

Alberta's Systemic Competitiveness

ANALYZING THE IMPACT ON VALUE CHAINS AND RELATED BIOINDUSTRIAL OPTIONS

I. TECTONIC ECONOMICS

Imagine Alberta's economy as a topographical map. Peaks rise up in oil, finance, and construction. Among them run the valleys of agriculture and forestry. Standing within this landscape, you see the rise and fall of niche opportunities and global markets.

Look below the surface to see the rising strength of key provincial companies. Huge energy players push up the peaks. Struggling forestry companies fight for survival. Industry associations and research agencies quietly build, adding strength and reinforcing companies.

Look up. A cloud of government regulations. Pressing down on the peaks are environmental concerns and aging infrastructure. Biofuel incentives tug up on agriculture and forestry. Labour constraints lie, like a heavy blanket, across the economy.

Step back to see the mix of layers. Peaks are muted. Valleys level out.

Comprehending the mix of micro and macro dynamics that define Alberta's economic landscape is a complex, complicated, and wicked¹ challenge.

This report builds on a 2012 analysis of Alberta's Jurisdictional Advantages. Like a Myers-Briggs assessment of places, the 2012 Jurisdictional Advantage Assessment defined the unique character of Alberta. It highlighted the strengths of the province (specifically in energy) that Alberta can leverage to reduce risk, increase the odds of success, and build upon for sustainable economic advantage.

¹ Rittel and Webber (1973) use "wicked" to describe the malignant, vicious, tricky (like a leprechaun), and aggressive problems of policy planning.

The Jurisdictional Advantage Assessment is both a landscape analysis and a measure of firm-level tectonics.² It provides a picture of the province's economy. It also shows how the capabilities of firms and their industrial ecosystem push and pull on market dynamics.

This project aims to flesh out the map sketched in the Jurisdictional Advantage Assessment. Here we dig into Alberta's system of policies, programs, and infrastructure. The competitiveness of this system defines Alberta's options in pursuing its strengths. We also dive deeper into the value chains of oil and gas, chemicals, and manufacturing. These chains offer a range of opportunities for bioindustrial producers. Combined, the Jurisdictional Advantage Assessment, Systemic Competitiveness Analysis, and Value Chains Assessment present robust picture of Alberta's best bioindustrial options and government's role.

II. MAPS ARE NICE, BUT WHY DOES THIS MATTER?

A quick glance at any newspaper will tell you that Alberta has lost its footing in the current economy. Surprised by falling energy prices, cut off from markets other than the US, and selling its energy at a discount—the province is shifting quickly.

Leaders need to decide which options to pick. This project provides clear evidence on some of the province's alternatives.

Prior to this project, it was clear that Alberta had only limited evidence describing its systemic position and competitive strengths. Through analysis and interviews, this work revealed fundamental gaps in the data available to decision-makers. At the very least, this project emphasizes how critical that data is in helping leaders move from guessing to actual decision-making.

² *Tectonicus*, in Latin, means “building.” In geology, tectonics are the forces or conditions within the earth that cause movements of the crust.

At a more tactical level, Alberta has already scaled back its investments in innovation. The dollars that remain need to be placed carefully. In providing clear evidence on the systemic competitiveness of the province and revealing driving forces in Alberta's key value chains, this work offers key inputs for picking research and innovation targets (in bioindustrials or any other area).

This work augments the good analysis already done by Alberta's Competitiveness Council³ and the Government of Alberta.⁴

We benefit from related work in Ireland,⁵ the United States,⁶ and the European Union.⁷ We also leverage analysis by McKinsey Global Institute⁸ and Booz & Company.⁹

Recent work by McKinsey and Booz & Company, along with past work by Michael Porter,¹⁰ highlights the importance of clear evidence when designing systems of infrastructure, policies, and programs. Macroeconomic scorecards are not enough. Nuanced, specific data on each sector is needed.

In 2010, we began to argue that analyzing competitiveness at a sector level reveals insights missed by high-level economic indicators.¹¹

³ Alberta Competitiveness Council. *Report on Competitiveness*. April 2010.

⁴ Government of Alberta. *Energizing Investment: A Framework to Improve Alberta's Natural Gas and Conventional Oil Competitiveness*. March 2010.

⁵ Forfas. *Ireland's Competitiveness Scorecard*. 2012.

⁶ US Manufacturing Competitiveness Initiative. *Make: An American Manufacturing Movement*. Council on Competitiveness, December 2011.

⁷ M O'Mahony and B. van Ark. "EU Productivity and Competitiveness: An Industry Perspective." *European Communities*. 2003.

