Bioindustrial options in Alberta

BUSINESS EDITION

May 2012

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INTRODUCTION

This project provides clear evidence on Alberta's bioindustrial options. The province will use this evidence to guide its bioindustrial investments.

The principle idea is to find core engines in the economy (areas that drive growth and sustain the province over the long term) that incubate diversification opportunities.

Aligning investment decisions with the core engines helps minimize risk and stack the odds of success. The result is tailored, strategic choices and deliberate investment targets.

With clear evidence to support its core advantages, Alberta is well positioned to pursue innovation investment, mitigate risk, and drive economic sustainability.

Jurisdictional Advantage Assessment

Jurisdictional Advantage Assessment is a conservative approach to investment decisions. It is an evidence-based process that identifies the unique strengths, weaknesses and opportunities that define the province's sustainable advantages.

Every region has its own character and set of economic strengths. Some are obvious, others are deeply hidden. Jurisdictional Advantage Assessment is a methodology for detecting distinct characteristics that provide unique opportunity to places.

The proprietary process utilizes executive interviews, global research, and a suite of 72 indicators to analyze the character of place. In addition to general economic indicators, measures are taken across five elements of Jurisdictional Advantage:

- 19 quantitative indicators evaluate regional capabilities (the set of skills and historical successes that companies leverage to compete today);
- 13 explore support institutions (the research agencies, trade associations and networks that glue economies together);
- 6 assess the natural environment, the mix of resources and proximity to key global markets that companies leverage to compete;
- 10 evaluate the constructed environment, the infrastructure (road, rails) and inertia of policies that influence markets; and
- 18 analyze industrial ecosystems (the mix of small, medium and large companies within specific value chains).

By gathering quantitative evidence across these five elements, Jurisdictional Advantage Assessment sifts every thing to deliver clear evidence for decision makers.

Report Overview

This report is divided into three sections:

Part I summarizes economic data on sectors related to bioindustrials in Alberta. The data is drawn from the 72 indicators used in Jurisdictional Advantage Assessment.

Part II presents the results of the Jurisdictional Advantage Assessment and presents the core economic engine of Alberta.

Part III outlines Alberta's best options for diversifying bioindustrials while leveraging its jurisdictional advantage. It includes themes and insights gathered from interviews with 71 Alberta-based executives, 32 located across Canada, eight in the United States and 10 international.

Part IV is an overview of key challenges raised by executives when considering bioindustrial opportunities in Alberta.

PART I: ECONOMIC SECTOR ANALYSIS

Forestry Sector Analysis

Alberta's forest sector is hurting. It has been punished by pine beetles, the United States/Canada softwood lumber agreement and the United States housing crisis.

Forestry output peaked in 2006, rising by 33 per cent from 2000. Since then production has fallen back. The province has about 12 per cent of national wood volume[1].

Forestry struggles with innovation. No patents were granted to the industry in the last 10 years. Forestry innovation is led by international heavyweights in Finland, Japan, and Norway.

Forestry in Alberta is controlled through Forest Management Units. The framework guides use of publicly owned lands. A majority of these lands (66 per cent) are under Forest Management Agreements that control annual allowable cuts and specify use, remediation and environmental criteria.

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
35 million hectares of public-owned forests.	No patents were granted to forestry in Alberta in the last 10 years.	11 industry associations and 31 NGOs support the sector.	Forest Management Units control the use of publically owned forests.	Alberta has 8% of the forestry companies in Canada.
Annual allowable cut is 30 million cubic metres. 90% of coniferous cut and 60% of deciduous cut are taken.		No Alberta-based institutions have achieved patents since 2000.	66% of publically owned forests are under Forest Management Agreements.	Of active employers, 65% have less than 4 people, 33% have less than 99 employees.
The United States takes 74% of exports.		12 NSERC grants averaging $0.5 million go to forestry each year.	The Mountain Pine Beetle Management Strategy is pushing up annual cuts.	There are 5 mid-size companies and no large companies in the province.

General Economic Overview

- Less than 1% of Alberta's GDP comes from forestry.
- In 2008, weekly average earnings were $1,037.
- From 2000 to 2006, forestry output increased 33%. Since 2006, pine beetles and the U.S. housing crisis has pushed back production to where it started in 2000.

Mining Sector Analysis

Mining in Alberta is limited to coal, gravel and sand. There are no reported metallic reserves in the province. As a sector, mining contributes less than one per cent to GDP ($452 million in 2010). That said, the 34 billion tonnes of coal reserves represent more energy than all other non-renewable sources combined.

Employment in mining has increased by four per cent since 2006 and 46 per cent from 2000.

There are three mid-sized firms and two large mining companies in the province. The rest are small.

