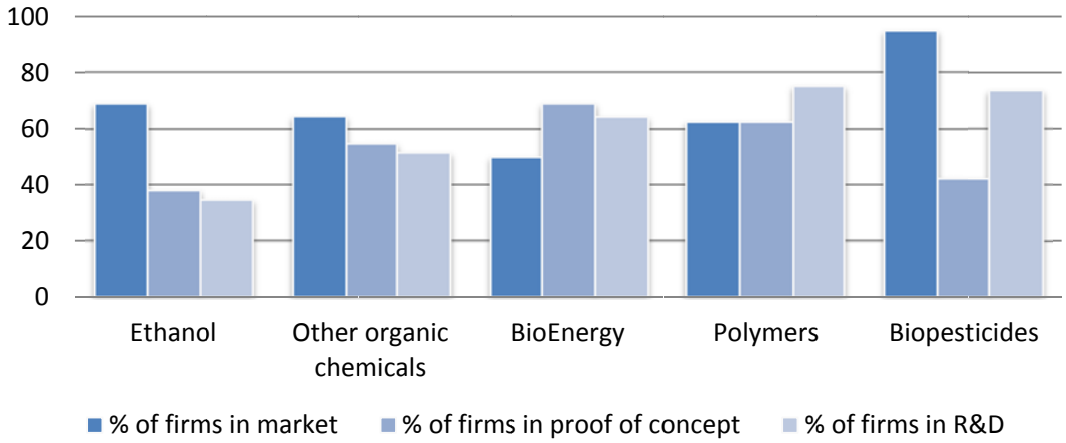


Figure 8: Percentage of firms for top bioproduct sectors (by BGR) at each stage of development, 2009 (Canada)
Source: Statistics Canada Bioproduct Development Survey 2009

Products and co-products

Due to changes in the survey questions and to the bioproduct classification and definitions from 2003 through 2009, it is not possible to report on the number of products being produced by bioproduct firms in 2009. Nor is it possible to accurately identify changes to the product portfolio of the industry over time. Table 6 presents an interpretation of the product shifts given the available data. The following general observations may be made:

1. There is a strong focus on 'bioenergy', 'biodiesel' and 'ethanol'
2. 'Biopesticide' firms – the only sector to have a consistent definition over the three surveys – are half the number they were in 2003
3. 'Biocatalysts' and 'composite' sectors show growth since 2006
4. 'Fibreboard' and 'agri-fibre panels' show a marked decline in number of firms since 2006.

A common observation from the 2006 and 2009 surveys is the proportion of firms reporting 'other' bioproducts (i.e. those not covered by the categories of biofuels/bioenergy, biochemicals, biopesticides, biocatalysts/enzymes and materials). It is difficult to determine what product types would be included, as Statistics Canada does not disclose this information. In 2006 and 2009 the 'other' category ranked first for number of firms with 96 and 57 respectively.

Table 6: Number of firms in each bioproduct sector

	2003	2006	2009
Ethanol (for fuel)	77[7]	41[8]	29
Biodiesel (for fuel)			40
Other liquid fuels (e.g., methanol, butanol, etc.)		n/a	18
Gaseous Fuels (e.g., bio-gas, syngas, hydrogen, etc.)		10	14
Solid Fuels (e.g., agri-straw pellets, agri-wood pellets, etc.)		26	16
Bioenergy (e.g., electricity, heat, co-generation, etc.)		n/a	42
Lubricants and greases	77[9]	47[10]	13
Polymers			16
Adhesives			x
Fine chemicals			12
Solvents			6
Other organic chemicals			31
Bio-pesticides (e.g., insecticides, fungicides, herbicides)	39	36	19
Bio-catalysts and Bio-enzymes	n/a[11]	4	10
Composites	42	7	12
Fibreboard/agri-fibre panels		23	7
Materials (e.g., foam, insulation, masonry, road materials,	n/a[12]	96[13]	13

[7] In 2003 sector was listed as *'Biofuels and bioenergy'*
[8] In 2006 sector was listed as *'Liquid fuel'* (bioethanol, biodiesel)
[9] In 2003 sector was listed as *'Biochemicals'*
[10] In 2006 sector was listed as *'Biochemicals'*
[11] In 2003 biocatalyst was included in 'Other' category
[12] In 2003 'Materials' sector was not included and would likely have been captured in *'other'* category
[13] In 2006 sector was listed as *'Other bioproduct or biomaterial'*

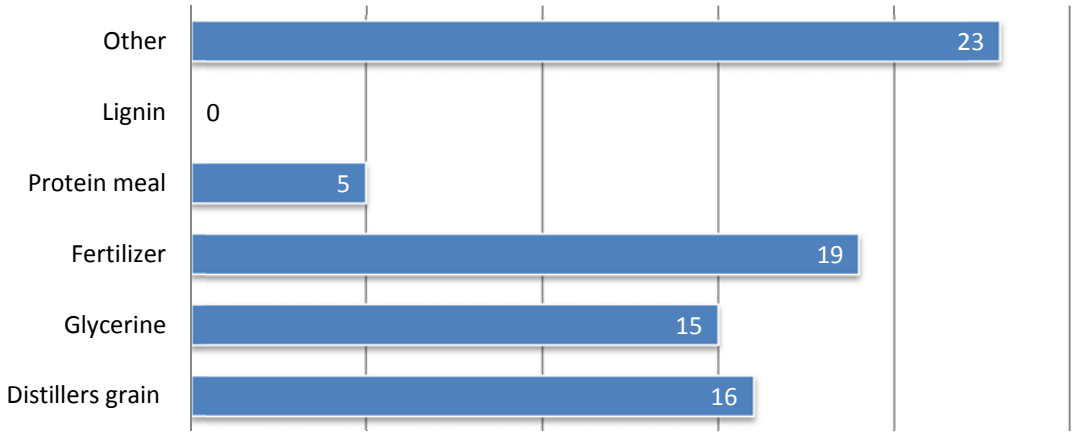
cement, geofibres, geotextiles, etc.)			
Other Bioproducts	51[14]		57

Note that individual firms may have products in multiple categories

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Co-products

Survey results indicate that an estimated 69 firms were producing co-products for sale in 2009, up from 50 firms in 2006. The 2009 survey went further than previous versions to query respondents on the type of co-products. Figure 9 highlights the type of co-products, with those associated with biofuel production – distillers' grains, glycerine and protein meal – making up 46% of the firms. The top ranked co-product by number of firms selling it was fertilizer, being sold by 19 firms. Although the survey did not report revenue from co-products, it is likely that distillers' grains, a bioproduct of ethanol production, makes up the largest share of revenue, given the industry dependence on revenue from ethanol.