⁸ J. Manyika et al. *How to Compete and Grow: A Sector Guide to Policy*. McKinsey Global Institute, March 2010.

R. Dobbs et al. *Resource Revolution: Meeting the World's Energy, Materials, Food and Water Needs*. McKinsey Global Institute, November 2011.

C. Roxburgh et al. *Trading Myths: Addressing Misconceptions about Trade, Jobs, and Competitiveness*. McKinsey Global Institute, May 2012.

⁹ A. Kaushal, T. Mayor and P. Riedl. "Manufacturing's Wake-Up Call." *Strategy and Business* 64 (2011).

¹⁰ M. Porter. "The Competitive Advantage of Nations." *Harvard Business Review* (1990): March-April.

III. FOR IMPATIENT EXECUTIVES

Isn't it tempting to start with dessert? For the sweet tooth and those in a hurry, let's take a quick taste of this project's results.

The big story in Alberta is the shift from conventional to unconventional oil and gas. Of particular importance are US discoveries of tight gas and sweet, light oil. The evolution of unconventional technologies and newly available resources create major turbulence among Alberta's future options.

Unconventional oil and gas require new chemicals and drilling fluids at high volumes. This is an opportunity for new bioindustrial products. It is particularly attractive because bioindustrials are already being used. The window is open.

At a systemic level, these changes put tremendous pressure on Alberta's policies, programs, and infrastructure. Infrastructure gaps (pipelines and roads) are eroding the province's market options and competitive position. Bioindustrial players should work hard to ensure their needs are also met when new infrastructure investments are made.

In the face of these challenges, the government will be tempted to step back from energy and "diversify" into other sectors of the economy. This is a mistake. Energy-related opportunities are Alberta's only realistic options for mitigating its current fiscal constraints. The other key drivers of the economy (finance, construction, and manufacturing) are heavily integrated with energy. Agriculture and forestry are too small and simply have not got the economic power to make up for current gaps.

With this in mind, bioindustrial players need to lean in. They need to leverage agriculture and forestry to meet the environmental, productivity, and operational needs of energy. And they shouldn't get distracted by the sudden interest in primary production.

¹¹ McKinsey argues the same: "Many governments worry about the 'economic mix'—and assume that if they achieve the 'right' mix, higher competitiveness and growth will follow; our analysis finds that solving for mix is not sufficient."

In this analysis and in the Jurisdictional Advantage Assessment, we present clear evidence that supports diversification through Alberta's core strength in oil and gas. The intent is to spill success in energy into success in other sectors. Just as finance, construction, and manufacturing leverage close integration with energy to compete in other sectors globally, agriculture and forestry should do the same.

Double down on energy. Leverage this core engine to drive opportunities in agriculture and forestry. Get biochemical options for energy from agriculture. Seek solutions to energy's environmental challenges in forestry. Invest in efficient production of bioindustrials to effectively support energy production. Leverage Alberta's competitive position in energy to continue driving its global opportunities in finance, construction, and manufacturing.

If Alberta goes the route of building agriculture and forestry through energy, it needs to revise its position on several key issues.

- Alberta's *Land-use Framework* is the province's best tool for integrating industrial activity, infrastructure, conservation, and environmental benefits. It is an opportunity to create a real market for ecological services—a market that integrates energy, forestry and agriculture.
- The province's Forest Management Agreements prevent forestry companies from capturing several key biomass-related opportunities that depend on high volumes of fibre supply.
- Infrastructure investments are needed. Just as the province supports pipelines, it needs to support forestry-related infrastructure (roads, rails, and fibre storage) if it wants integration within its key resource sectors.
- The biochemical industry in the US is already mature and easily outruns Alberta's producers. Any market an Alberta producer creates, the US companies quickly take away. If the province wants to invest in anything, fortify Alberta's existing biochemical producers. Most needed are investments, within companies, that drive new product development.
- It must be crystal clear, for all decision-makers, that outside of legislative constraints and infrastructure gaps, there are no

major interventions that can transform agriculture and forestry into economic engines or deeply integrated enablers. The solution has got to be a highly tailored, specifically targeted set of programs while recognizing that, in each case, only a few companies will benefit. Not everyone can win this game right now. But wins are needed to climb out of the province's current position.

- Finally, the province needs to discipline its programs to focus on the needs of mid-size companies. Too much programming and government investment goes to start-ups that are too small and too vulnerable to create real change among large players. Too much of the government's policy attention goes to companies that are too large and too risk adverse to adopt practices that integrate the resource sectors. Mid-size companies can make the difference the province seeks.