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
Alberta's coal reserves are 34 billion tonnes and contain more energy than all other non-renewable sources combined.	Employment in mining is growing, it is up 46% from 2000 and 4% from 2006.	The Coal Association of Canada is located in Calgary.	There was 1 venture capital investment in mining since 2006.	TransAlta is one of the top 200 companies in Alberta. It owns 2 coalmines.
No metal reserves are reported for Alberta.		The University of Alberta has 2 research chairs in mining and minerals. 1 is in petroleum, the other is for coal.	NSERC granted 184 mining related projects since 2000. Most are focused on oil sands.	Exploration activities in the province are minimal compared to places like BC.
			Federal policies related to coal-fired power will impact Alberta, 70% of produced coal is for power generation.	Of mining companies in the province, 30% are micro-sized, 66% are small, 2% are mid-sized and 1% are large.

General Economic Overview

- Real GDP from coal and non-metallic mining was $452 million in 2010. Data is suppressed from 2000 to 2007.
- Most of the province's mining companies are in gravel and sand. Of 162 mines, only 9 are coal.
- Average weekly earnings were $1,522 in 2010, up 35% from 2006 and 28% from 2000.

Non-Core Manufacturing: Agri-Food & Wood Products Sector Analysis

Together agriculture, forestry, agri-food, pulp/paper and wood products manufacturing comprise four per cent of provincial GDP.

Non-core is not meant to suggest relative significance. It only distinguishes these businesses from sectors that support or take inputs from the core engine of Alberta's economy: oil and gas. These politically and socially important sectors support communities that often have no other industrial activities.

Exports from agri-food are improving (up 10 per cent from 2000 to 2010 and up 25 per cent from 2006 to 2010). Wood products exports are down by almost 50 per cent from 2000 to 2010. Pulp and paper exports held steady from 2000 to 2010.

Agri-food manufacturing in Alberta is saturated with small and very small companies (about 91 per cent). Wood products manufacturing is similar. Eighty-nine per cent of firms are small or micro.

Of the 26 pulp and paper employers in Alberta, four are micro, 12 are small, 10 are mid-sized. There are no large firms.

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
Abundant arable land, livestock production and forested land.	Real labour productivity for non-durable manufacturing (includes food) has increased 18% since 2000.	There are more than 50 agri-food business and trade associations in Alberta.	2 venture capital deals have gone to food manufacturing since 2006.	Food manufacturing exports increased 10% from 2000. Wood product exports fell 50% and pulp/paper went down 19%.
Close proximity to the United States, Canada's strongest consumer of food and wood products.	Real labour productivity for durable manufacturing (including wood products) increased 34%.	There are 42 forest and forest products associations.	Since 2000, 62 NSERC grants went to food processing (totaling $287,000).	In food manufacturing and wood products about 90% of firms are small. In pulp, 60% are small and 40% are mid-sized.
		There have been no patents to either sub-sector in the last 10 years.	16 NSERC grants went to wood products and totaled $71,000.	

General Economic Overview

- Food manufacturing data is suppressed. Estimates for real GDP in 2007 were $2.2 billion. Real GDP in wood product manufacturing was $1 billion in 2010. Estimates of real GDP from wood pulp were $507 million in 2007.
- Average weekly earnings are growing in these sectors. From 2000 to 2010, earnings in wood product manufacturing increased 2% annually, in pulp and paper it increased 1%, and food manufacturing grew at 1%. Since 2006, earnings in food manufacturing fell by 4%.

Agriculture Sector Analysis

Real output in agriculture significantly lags behind the Alberta economy as a whole. From 2000 until 2010, real GDP for Alberta grew at an annual rate of two per cent, while real agriculture GDP only grew at an annual rate of 0.5 per cent.

Slow growth does not fully account for the degree to which agriculture has underperformed the rest of the economy. The Alberta economy as a whole has benefited from improving terms of trade, as the price of exports increases faster than the price of imports. However, agriculture has not enjoyed improving terms of trade. The Farm Product Price Index (FPPI), capturing the prices that farmers receive for the sale of their products, has declined by two per cent from 2002 to 2010, while the input costs have increased by 24 per cent over the same period[2].

The discrepancy between weekly earnings in agriculture and the provincial average is striking. Not surprisingly, employment in agriculture is declining and the average age of farm labour is increasing. In order to maintain employment, the agricultural sector will be forced to increase wages, further eroding the terms of trade.

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
Alberta represents 31% of Canada's total agricultural land.	19 patents have gone to agriculture since 2000.	Huge, fragmented number of supporting institutions.	NSERC grants an average of 37 projects (each $1.8 million) in the sector each year.	1 agriculture company, Agrium, is in the top 200 companies of Alberta in 2010.
Alberta generated 20% of the total value of national agricultural production in 2010.	Employment is declining, down 12% from 2009 to 2010.	Government gets over 1/2 the patents assigned to agriculture in Alberta.	Biofuel incentive programs are aggressively trying to encourage new uses of agriculture production.	About 80% of agricultural firms have less than 4 employees.
The United States is Alberta's largest trading partner for agriculture.	Labour productivity is improving, up 6% each year since 2000.	Universities of Lethbridge and Alberta offer strong support to the sector.	Since 2006, there were 2 venture capital investments.	20% have less than 100 employees.