Note: CO_2, compost and food ingredients did not have sufficient data to report

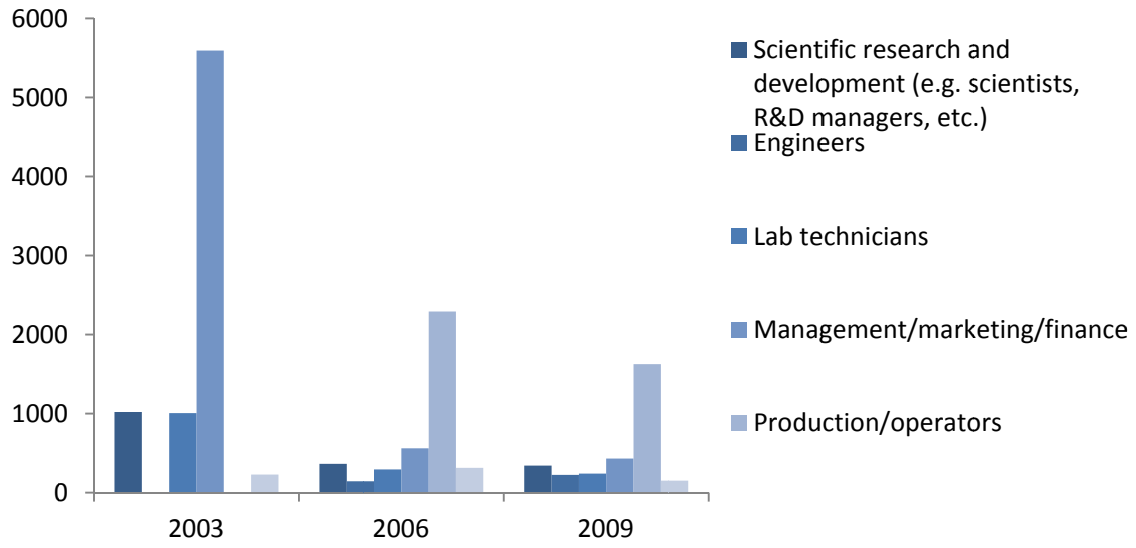
Figure 9: Number of firms producing co-products, by type 2009 (Canada)

Source: Statistics Canada Bioproduct Development Survey 2009

Human resources

After a substantial decline in 2006, employment numbers continued to drop in 2009 (Figure 10). According to survey estimates, the bioproduct industry employed 3,019 people in 2009 in bioproduct related activities – only 38% of the workforce reported in 2003, with huge declines in management/marketing and finance as well as significant cuts in research and engineering staff.

[14] In 2003 '*Other*' category included 'biocatalysts, biosensors, bioplastics, other'



Note: In 2003 survey question did not query number of 'Engineers'; and 'Production' was included with 'Management/marketing/finance/production'

Figure 10: Number of employees with at least 50% of their responsibilities related to bioproducts production, development or administration (Canada)

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Bioproduct-related employment in small firms has been fairly consistent over the three surveys, while in medium and large firms, bioproduct employment has continued to decline (Figure 11).

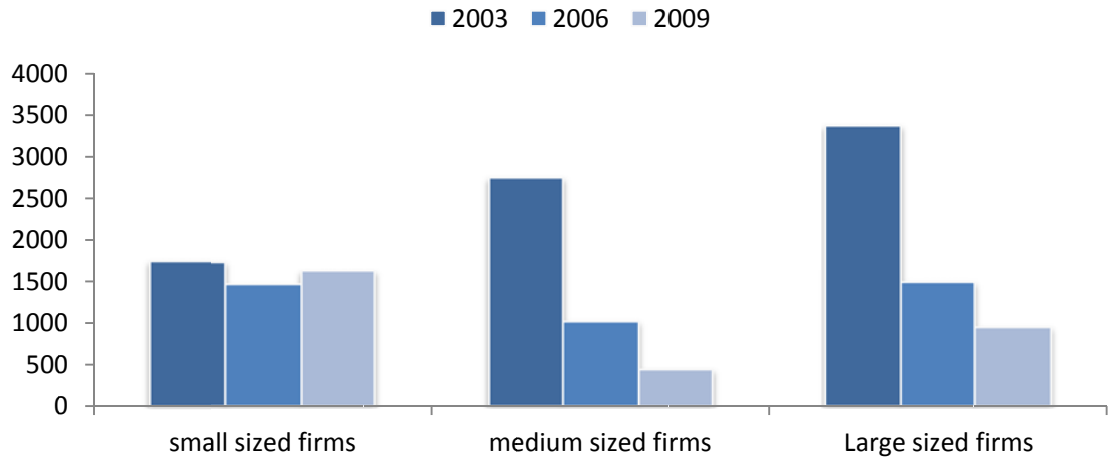


Figure 11: Number of employees related to bioproducts production, development or administration by firm size, year (Canada)

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Bioproduct related salaries as a percentage of total salaries show that small firms are even more focused on bioproducts than they were in 2006, medium firms have held steady at about 66 % and large firm bioproduct salaries have decreased significantly (Table 7).