IV. PLACES COMPETE

In the last 2.5 years, Sift Every Thing interviewed 467 executives about their corporate priorities, key barriers, and future opportunities. Keystone companies in Western Canada say they are sensitive to the systemic competitiveness of regions. It's the top driver in investment decisions.

For this project, we interviewed 43 companies¹² and 12 government executives.¹³ As a group, these executives clearly see the critical importance of competitive access to resources and inputs, regulations, infrastructure, taxes, and incentives. But companies

¹² We interviewed executives from Agrium, Carbon Capture and Environmental Management Corporation, Cessco Fabrication and Engineering, CNRL, McCoy Corporation, Mircan Resources, Nova Chemicals, Shell Chemicals, and Williams.

¹³ We interviewed executives from AI Energy and Environmental Solutions, AI Technology Futures, Enterprise and Advanced Education, Environment, Executive Council, International and Inter-governmental Relations, Transportation, and Treasury Board and Finance.

find it difficult to translate the tangible impact of government activities in these areas. And government struggles to model and benchmark the dynamics it manages.

A. Alberta Embraces Its Strengths

Alberta's strength is energy. Oil and gas pushes the province forward. Finance, construction, and manufacturing mirror energy trends.

Real gross domestic product (GDP) per citizen is very high.¹⁴ It rose three per cent, from \$177 billion in 2009 to \$183 billion¹⁵ in 2010.¹⁶ That's \$47,000 per capita.

Big investments in energy produce huge returns for the small population (3.9M) of Alberta. As a result, income levels are high. In 2010, personal disposable income was over \$37,000.¹⁷ The Canadian average was \$29,700.

High incomes tend to drive inflation. Measured by the consumer price index, inflation was up 2.6 per cent in Alberta in 2010. Across Canada, it was 2.1 per cent.

¹⁴ In 2011, Statistics Canada moved from basing its GDP estimates on 2002 data to 2007. To preserve integration with other data here and other reports for the province, we stayed with the earlier data.

¹⁵ Statistics Canada. *Table 384-0038 - Gross Domestic Product, Expenditure-Based, Provincial and Territorial Annual (Dollars x 1,000,000)*. CANSIM [database].

¹⁶ Statistics Canada. *Table 384-0002 - Gross Domestic Product (GDP), Expenditure-Based, Provincial Economic Accounts, Annual (Dollars x 1,000,000)*. CANSIM [database].

¹⁷ In nominal terms.

But high incomes reflect labour shortages. Unemployment, in 2011, was 5.5 per cent (nationally it was 7.4%). Like labour, other inputs are also scarce. Production costs are rising. From 2011 to 2012, the industrial construction costs jumped 22 per cent¹⁸ (4% higher than the Canadian average).

So it's clear that, while desirable, a hot economy has some important consequences. Scarce inputs rise in cost but also become production bottlenecks.

In Alberta, productivity takes a big hit. In 2011, the average worker generated \$48.10 per hour.¹⁹ The weighted Canadian average was \$42.30. This looks impressive, but a closer look at growth shows the pressure of input shortages. Alberta had the lowest productivity growth²⁰ of all provinces. The growth rate of Canadian labour productivity was 0.88 per cent. In Saskatchewan, it was 1.4 per cent. In Alberta, it was 0.29. In oil and gas specifically, it was negative 3.8 per cent. In construction, it was negative 1.6 per cent.

1. Innovation

Investing in innovation helps reduce the impact of price escalation. When innovation enhances efficiency, it reduces the need for inputs. When innovation creates high-value products, it improves margins.

In our analysis, relative patent data, corporate research and development expenditure, and productivity-improving investments are a proxy for innovation.

¹⁸ Seasonally adjusted, fourth-quarter comparison. Statistics Canada. *Table 026-0016 - Investment in Non-residential Building Construction, by Type of Building, Province and Census Metropolitan Area (CMA), Quarterly (Dollars)*. CANSIM [database].

¹⁹ Value of output per hour, in chained 2002 dollars.

²⁰ Compound annual growth rate (CAGR) is the year-over-year growth rate.

Alberta averages about half a patent per 10,000 people. In Canada, the average is 1.3. The US averages 3.3, Finland 1.7, and Australia and Norway 0.6 each.²¹

Using patent data as an innovation indicator is always specious and readily discounted. Still, the oil and gas sector is beginning to patent aggressively, which suggests it remains a relevant indicator. But Alberta's general lag in this area signals vulnerability.