General Economic Overview

- 3% of Alberta's GDP comes from agriculture ($4.8 billion). GDP is slowly improving. It was up 1% from 2005 to 2010.
- Average weekly earnings are low at $723. The provincial average is $1,063.
- The sector is vulnerable to oil and gas demand for labour.

Core Manufacturing: Non-Metallic, Primary Metal, Metal Fabrication & Construction Sector Analysis

For this report we use the phrase "core manufacturing" to describe sub-sectors that feed products directly to the core engine of Alberta but take nothing from it as inputs. Core manufacturing includes non-metallic (mostly cement), primary metal, and metal fabrication as well as construction.

These sub-sectors are diversified. They supply more than just oil and gas. But oil and gas is a big part of incubating their growth.

Core manufacturing contributes at least eight per cent of provincial GDP ($15 billion). Since 2000, 13 patents were assigned to general manufacturing in Alberta. No patents went to colleges, universities, or provincial research agencies.

Weekly average earnings have trended upwards. For workers in non-metallic manufacturing, wages rose 42 per cent from 2000 to 2010, 40 per cent for primary metal, 33 per cent for fabricated metal and 52 per cent for construction.

However, employment was down 12 per cent in non-metallic manufacturing and 25 per cent in primary metal manufacturing over the same period. In metal fabrication employment increased 11 per cent and in construction there were 81 per cent more workers. Apprenticeship increased significantly across all areas of manufacturing. The number of registered apprentices increased by 25 per cent for machinists, 128 per cent for metal workers, 32 per cent for millwrights, and 45 per cent for metal workers.

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
These sub-sectors feed directly into oil, agriculture and forestry production.	Fabricated metal and construction are adding jobs. Non-metallic mineral products and primary metal mnfg. shed jobs. The number of registered apprentices jumped significantly (between 25% and 128% across core mnfg.). 13 general mnfg. patents since 2000.	47 associations for construction and engineering, 24 metal fabrication/machinery mnfg. associations. No patents since 2000 assigned to institutions in these sub-sectors.	Since 2006, there were 3 venture capital deals in manufacturing and 1 in construction.	Among the top 200 firms in Alberta, 9 are construction companies and 7 are manufacturing firms. Exports of primary metal and fabricated metal are increasing. Non-metallic exports are decreasing.

General Economic Overview

- Total revenue from fabricated metal manufacturing was $5.1 billion in 2009. It was $2.2 billion for non-metallic manufacturing and $1.6 billion for primary metal manufacturing.
- Real GDP from construction was $14.1 billion in 2010 (it was $17.3 billion in 2008).
- All average weekly earnings are trending up and fast (up 30% from 2000).

Hybrid Manufacturing: Chemicals, Refined Petroleum & Machinery Sector Analysis

Hybrid manufacturing includes chemical, refined petroleum and coal product, and machinery manufacturing.

Together these industries comprise three per cent of GDP. Growth in GDP from 2000 to 2010 in chemical manufacturing was under one per cent annually ($2.6 billion in 2010, see Table 10) and from petroleum and coal manufacturing it fell at six per cent per year ($729 in 2010). GDP in machinery manufacturing grew by 88 per cent ($2.3 billion in 2010). Total revenue for machinery manufacturing was $5.4 billion in 2010 and half ($2.7 billion) came from oil field machinery manufacturing.

Alberta's chemical industry is built on the back of cheap ethane. This competitive position is threatened by declining conventional natural gas stocks. In 2008, Alberta demand for ethane began to surpass existing supply.

From 2000 to 2010, employment in chemical manufacturing declined by six per cent. Over the same period, employment in machinery manufacturing increased by 47 per cent. In petroleum and coal products manufacturing employment declined by nine per cent between 2000 and 2009. In 2009, employment numbers spiked up 98 per cent.

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
Alberta's position in chemicals is built on its competitively priced ethane. This position is threatened.	An average of 3 chemical and 13 general mnfg. Patents are assigned annually.	There are 16 chemical and petroleum and coal products business associations.	Since 2006 there were 8 venture capital deals in machinery mnfg. and 1 in chemical production.	Of the top 200 companies 2 are chemical companies: Dow and Nova.
Oil drives petroleum manufacturing and most of machinery mnfg..	Employment is declining in all 3 sub-sectors.	Institutions get 4 patents a year in mnfg..	Alberta's Incremental Ethane Extraction Program targets ethane shortages.	Exports are key to all 3 sub-sectors and all are growing significantly.
	National data shows declining capital intensity across 3 sub-sectors (but still high relative to U.S.)	Alberta has 12 research chairs in theoretical chemistry and 5 in chemical engineering.	NSERC is relatively active in the 3 sub sectors.	