Table 7: Salary costs and average employ salaries for bioproduct related activity, by firm size (Canada)

Total salary costs for employees (thousands)

	All employees		Bioproduct related employees		bioproduct salary as % of total salaries	
	2006	2009	2006	2009	2006	2009
Canada	1,075,894	3,557,104	195,859	210,369	18%	6%
small firm	137,670	109,403	66,876	91,642	49%	84%
medium firm	78,804	49,022	52,916	32,278	67%	66%
large firm	859,420	3,398,679	76,067	86,450	9%	3%

Source: Statistics Canada Bioproduct Development Survey 2006 and 2009

Industry Practices

Time in bioproducts: new entrants help balance a substantial exit rate

Results from the surveys allow for longitudinal observations of the changes since 2003. In all versions of the survey respondents were asked to identify when their firm began its bioproduct related activities in Canada. Results are presented in grouped age categories (Figure 12). In 2003, 80 firms identified as being 0-5 years of age. Most of this group would fall into the category of being 6-10 years of age in 2009. The number in the 6-10 year old category in 2009 is half the size of the 0-5 in 2003, indicating that many firms exited, were acquired or failed to survive. Although the timeframes don't match exactly, a similar pattern can be observed for the firms which were 6-10 in 2003 and would have been 12-16 in 2009. The number of firms 11-15 years old in 2009 is roughly half the number of firms 6-10 years in 2003. These results are indicative of a young, technology-driven industry where the exit and entry of new firms leaves the industry in a state of constant flux.

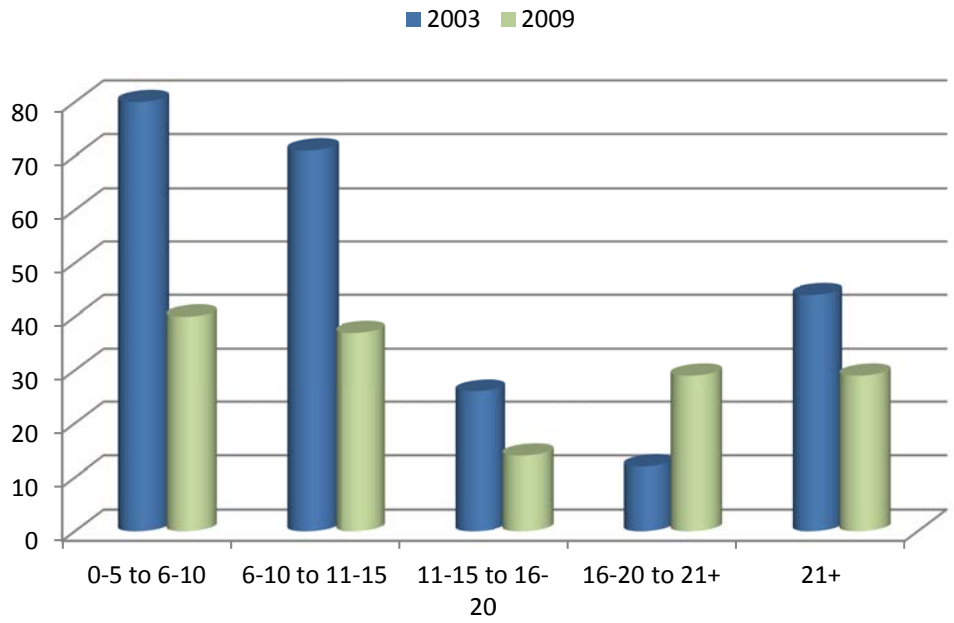


Figure 12: Number of firms in bioproducts by time involved in bioproduct development and/or production 2003 to 2009
Source: Statistics Canada Bioproduct Development Survey 2003 and 2009.

Initial involvement in bioproducts

Bioproduct involvement in Canada continues to be initiated primarily through internal corporate activities (Table 8). Roughly 20-35% of firms become involved through collaborations, licensing agreements or purchases from another firm or lab.

Table 8: Reasons for initial involvement in bioproducts

Canada	2003	2006	2009
Mainly as a result of domestic activities of your firm (e.g., utilization of by-products, as part of a R&D project etc.)	65.89%	51.05%	63.92%
In co-operation/collaboration with other firms or organizations	15.20%	15.06%	7.73%
Merger with/acquisition of another firm/or firm's bioproducts activities	4.87%	4.48%	
Acquired/licensed technology from a domestic firm or lab			8.25%
Acquired/licensed technology from a foreign firm or lab			8.25%
Purchase of another firm's bioproducts development activities	2.02%	6.23%	
Other	12.02%	23.01%	11.86%

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

The factors which influenced firm involvement or the decision to produce bioproducts has remained fairly consistent over the three surveys. Firms see bioproducts as an 'opportunity to increase product range to increase sales and market share' (p.10). The use of biomass to reduce production costs usually ranked third and was never the leading influencer.

Spin-off activity

Overall, there has been a downward trend in spin-off activity, falling from a high of 45 firms in 2003 to 29 in 2009. In 2009, the largest fraction of spinoffs came from universities (13), with eight from '*another firm*' and eight from '*other*'; none were reported from a government agency/lab (Figure 13). The results from 2009 show a resurgence of activity coming from universities/academic institutions which had fallen significantly in 2006.

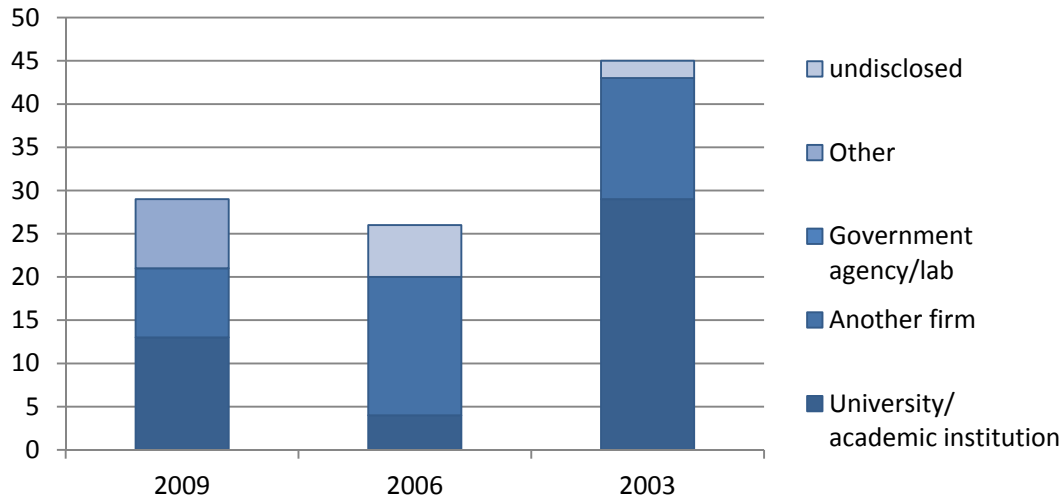


Figure 13: Spin-off origins by year (Canada)
Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Barriers to production