In productivity-improving investments, Alberta does well. Alberta leads other provinces in total asset investments and in telecommunications equipment. But none of the provinces show much in the way of productivity improvement.

Across the economy, the strongest areas of technology adoption are computerized engineering and design (with 24% of companies indicating use), communication technologies (23%), and processing/fabrication technologies (18%).²²

Oil and gas is above the provincial average in several areas. Computer design and engineering (37%), integrated and control technologies (12%), and automated material handling (8.0%) are all above average. The sector lags in biotechnologies (less than 1%), green technologies (8.0%), and nanotechnologies (less than 1%).

Chemical producers and manufacturing companies are relatively strong adopters. Chemical companies in particular see the value of biotechnologies (4.0%), green technologies (12%), and nanotechnologies (3.0%).²³

²¹ Of course, not all companies choose to register patents in the US, but it is common practice.

²² Statistics Canada Survey of Innovation and Business Strategies (2009).

²³ Highlighting the sectors relevant to bioindustrial producers.

Bottom line for bioindustrial options

- The door is swinging open for biotechnologies and green technologies in the energy and chemical sectors.
- To offset labour shortages and high wages, bioindustrial innovators should pay careful attention to automation options. For the same reasons, bioindustrial inputs related to automation or labour efficiency (hydraulic fluids, longer-lasting inputs, etc.) are attractive.
- Looking at the low levels of Alberta's innovation-oriented investments should encourage local bioindustrial companies to look outside the province for markets. Alberta's energy industry can incubate many new products, but the strongest markets might be in other places.

2. Fiscal Policy

Alberta's 2011–2012 budget estimated a deficit of \$1.3 billion. It came in around \$4 billion. The government had expected to return to surplus by 2013–14. The 2013–14 budget forecasts a \$2-billion deficit, and the government will borrow \$4.3 billion for capital projects.

Saskatchewan anticipates a pre-transfer surplus of \$9 million,²⁴ British Columbia predicts a \$1-billion deficit,²⁵ and Ontario anticipates a deficit of \$12 billion.²⁶

Federal fiscal policy is also important. A portion of federal liabilities fall to Alberta. The 2012 federal budget estimated its deficit at 1.4 per cent of GDP, increasing total debt to 34 per cent with debt service charges consuming 13 per cent of total revenue.

²⁴ Government of Saskatchewan. *Saskatchewan Remains on Track for Balanced Budget* [news release]. February 2013.

²⁵ Government of British Columbia. *Balanced Budget 2013*. February 2013. www.bcbudget.gov.bc.ca.

²⁶ Government of Ontario. *Ontario Finances*. December 2012. www.fin.gov.on.ca/en/budget/finances/2012/ofin12_3.html.

Updates confirm the federal government is poised to run a \$26-billion deficit²⁷ this year. Still, the 2013 federal budget projects a balanced budget by 2015.²⁸

Bottom line for bioindustrial options

- Budget gaps will drive government interest in agriculture and forestry. Bioindustrial producers need to maintain focus on energy.
- Fiscal constraints will limit government spending in bioindustrial-related areas. Bioindustrial networks, greater integration of bioindustrial research with companies, and low-cost brokerage services are valuable mechanisms that cost relatively little.
- Fiscal instability and massive infrastructure investments mix poorly. Most of Alberta's best bioindustrial options also need infrastructure support. The larger opportunities might get sidelined by niche options that need lower provincial investment.

3. Taxes and Cost of Doing Business

Alberta's resource wealth permits a low-tax environment. In 2010, Alberta had the lowest effective marginal tax rate on capital investment, at 20 per cent. British Columbia was slightly higher, Saskatchewan was at 27 per cent, and Ontario was just over 21 per cent.

Alberta also ranked well internationally. The US runs at 27 per cent, Australia 26 per cent, Norway 24 per cent, and Finland 20 per cent.

The KPMG 2012 *Competitive Alternatives* report gives good data on the relative cost of doing business in Alberta. It indexes cities according to total business costs (including location-sensitive salaries, transportation costs, utilities, etc.).

Business costs rank very high on the list of executive concerns.

²⁷ TD Economics. *Lower Economic Growth Assumptions Bleed into the Federal Fiscal Plan*. November 2012.

²⁸ Government of Canada. Budget 2013.

Compared to other major cities in Canada, companies in Calgary, Vancouver, and Edmonton have the highest operating costs.

- Calgary is number two on the list for labour costs.
- Edmonton leads on electricity costs; Calgary is second.
- Calgary ranks highest for property-based taxes.
- Edmonton has the second-highest effective income tax rate.