General Economic Overview

- Real GDP from chemical manufacturing is stagnant at $2.5 billion. $729 million from petroleum and coal products generate (grew by 6% annually since 2003). Machinery manufacturing produced $2.3 billion, up 88% from 2000.
- Weekly earnings are strongest in petroleum and coal products, $1,744 (grew 62% from 2000). Chemical manufacturing showed earnings of $1,439 (grew 23%) and machinery manufacturing pays $1,265 (grew 11%).

Oil & Gas Sector Analysis

Of all oil and gas extraction companies in Canada, 78 per cent are in Alberta. The province also has 65 per cent of the oil and gas service companies operating in the country.

Wages in the sector increased by 32 per cent from 2006 to 2010. GDP figures for oil and gas are declining (falling by 3.5 per cent over the last five years and 3.8 per cent over the last ten years). Real labour productivity is also declining. It is a signal of eroding competitive strength. Since 2000, labour productivity has declined by three per cent annually (30 per cent in total).

Oil and gas is aggressive in the areas of research and development. It accounts for more than 20 per cent of all patent activity in the province (324 patents granted between 2000 and 2010). Of the 168 venture capital investments that occurred between 2006 and 2010, oil and gas attracted 54 (almost one third of the total number of investments). Of the 342 patents granted to the sector since 2010, 18 were assigned to government-supported research universities and agencies. The province has 79 research chairs in the areas of natural science and engineering (19 national chairs in engineering research, two in mining and mineral in fuel and energy technology).

Natural Environment	Capabilities	Supporting Institutions	Constructed Environment	Industrial Ecosystem
Alberta has 13% of global, proven oil reserves.	On average, 31 patents are granted to the sector each year.	Only 18 patents are registered by government agencies.	Since 2006, 1/3 of all venture capital investments went to oil and gas.	Of top 200 firms in 2010, 109 are directly related to oil and gas. Another 12 are indirectly related.
Close proximity to the U.S., the largest consumer of oil in the world.	Real labour productivity is slowly improving.	Strong representation by provincial and national business associations.	The sector attracts, on average, 107 NSERC grants annually. Average size is $6.7 million.	The ecosystem is well populated with a good mix of micro, small, medium and large size companies.
Conventional natural gas reserves are limited. Non-conventional assets in coal-bed methane and shale gas are significant.	Strong overall capital intensity includes growing investments in machinery, equipment and ICT.	Strong support from research centres (COSI, OSTRF, CONRAD, ISEEE).		Exports have increased by 55% since 2000.

General Economic Overview

- 19% of provincial GDP comes from oil and gas and related services.
- Average weekly earnings continue to increase, up 32% since 2006 and 61% since 2000.
- Real GDP from oil and gas is falling. It is down 35% from 2005 and 38% from 2000.
- Labour challenges remain a critical issue for the sector.

PART II: ALBERTA'S TRUE CORE ENGINE

Of all the sectors analyzed, oil and gas is the province's top performer. Real GDP from oil and gas extraction was $28.8 billion in 2010. Another $5 billion was generated in oil and gas services. And nineteen per cent of provincial GDP (including oil and gas services) was generated by the oil and gas sector in 2010.

The strength of the oil and gas sector was further reinforced in the responses received from the one-on-one interviews we conducted with 71 Alberta-based executives.

We asked business leaders in Alberta, Western Canada, the United States, and other countries where they would place their poker chips if they were making bets on the future of their companies and the province. Although two-thirds of these executives manage companies unrelated to oil and gas, 100 per cent answered they would bet on the energy sector.

The evidence is clear: Alberta's economic engine is oil and gas. The odds of success go up and risk and cost go down if the incubation power of the energy sector is leveraged to diversify the economy. Instead of venturing outside the core strength, diversify within and tap into the economic adjacencies in complementary sectors.

There is a view that every option other than oil and gas should be a priority. This seems counter-productive. Policy makers had hoped bioindustrials would be an alternative to oil and gas and provide Alberta a green path to prosperity.

Farmers, foresters and governments do not have the margins needed to outrun oil and gas in Alberta. Biofuels and bioplastics are left to wander among the agendas of endless conferences because they are too far from reality to be a threat. Forcing agriculture and forestry to compete with oil and gas also ignores what productive, successful, and advisable diversification would really mean.