Respondents were asked to rank the barriers to developing or producing bioproducts on a scale of low to high. Scores were weighted and tallied for comparison purposes (Table 9). In 2009, '*lack of financial capital*' led the list followed closely by *'regulatory approval'* and *'cost of biomass'*, responses that were consistent with those of 2003.

Table 9: Barriers to bioproduct development 2003-2009 ranked by importance (Canada)

	2009	2006	2003
1	Lack of financial capital	Higher transportation cost of biomass	Lack of financial capital
2	Regulatory approval	Higher price of biomass	Higher cost and timeliness of regulatory approval

3	Higher transportation cost of main feedstock/raw material	Difficulty in entering commercial marketplace	Higher price of raw materials/feedstock
4	Commercial marketplace	Cost and timeliness of regulatory approval	Higher transportation cost of main feedstock/ raw material
5	Ongoing regulatory costs/requirements	Lack of financial capital	Unreliable supply of raw materials/ feedstock

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009.

Outsourcing – accessing expertise, competencies and R&D capabilities

Of the 208 companies surveyed in 2009, 117 were involved in contracting out – or outsourcing – for bioproduct related activities. The majority of these firms were small (97); however the percentage of firms contacting out was comparable across size categories with 57.3% of small firms, 57.1% of medium-sized firms and 47.2% of large firms contracting out. Firms of all sizes identified research and development, engineering and production of goods as the top activities sought from outsourcing.

When asked to rate the degree of importance of selected reasons for contracting out, the highest rated reasons in 2009 included '*accessing outside scientific expertise/knowledge*', '*bioproduct activity was outside core competence of firm'* and *'access external R&D expertise'*. There was some variation by firm size. Only small-sized firms rated 'access to production facilities' as high suggesting that medium and large sized firms have production facilities in place. One hundred percent of large-sized firms rated '*access [to] outside scientific expertise/knowledge'* as high, reinforcing the suggestion that bioproducts are not core activities for large firms.

Cooperative/Collaborative arrangements[15]

In 2009 almost half of Canadian bioproduct companies were involved in cooperative/ collaborative relationships which involved longer term and closer relationships than contracts (Figure 14). One third of the collaborations involved more than one partner.

[15] Statistics Canada defines cooperative and collaborative arrangements as involving the active participation in projects between the responding company and other companies or organizations in order to develop and/or continue work on new or significantly improved bioproducts processes and /or products. Pure contracting-out work where money is paid for a service is not regarded as a cooperative and/or collaborative arrangement (p.17 Statistics Canada Bioproduct Development Survey 2009)

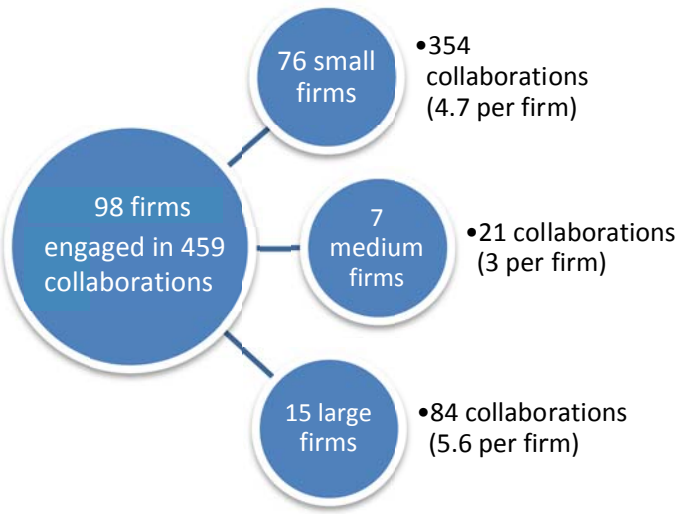


Figure 14: Number of firms engaging in cooperative/collaborative arrangement, by firm size and number of collaborations
Source: Statistics Canada Bioproduct Development Survey 2009

Universities and government labs, both federal and provincial, figured most prominently in the collaborative arrangements (Table 10). However, firms engaged in numerous partnerships with other firms in Canada and outside.

Table 10: Type of partners in bioproduct cooperative/collaborative arrangements

	Small firms	Medium firms	Large firms	Total
Other firms in Canada	51	5	8	64
Other firms outside of Canada*	X	X	12	44
University in Canada	47	7	8	62
University outside of Canada	X	0	X	8
Federal agency/lab	29	X	X	36
Provincial agency/lab	28	X	X	35

*own firm's operations outside of Canada were excluded
Source: Statistics Canada Bioproduct Development Survey 2009

Firms were asked to rate the importance of selected reasons for collaborating with partners. Answers were weighted and tallied to allow for comparison. The reasons for collaborating are similar to those for contracting out; accessing scientific knowledge and conducting research (Figure 15). A third reason for collaborating was to access capital. Reasons for collaborating were consistent across all firm sizes though large firms ranked

accessing intellectual property ahead of accessing capital.