Hardly any Alberta bioindustrial companies interviewed or reviewed online are involved in activities that complement oil and gas. Many are anxious to produce biofuels as alternatives to oil and gas. Several want to create something from fibre instead of petrochemicals. But only a few are making inputs, solving problems, and creating options that make oil and gas in Alberta better. And what is remarkable is that those few working in the oil patch are finding more business than they can handle.

Only a few companies are reaping a virtually uncontested harvest of opportunities. They provide reclamation services, clean up wastewater, design bioploymers to fix tailings ponds, gasify polluted wastestreams, and guide ecological services.

PART III: ALBERTA'S BIONIDUSTRIAL POTENTIAL

Current Bioindustrial Activities in Oil & Gas Are Sparse

Hardly any Alberta bioindustrial companies interviewed or reviewed online are involved in activities that complement oil and gas. Many are anxious to produce biofuels as alternatives to oil and gas. Several want to create something from fibre instead of petrochemicals. But only a few are making inputs, solving problems, and creating options that make oil and gas in Alberta better. And what is remarkable is that those few working in the oil patch are finding more business than they can handle.

Only a few companies are reaping a virtually uncontested harvest of opportunities. They provide reclamation services, clean up wastewater, design bioploymers to fix tailings ponds, gasify polluted wastestreams, and guide ecological services.

The Bioindustrial Big Picture

Clearly policy makers hoped bioindustrials would be an alternative to oil and gas and provide Alberta a green path to prosperity. There is a view that every option other than oil and gas should be a priority. This seems counter-productive.

If programs and policies meant to improve revenue to farmers and foresters force a battle between the fields and the oil producers, it is easy to see who will win.

Farmers, foresters and governments do not have the margins needed to outrun oil and gas in Alberta. Biofuels and bioplastics are left to wander among the agendas of endless conferences because they are too far from reality to be a threat. Forcing agriculture and forestry to compete with oil and gas also ignores what productive, successful, and advisable diversification would really mean.

Farmers and foresters in Alberta need to make money. Better to help change how oil and gas is produced than develop an alternative to the product itself.

Bioindustrials: A Collection Of Niches

In the distant future bioindustrials might be the cure for chronically thin margins in agriculture and forestry. But that is not the case today.

We found no evidence in Alberta of the high-volume, high-premium, bioindustrial options that advocates long to discover. We did find high returns and booming companies, but not enough to save everyone. We also found specialized opportunities but these go to a special few. Bioindustrials continue to be a collection of niches.

Three fundamental issues keep bioindustrials from being big business in Alberta.

- The first is volatility of feedstock supply, which is notoriously difficult to sustain.
- Second, fibre suppliers want to make premiums and fibre processors want it free or very cheap, which creates market tension.
- And finally, the only options that create the volume (to handle the first issue) and might generate high prices (to tackle the second issue) run headlong into cheap, reliable, abundant, ubiquitous petroleum-derived product standards. Most chemical and energy alternatives deal directly with this challenge.

Thus, bioindustrials will not be the salvation of agriculture and forestry any time soon. Bioindustrials will, however, make many people wealthy and could grow to become an important economic engine in the future.

ONLY A FEW WILL WIN In this report we focus on the opportunities highlighted by executives on the market-side (mostly oil and gas, chemical, manufacturing, construction, power, oil and gas services, and waste/waste management). Many of the options the supply-side (input suppliers such as agriculture, forestry, biorefining, biofuels and environmental services) are ready to provide do not match the interests of market-side

companies. In the case of biofuels, market-side executives specifically advised against further development. Market-side buyers are often skeptical of input options that depend on government programs or tipping fees for viability. For example, many of the market-side companies explicitly evaluate biofuel alternatives and turn away because the economics break on production costs and price. Only government intervention makes them work, and market-side buyers are not willing to bet on government support.

FOCUS ON MARKET-SIDE OPPORTUNITIES Because this report is about markets for bioindustrials in Alberta (and globally, where relevant), our focus moving forward will be on market-side opportunities, specifically, the highest potential options raised by executives. (The debate on supply-side opportunities will be left to the stakeholders that pursue them.) It's also important to note that large, often multinational companies represent the "market-side" of this conversation. The options they highlight sometimes represent volumes of inputs that the Alberta bioindustrial sector would not be able to meet. That said, most of the executive perspectives that are included in this analysis acknowledged the sector's limitations and tailored their positions accordingly.

Options To Diversify Bioindustrials

Based on analysis of Alberta's jurisdictional advantages and the perspectives of the executives interviewed, options to diversify bioindustrials include:

FEEDSTOCK LOGISTICS Without fail, every market-side executive with an interest in bioindustrial options raised the issue of feedstock risk and logistical challenges. It is a major barrier to getting a detailed assessment of bioindustrial opportunities. The conversation virtually stops when it is clear that feedstock can hold investments hostage.

Feedstock risk includes volatility of supply, volatility of feedstock characteristics (quality, moisture, age), and price volatility. Weather, harvesting practices, transportation options (included in logistical challenges), and alternative uses for feedstock (food, feed, lumber, pulp) make strategic investors and procurement officers nervous.

Logistical challenges impede progress too. As several feedstock providers said, biomass is wet, bulky and extremely disbursed. One of the main concerns inside the feedstock and logistical riddle is the economic hurdle it creates. Even if biomass can be transported and stored and remain economically viable, it requires tremendous volumes of cash to sustain. Without loan guarantees or novel financing arrangements, most new bioindustrial ventures cannot sustain the load. Pushing the weight to feedstock suppliers means that the volatility described above stops the market.

Forest fibre producers, such as Alberta Pacific, have introduced hybrid plant species for specific bioindustrial purposes. And crop engineering companies are doing the same in oilseeds and starting to work on cereals. Everything else in the value chain is above the feedstock. The fibre goes into primary and secondary processes and off to various industrial purposes.

Alberta has sophisticated forest and agriculture fibre producers. The main challenge, at this level, is cost-effective, timely delivery of consistent fibre quality and characteristics. There are a myriad technological issues that prohibit bioindustrial success but none are so obvious or difficult to overcome as feedstock-related challenges. Fixing this issue is the top bioindustrial opportunity in Alberta.

CARBON DIOXIDE AND GREENHOUSE GAS REDUCTION, SEQUESTRATION AND OFFSETS Power, oil, gas and chemical manufacturing are carbon-dioxide-intensive industries with large environmental footprints. Industry executives believe agriculture, forestry and bioindustrials offer part of the solution.

Verified sequestration in forests set aside and protected from harvesting, reforestation, afforestation of agricultural land, and improved biochar is being considered by the UNFCC for

inclusion in UN Certified Emission Reductions and Clean Development Mechanism. Biochar has potential to sequester carbon, enhance biofuel production and improve soil health.

Unfortunately, much of this opportunity depends on government regulation. Companies want to know how they will be measured, held accountable and made responsible to achieve environmental benchmarks. They need governments to define emissions markets before they will engage biomass-related options. The federal government's recent retreat from the Kyoto Protocol further undermines this option.

Alberta is the only jurisdiction in North America with legislated requirements for greenhouse gas emission reductions[3]. Regulated firms can buy verified emission reduction and/or removals of greenhouse gas from voluntary actions. The Specified Gas Emitters Regulation requires Alberta facilities that emit more than 100,000 tonnes of greenhouse gas a year to reduce emissions intensity by 12 per cent.

Alberta's Emissions Offset Registry shows 90 registered projects credited with reductions of 15.6 million tonnes of the carbon dioxide equivalent of greenhouse gas[4]. Only a portion of these reductions is available as credits. This means that giant greenhouse gas emitters such as power producers, oil sands producers and chemical manufacturers have few market options, beside internal reductions, to offset emissions by 12 per cent.

Since 2007, the selling price of agricultural offsets rose slightly and ranges from $10 to $14 per tonne of carbon offsets for compliance increased from 18 per cent in 2007 to 30 per cent in 2010. Agricultural offsets represent 37 per cent of total offsets created. They have been used to meet a total of 5.1 million tonnes of reductions since 2007, representing 20 per cent of actual emission reductions. This has generated close to $61 million of income for agriculture in Alberta. Without protocols, the options in forestry are not advancing.

The market-side of this option is keenly interested in offsets. Their major concerns are sufficiency of supply (demand dwarfs current supply) and validation. Every thing in this opportunity depends on federal and provincial law (which is distinctly different from government support). But no one is prepared to offer viable opportunities in this space.

CLEAN COAL WITH BIOMASS: COAL BENEFICIATION, PYROLYSIS, TORREFACTION AND CO-FIRING Power production in Alberta is a tough business. Even though the sector is deregulated, the structure of deregulation continues to dominate the market. Several key power generation companies, bound by legacy power purchase agreements, see few alternative futures beyond greater efficiency and further investment in power generated from aging infrastructure.

A culture of conservative technology investment and aggressive operational efficiency leaves little room for innovation. Until recently, bioindustrial options received, at best, reserved interest from Alberta-based power generators. Today the context of power generation is much more fluid. Federal regulations put significant pressure on power producers that depend on coal.

Price is a big issue. The value of alternative uses, handling and transportation costs, and pre-processing costs combine make it difficult to compete with coal or natural gas. The major incentives to use biomass come from regulations which will eventually grow as fossil fuel reserves are depleted.

Of the five diversification options presented here, none are more vulnerable to feedstock risk than this one. It would require significant and sustained effort to achieve the volumes of biomass necessary to positively impact the emissions that power utilities are on the hook to control. Even if emissions are not the driver, the amount of biomass needed to produce any significant amount of power outstrips any Alberta supplier's ability to provide it[5].