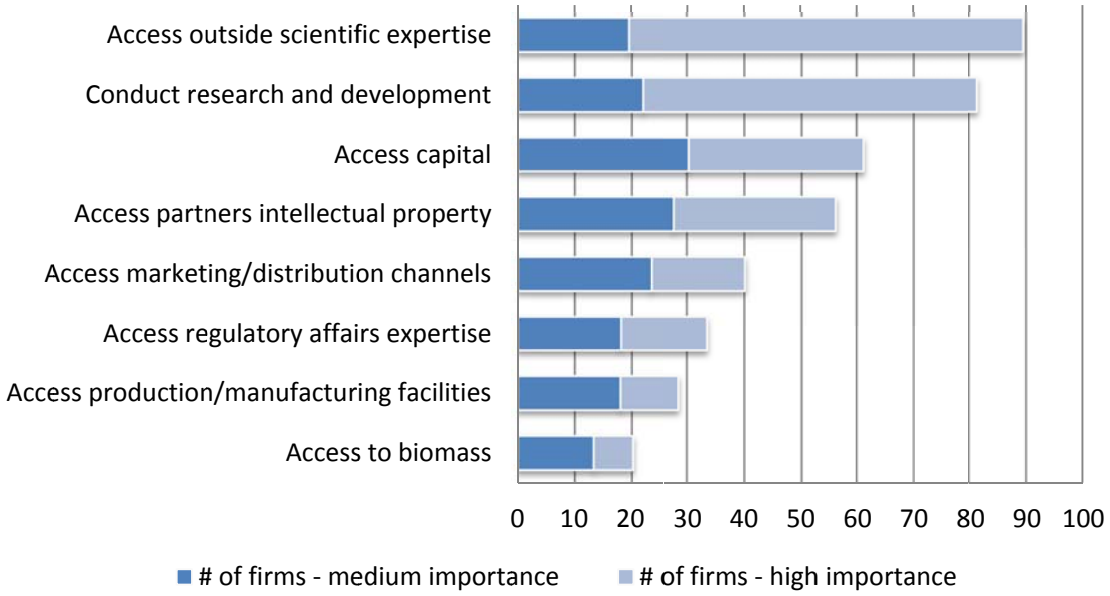


Figure 15: Reasons for cooperative/collaborative arrangements 2009 (Canada)
Source: Statistics Canada Bioproduct Development Survey 2009

Biomass contracting and sourcing

Ninety-five firms, roughly 46% of bioproduct firms, contracted with external organizations to acquire biomass in 2009, essentially the same percentage as in 2006. Farmers and grain suppliers account for half of those contracting relationships (Table 11).

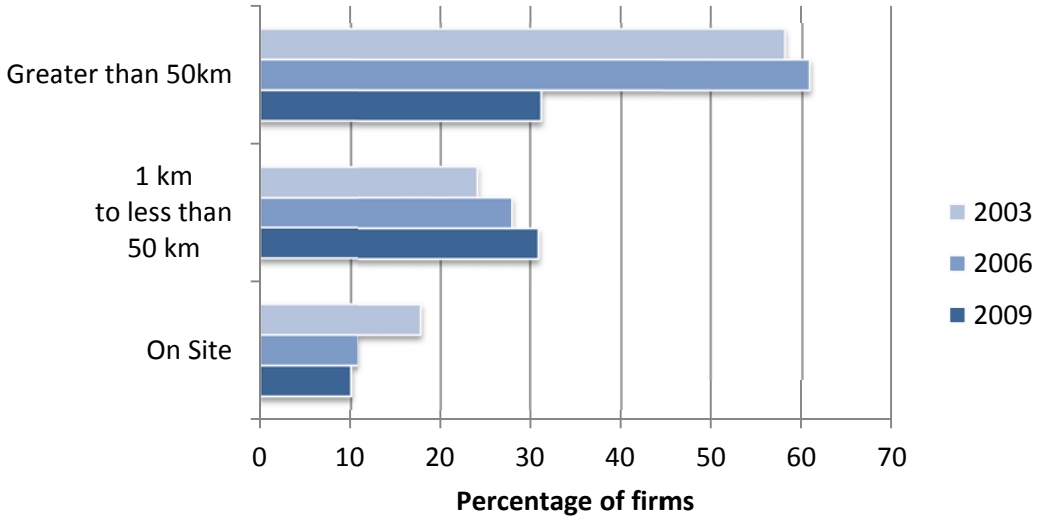
Table 11: Number of firms contracting for biomass by supplier type

Number of firms contracting for biomass by supplier type, 2009	
Canada	
Farmer	32
Grain supplier	16
Food/feed processor, food service (e.g., restaurants)	14
Municipality	9
Forestry harvesters	7
Forestry mill	12
Pellet producer	0
Other	26

Source: Statistics Canada Bioproduct Development Survey 2009
Note: question asked respondents to 'check all that apply' therefore sum of the table may be larger than the total number of firms contracting for biomass as firms may contract with multiple organizations.

Firms in 2009 appear to be sourcing biomass closer to their location (Figure 16). Just over 30% of firms sourced biomass at a distance greater than 50km in 2009 versus

approximately 60% in 2006. However, on-site production of biomass is trending downward falling from almost 18% in 2003 to 10% in 2009.



Note: In 2009 27.9% of respondents answered "I don't know". This option was not available on earlier surveys.

Figure 16: Distance of firm from source of biomass by year (Canada)
Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Patents and Intellectual Property

The total number of patents held by bioproduct firms increased by 36% between 2006 and 2009 (Table 12). The location of patents held shifted, with less emphasis on Canada and the United States and much more on other regions of the world. A significant part of this is likely firms expanding the range of patents already held in the U.S. and Canada to other parts of the world, but it indicates a more global perspective to patenting in the industry. Ontario firms showed the largest increase in firms with patents (from 6 with Canada/U.S. patents in 2006 to 27 in 2009) and U.S. patents held (from 25 in 2006 to 49 in 2009). Most other regional data was suppressed for confidentiality reasons. Quebec and the Prairies showed considerable declines in firm numbers and patents.

Table 12: Number of patents by patent office location (Canada)

Canada	Number of firms 2006	Number of patents granted 2006	% of total patents	Number of firms 2009	Number of patents granted 2009	% of total patents
Canadian Intellectual Property Office (CIPO)	66	92	22.4%	67	81	14.4%
U.S. Patent & Trademark Office (USPTO)	72	157	38.1%	62	93	16.5%
European Patent Office	43	100	24.2%	34	110	19.6%

Source: Statistics Canada Bioproduct Development Survey 2006 and 2009

Small firms are often involved in early stage, innovative activities requiring fewer assets besides knowledge and research capacity. Patents are frequently critical elements in securing early stage investment. As a result, small firms are the most actively involved in patenting. Of the three main patent office locations reported – Canada, United States and European Union (EU) – small firms help 88%, 92% and 91% of the patents respectively. In 2009, all US and EU patents were held by small firms and the vast majority of pending patents were also within small-sized firms.

Licensing - many more firms exchanging intellectual property

A significant change from 2006 was the number of firms sharing intellectual property (IP) through licensing agreements. In 2006, only nine firms assigned IP to another firm through out-licensing. By 2009, the number of firms out-licensing to other firms increased to 26. In-licensing, contracting with other firms to acquire IP, increased from four firms in 2006 to 17 firms in 2009. It is believed this question (Q 36/37, 2009) may not fairly depict the true movement of IP into bioproduct firms as the wording asks only for IP rights acquired from 'another firm'. Respondents may not have included IP acquired from universities/academic institutions or government sources.

Bioproduct trademarks: unregistered trademarks on the rise

While the total number of registered bioproduct related trademarks dropped from 2005 to 2009, firms increased their use of unregistered trademarks dramatically over that period (Figure 17). There was also a dramatic shift in the regional distribution of trademarks. In 2006, 38 firms in the Prairies accounted for 63% of registered and 36% of unregistered trademarks, while Ontario had only 15 firms which accounted for just 6.5 % of registered and 6% of unregistered trademarks. By 2009 a significant regional shift had occurred. Twenty-eight Prairie firms still accounted for 42% of registered trademarks (dropping from145 to 86) but they only held 5% of unregistered ones. Twenty-four firms in Ontario owned 38% of registered trademarks and a staggering 88% of unregistered trademarks, increasing from 10 in 2006 to 333 in 2009. Registered trademarks in Quebec dropped from 40 in 2006 to only 24 in 2009.

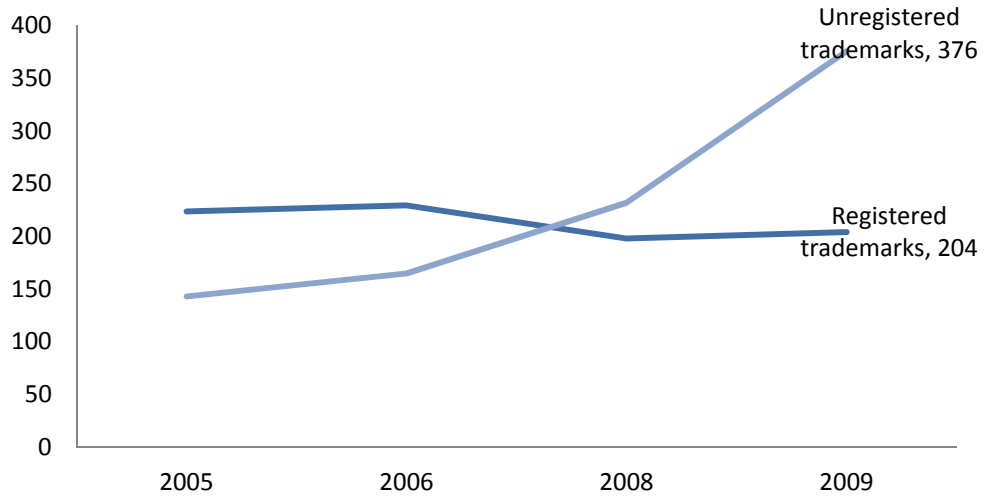


Figure 17: Number of bioproduct related trademarks by year (Canada)
Source: Statistics Canada Bioproduct Development Survey 2006 and 2009.

Financing

The impact of the global financial crisis was evident in the financing experience of bioproduct firms in 2009. Although more firms were successful in raising money than in previous surveys, the amount raised was smaller, with more than 50% coming from government loans and grants. In 2009, 130 firms raised an estimated $221,637,000 from private investors and government sources, including loans and grants (Table 13). This amount represents about 60% of the total funding target for these firms. The vast majority, $192,858, 000, went to 120 small firms, representing an average of $1.6 million raised per small firm. In 2006, 87 firms raised $219,000,000 with small firms raising an average of over $2.7 million per firm. In 2009 all of the Canadian venture capital went to small firms, there were no Initial Product Offerings or placements with American venture capital firms.

Table 13: Sources of funding (Canada)

Year	Target amount	Amount raised
2009	$371,286,000	$221,637,000
Small firms	$343,521,000	$192,858,000
Sources of funds		
Canadian based private venture capital		$ 35,657,000
American based private venture capital		$ 0
Other private venture capital		$ 2,575,000
Angel investors/family		$ 17,599,000
Other		$ 51,841,000
PRIVATE INVESTORS TOTAL		**$107,672,000**
Government – loans (e.g. BDC, FCC, EDC, STDC)		$ 47,460,000
Government – matching funds		$ 2,218,000
Government – grants (e.g. IRAP)		$ 60,493,000
GOVERNMENT TOTAL		**$113,965,000**

Source: Statistics Canada Bioproduct Development Survey 2009

The average amount of money raised per firm dropped significantly between 2006 and 2008 (Figure 18). A dwindling number of funding sources and a strong reliance on government programs has resulted in a thin distribution of funds to a larger pool of companies (130 vs. 87). One would want to ask if this is a desirable practice or if more money to fewer companies would help Canadian businesses build winning companies capable of attracting other sources of investment.