At the root, power companies seem to doubt that regulations will have enough force to actually drive sweeping change in their business. They are talking about new technologies but not really embracing them. They might believe that the public and private

companies, dependent on cheap power, will rise up in their defense. This makes sense. Wise investors are always wary of government-generated markets. Until the force of government is unquestionable, no incentive will be enough to push the right set of partners together to make large, biomass-based power generation within power utilities a reality.

Without incentives it is too difficult to build partnerships, given the recipe of players. The appetite for risk on all sides is small. Forestry companies, the main sources of fibre in this case, are conservative. Power utilities are too. The gulf between them requires a willingness to accept risks that neither side has. The challenge of getting biomass into co-generation facilities in oil and gas companies is much lower. Most oil sands companies already operate as "energy companies," generating their own power and heat. They're pinched hard on emissions and other environmental issues and are investing in alternatives.

BIOPOLYMERS AND GREEN FLUIDS Biopolymers are naturally derived polymers. They initially attracted attention for use in bioplastics. Cellulose, oilseed protein, and starch are seen as potential replacements for plastics based on petrochemicals.

Biopolymers could also be important inputs in industrial wastewater treatments. Work to find non-toxic, renewable flocculents for treating tailings ponds gets attention from oil sand companies.

Some types of biopolymers are an important category of foulants that prevent pre-treatment and treatment of organic waste streams such as sewage and industrial process water. Biopolymers plug filter membranes. Finding ways to clean membranes or create membranes that withstand fouling is important.

Fracing gets a lot of attention these days for its environmental impacts. As conventional natural gas reserves decline the industry is under pressure to produce in unconventional ways. Unconventional gas is a critical energy source and industrial input (made even more important by current legislation against coal-based power generation). Fracing of shale gas, coalbed methane and tight sandstones are the main unconventional plays. Highly pressurized fracing fluid is injected to open and extend fractures that release locked gas. The fluids carry proppant (suspended particles) that hold the fractures open. Sometimes the fluid and proppants get into ground water but disposal of the fluids is also a concern. Replacing toxic components of fracing fluids with bio-alternatives is an important step in relieving pressure on unconventional gas production.

Hydraulic fluids are essential in most modern industrial processes. The fluids transfer power, lubricate, transfer heat, and must be compatible with the gaskets, seals and metal components they interact with. Today most hydraulic fluids are petroleum-based. Like fracing fluids, when hydraulic fluids get into the environment they are toxic. Hydraulic fluid leaks are common and little is done to clean up spills. Using a fluid that is non-toxic and biodegradable would eliminate this concern.

Cutting fluids are used to lubricate cutting tools and reduce heat. They are used in metalworking and machining. Mineral-based, semi-synthetic and synthetic options are available and the type depends on the sort of cutting being done. Key issues with these fluids are toxicity (sometimes causing respiratory issues), bacterial growth, toxic biocides needed to control bacteria, and toxic corrosion inhibitors (since fluids are often water-based). Management (replacement and disposal) of these fluids requires regular labour and machine downtime.

Fluid and wastewater management is a fast growing business. Processed water from oil, gas and chemical production and wastewater/fluid from drilling operations must be properly handled and disposed. Replacing conventional cutting fluids with bio-based alternatives can reduce toxicity, downtime and input costs.

LAND REMEDIATION AND ABANDONMENT SERVICES Whenever new pipelines are run, wells are drilled, and oil sands operations are developed, the province requires a range of baseline soil surveys, soil and vegetation monitoring programs,

environmental impact assessments, and reclamation planning. In an effort to protect biodiversity and ecosystem services, companies are obligated to preserve fragile environments and prepare ahead of time for the eventual work of return the land to its natural state. Included in the mix is a dynamic relationship between resource developers, other users of the same land, and land owners. Tracking biodiversity runs from the micro-organisms in the soil up through to the trees, animals and water on the surface. Agriculture and forestry play a role in preserving biodiversity.

Agriculture and forestry can be a source of biodiversity offsets for other resource producers. Where land disturbance is unavoidable, the developing provincial land use framework may make room for trading a disturbance in one area for returning land to its natural state in another[6]. Forestland management practices often overlap with oil and gas and mining activities, where the forest developer plays a direct role in managing the disturbance of the other industrial players.

Bioremediation and bioreplenishment are applications that bring waste streams from agriculture and forestry as inputs to manage development disturbances. Specialized equipment and pelletized biomaterials are used to inject material beneath the soil surface to enhance soil recovery. Other land management practices from agriculture, like tillage practices, work well in remediation and reclamation of disturbed sites. Techniques to grow and plant native plant species on remediated sites were first developed for deforested lands. Replanting of native species is a key activity in land remediation.