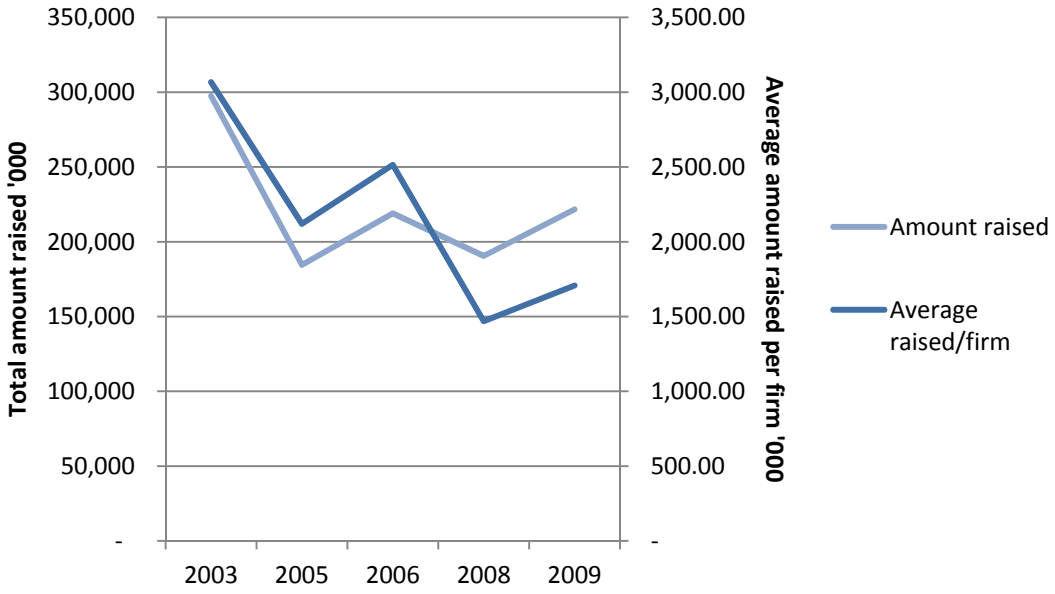


Figure 18: Total amount raised by the bioproduct industry and average amount raised per successful firm

Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Scientific Research and Experimental Development (SR&ED) tax program

There are been little change in the use of Canada's Scientific Research and Experimental Development (SR&ED) tax program. In 2009 there was a slight increase in the number of firms applying for tax credits, hitting a high of 120 firms (Figure 19). Small firms have been more prone to apply to the program and had accumulated credits of over $82 million in 2009.

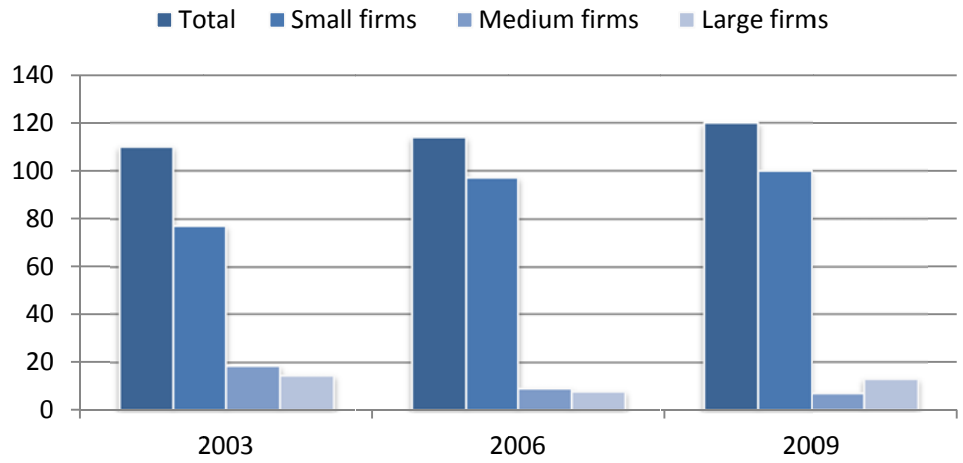


Figure 19: Number of firms applying for bioproduct related activities under SR&ED tax program by firm size
Source: Statistics Canada Bioproduct Development Survey 2003, 2006 and 2009

Environmental Practices and Plans

The need for environmental plans and certification systems like ISO 14001 is becoming evident. In 2009, more than half of Canadian firms surveyed had been asked by their customers about their environmental practices and an estimated 28% had already implemented environmental plans. Both questions and implementations have been particularly strong in Ontario (Table 14).

Table 14: Number of firms asked about environmental practices and number of firms with environmental plan in place (Canada)

	Customer Requests	Environmental Plans in place
Region	Number of firms whom customers asked about environmental practices, 2009	Number of firms who have an environmental plan (e.g., ISO 14001) in place for 2009
Canada	112	59
Atlantic	8	X
Quebec	25	7
Ontario	49	32
Prairies	14	8
British Columbia	16	X

Source: Statistics Canada Bioproduct Development Survey 2009

Discussion and Concluding Remarks

Discussion

The Statistics Canada Bioproduct Development Survey (2003, 2006 and 2009) provides an interesting glimpse into the bioproduct industry from a supply side perspective. The results presented above showcase an industry heavily weighted toward ethanol and forestry bioproducts, with small amounts of market activity evident in the chemical (including pesticides) sector. The product pipelines for both bio-based chemicals and bioenergy are encouraging; if in fact the market is ready to adopt these products and technologies. This appears to be the underlying question for the industry as a whole: what is the market demand for bioproducts (including biofuels)? To fully understand the industry dynamics it is necessary to define the demand side of the equation and ensure that market drivers and demand conditions are present to support a bio-based industry.

A quick scan of international activity in bioproducts shows strong advances taking place in the United States and to a lesser degree in the European Union. In the last nine months the industry has witnessed four IPOs in the U.S. with the latest raising US$150-million, creating a *pre-revenue* company valued at US$1.49-billion (Reuters, 2011, Lane, 2011). Investors are showing strong interest and engagement in the industrial biotechnology space even in the midst of economic uncertainty and weak overall market signals. These early public companies have followed a path to market reminiscent of pharmaceutical biotechnology companies in the early 1980's. That industry has seen few companies reach large scale success but the industry dynamic remains strong with large pharmaceutical companies continuing to invest heavily in R&D, driving the demand for small technology-driven companies that have spun out of universities, government labs and other firms.