Spill recovery, whether it is dealing with oil spills, fracing hydraulic fluids, or other forms of waste, can sometimes be dealt with through biological methods. Some options exist to use waste wood products, agriculture fibres and even fibre mat to absorb spills. Companies are also interested in bacteria or other micro-organisms that naturally or, through synthetic genomics, artificially degrade spilled substances.

Abandonment services are related to land remediation but differ dramatically in scale. Where land remediation is meant to tackle roads and isolated spills, abandonment services are intended to address the huge cost and liability of abandoned mines, oil wells, and decommissioned lumber mills. Abandoned lands have negative impacts on soil, water, plants and animals. Companies concerned about liability for these impacts are acutely interested in remedial options. Some companies believe the cost of decommissioning will often be greater than the total cost of development. The business opportunity for bioindustrial solutions in this space is immense.

PART IV: CHALLENGES IN CAPTURING MARKETS

Some themes rose to the top in our analysis, interviews, and the synthesis presented above. These themes include:

MEET STANDARDS AND CERTIFICATION Some of the companies (especially waste/water treatment and environmental services) struggle to meet the quality and safety requirements of the large companies that own these opportunities. Several large companies told us that they simply cannot work with the service providers of choice because the service company cannot meet quality and safety thresholds. Rigorous quality assurance and well-documented health and safety practices are a prerequisite.

PARTNER WITH MID-SIZE COMPANIES AND EPCS From our perspective the most important result of this work is the clarity it offers on the importance of mid-size companies. Focusing on start-ups and new technology development is not enough. Only mid-size companies have the credibility, mobility, and stability needed to bring bioindustrials into oil and gas, power, chemicals and other sub-sectors of manufacturing.

TARGET MANUFACTURING In oil and gas, the production companies hold the cards. In electricity it is the manufacturers of power generation components. In chemicals, it is the markets that define everything. In spite of their differences, all three of these sectors deeply depend on the manufacturers and service companies that support them. The oil and gas, power and chemical sectors are too big for Alberta's existing bioindustrial ecosystem to handle, but the manufacturers and companies that serve these industries are just the right size. This does not mean that manufacturing is the market. It is the window. The market must always be the engine of Alberta's economy.

PROVIDE PERFORMANCE GUARANTEES Everyone wants guarantees. When a big company says it is interested in a pilot project, it usually means a project that includes guarantees. These players will not risk optimized, high-volume processes. The need for guarantees drives the push for mid-size partners (as above) and a need for industrial-scale testing facilities. Operations like CANMET offer bioindustrial options a chance to reach levels of sophistication where guarantees are an option. The same is needed for power generation and chemical manufacturing.

SOLVE PROBLEMS Bioindustrials in Alberta should solve problems, not produce alternatives. Drop-in substitutes sound nice but only matter if there is a problem with whatever they replace. The challenge, when substituting bioindustrials for petrochemicals, is that petrochemicals are cheap, abundant, ubiquitous and work well. Better to start with jobs that petrochemicals cannot do well than go head-to-head. The options targeted in the priority list presented earlier in Part II are about fixing big problems in big companies.

FOCUS ON PERIPHERY PROCESSES Large companies are reluctant to interfere with proven operating processes. But many are open to environmental wins and waste management options. In this report we deliberately target options outside the established processes of large companies and pick at the periphery. For opportunities close to established processes (like coal beneficiation or fracing), we highlight opportunities inside the environmental issues the sectors are forced to tackle. Without extremely powerful incentives, getting bioindustrials into established operating processes will be very hard. This does not mean that process-related bioindustrial options for oil, gas, power, and chemicals should be avoided. But any option provider should expect (and be ready to pay for) a long, steep climb.

ENDNOTES

[1] National Forest Database. Government of Canada. http://www.nfdp.ccfm.org/compendium/data/2003/tables/com12e.htm Site accessed: December, 2011.

[2] Statistics Canada. Table 328-0015 - Farm input price index, quarterly (index, 2002=100), CANSIM (database).

[3] Agriculture and Rural Development. Government of Alberta. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl13212 Website accessed: December 2011.

[4] Carbon Offset Solutions. Alberta Emissions Offset Registry. http://carbonoffsetsolutions.climatechangecentral.com/offset-registry Website accessed: December 2011.

[5] Electrabel, a power generation company in the Netherlands, uses 470,000 tonnes of wood pellets to replace one quarter of the coal burnt annually in a 590MW facility. Source: Electrabel, http://www.electrabel.com/newsroom/pressreleases_new.aspx?id=1406911 Website accessed: December 2011.

[6] The is already practiced in wetlands and artificial wetlands construction. In parts of Canada and the United States, land developers that disturb wetlands are obligated to rebuild or create wetlands to replace them.

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