It is evident that industrial biotechnology would like to follow a similar path. Companies such as Kior, Gevo, Amyris, Solazyme and Codexis are notable leaders that could act as pillars to the industry as it struggles to establish a foot hold and successfully launch products onto the market. These companies each have patent portfolios which secure value for investors and offer unique technology propositions to the market. What they lack is sales. Similar to revenue streams and profitability reported in the Canadian Bioproduct Surveys, the industry leaders are still in the start-up phase. However the authors contend that there are key difference between U.S-based firms and Canadian firms. The U.S. ethanol industry (used an indicator for the larger bioproduct industry) contributed 0.37% of the Gross Domestic Product (GDP) in 2010 (Urbanchuk, 2011, BEA, 2011). In comparison the Canadian ethanol industry contributed 0.016% of the GDP in 2003 (Mukhopadhyay and Thomassin, 2011, Statistics Canada 2004). The Canadian ethanol industry has expanded considerably since the 2003 snapshot used in Mukhopadhyay and Thomassin (2011) but certainly not the 23 times needed to bring it on par with the U.S. industry.

The state of the U.S. industry is due to a number of factors. First, total investments in U.S. firms dwarf the $221-million invested in Canadian bioproduct firms in 2009. The four IPOs noted above raised over $528-million (USD) alone since September 2010. The U.S. Department of Energy Biomass Program has invested nearly $2-billion since 2002 into its biomass program (DOE, 2011). Combined with sizable investments made by American and international private investors, the scale of investment and the resulting advancements – both technologically and strategically – have catapulted the industrial sector in the U.S. into the limelight. Government procurement programs, as well as military procurement programs—and admittedly renewable fuel standards – have also helped to create market pull.

But many economists would ask if flooding the green landscape with sizable public investment is the best policy for reaching the desired goal of both economic and environmental prosperity. Some consider this course of action disquieting and likely to entice misallocation of scarce resources (Nordhaus, 2002). What then are the foundations of a prosperous, economically sustainable and truly profitable industry? Porter (2008) contends that one of the major forces required in any market is a sophisticated consumer. To date the bio-based consumer has been focused mainly on price and substitution strategies that require little change to products or processes, time and money (Sparling et al, 2011). As this industry moves forward – in Canada and abroad – buyers and sellers need to be engaged, informed and balanced in their purchasing decisions. A market of sophisticated buyers holds far more power than mandated or subsidized markets, and promises greater returns to investors and governments alike.

The survey results provided by Statistics Canada and the analysis presented above give a limited view of the bioproducts sector in Canada largely skewed to the supply side of the market. Future research therefore needs to better capture the nature and scale of demand for the industry. Additionally future research needs to target the ethanol and energy sector, drawing out differences in sector performance metrics and barriers and going further to assess the bioproducts portfolio by product rather than as a whole. Work into firm level strategies specifically bio-based chemical firms, will also be completed. Where possible this will be done in combination with case based research already underway.

Several questions persist around the sample frame of the survey and the accuracy of the data presented by Statistics Canada.[16] As such, future research on this sector should be undertaken with the goal of building upon the broad industry data provided though the survey with additional primary research. Additional data from Statistics Canada will help to better define the scale of the industry as of 2010/2011 and secondary data will help to build a model that is perhaps more representative of the industry today and changes that have taken place in the last two years. Anecdotal evidence suggests that there are Canadian firms succeeding in this industrial sector and that a transition is underway that will see the processing infrastructure established through the ethanol industry grow into an advanced bio-based chemical and fuel platform.

[16]Statistics Canada sampling criteria as well as data sources and methodology can be find at http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=5073&lang=en&db=imdb&adm=8&dis=2

Concluding remarks

For almost a decade Canada has been promoting the opportunities for growing the bioeconomy. Companies, universities, non-governmental organizations and governments at every level have waved the bioeconomy flag as a means of attracting interest, partners and ultimately investment. The survey results to 2009 can only be described as disappointing and suggest that somehow Canada is missing its potential in bioproducts. Policies for biofuels, particularly mandated biofuel content for transportation fuels, have allowed a handful of ethanol and biofuel companies to build their businesses on a combination of private investment and government grants and loans. Some argue that these large scale investments in the biofuels sector have resulted in a viable processing foundation for the creation of additional bio-based chemicals beyond the commodity fuel products on the market today. This certainly appears to be the trend globally, as large multi-national enterprises move into the industrial biotechnology and bioproduct space. Bio-based chemicals are the growing focus of chemistry firms for reasons ranging from cost and assurance of supply to environmental impact. While the landscape of active players consists primarily of smaller new technology companies – as is also evident in Canada – an increasing number of large multinational firms are showing an interest in bio-based technologies and products (King, 2010). The current estimate of the worldwide market potential for these chemicals is USD $164-billion. Yet, as the global industry begins to take shape, making strategic investments in technologies, companies and locations – the landscape in Canada remains stagnant.

Many speculate that the rapidly growing interest in bio-based products will continue in the near future, spurred by two underlying trends. First, the depleting supply of oil and the increased cost and price volatility is creating market opportunities for bio-based alternatives. Second, public pressure for environmental sustainability is resulting in policies and regulations to support the development of bio-based products. As a result bio-based products, including chemicals and materials, have moved higher on the strategic agendas of many industrial value chains. However the question remains, what role will Canada – its businesses, consumers and governments – play in the global shift toward bio-based industrial production?

Canada is in an enviable position with forests and agricultural lands that yield an abundance of biomass, and the skilled labour, research capabilities and education systems needed to support innovation and the growth of a new economy. However Canada has yet to turn those advantages into a successful bioproduct industry. One contributing factor appears to be the lack of a vision and plan to use these natural assets to Canada's advantage. This lack of vision leaves the Canada vulnerable to others who can move quickly to seize its natural resources and turn them into value-added commodities and products that Canadians will ultimately buy as foreign-made goods.

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