On the upside, Edmonton and Calgary were the low-cost jurisdictions for natural gas.

Bottom line for bioindustrial options

- Alberta can continue attracting international technology companies pressed by rising taxes.
- Bioindustrial options that reduce construction costs, increase efficiency of construction, and reduce construction-related labour are worth pursuing. Biocomposites, insulating materials, advanced coatings, and similar options will get attention if they can also deliver on these key drivers.

4. Infrastructure

Infrastructure is an area where companies want to see government engage. From 2000 to 2010, Alberta spent an average of 2.8 per cent of GDP on fixed capital formation.²⁹ Canada averages 3.0 percent. Alberta's spending reached a peak of 4.6 per cent in 2010.

²⁹ Capital formation is a concept used in macroeconomics, national accounts, and financial economics. It refers to a measure of the net additions to the physical capital stock of an economic sector in an accounting interval, or a measure of the amount by which the total physical capital stock increased during an accounting period. To arrive at this measure, standard valuation principles are used.

In 2007, Statistics Canada estimated the average age of various pieces of infrastructure. Alberta's infrastructure was estimated to be newer than the Canadian average for all categories of infrastructure except highways and roads.

Government executives tell us that the average age of Alberta's highways is 50 years. The roads need replacing.

Bottom line for bioindustrial options

- Infrastructure needs are deep, and available funds are limited, so bioindustrial producers need to work hard at leveraging the scarce resources available. They should work with energy to meet the sector's needs and leverage its interest to capture infrastructure investment.

B. Implications for Alberta's Systemic Competitiveness

We presented a barrage of economic indicators above. What does it all mean for the province's competitive context?

Income indicators for the province are strong. Only volatile and rising inflation suggests some reason for concern. At a sector level, the inflation issues show up as expensive labour that bottlenecks growth. Construction costs are rising, making further investment difficult.

The productivity data is concerning. Labour productivity is high (relative to other provinces), but this is expected. Alberta's resources require heavy capital investments, which jet up the productivity of labour. But labour productivity is not growing in Alberta as it is in other jurisdictions. Its competitive position is being eaten up.

The innovation data highlights the province's vulnerability to competitive innovation investments in other jurisdictions. All the indicators for Alberta are low.

Fiscal policy seemed strong several months ago. Today, with volatile prices in oil and gas, it is not quite as robust. With global instability rising, Alberta is in an uncomfortable position.

Human capital is vital to Alberta, and the province's related investments lag those of other jurisdictions. Given Alberta's dependence on labour, investing in human capital appears to be a rich opportunity to shore up a critical component of competitiveness.

The infrastructure data highlights the province's need to make major upgrades. Indeed, the government is taking itself into significant debt to finance the investment. At a time of fiscal insecurity, this creates risk. Clearly the government recognizes that it has option but to upgrade.

The cost of doing business in Alberta is extremely high, relative to other provinces. This cost is mostly driven by high wages and costly real estate.

V. ANALYZING SECTORAL VALUE CHAINS

We already mentioned McKinsey's advice that competitiveness assessments focus on sectors within regions (not the regions themselves). This is broadly aligned with our interviews and other research.

Initially we anticipated having separate systemic competitiveness and value chain analysis. Our research and interviews encourage us to put the two together.

This project digs deeply into oil and gas, chemical production, and manufacturing, for two reasons. First, the Jurisdictional Advantage Assessment of early 2012 highlighted these sectors as engines and enablers of the economy. Second, executives suggested that they were the best targets for bioindustrial opportunities. A value chain analysis helps target specific opportunities.

A. Unconventional Oil and Gas

Alberta's big story is the lightning leap to unconventional oil and gas. It's a tremendous change with mind-boggling implications. And the shift is just getting going.

The new millennium marked a turning point for oil sands development. From 1980 to 1986, Alberta production of synthetic crude and bitumen doubled, growing from eight million cubic metres to 16 million. It took 13 years to double again, reaching 33 million cubic metres in 1999. In the 20 years between 1980 and 1999, output increased by 1.4 million cubic metres a year.

Seneca said luck is what happens when preparation meets opportunity. In 2000, Alberta got lucky. Building on its growth record, the province was perfectly positioned when the price of West Texas Intermediate (WTI), for the first time in modern history, averaged above \$30 per barrel at Cushing, Oklahoma³⁰ (see Exhibit 1). From 2000 to 2010, output accelerated dramatically to 4.8 million cubic metres per year.

1. Shift to Unconventional Oil

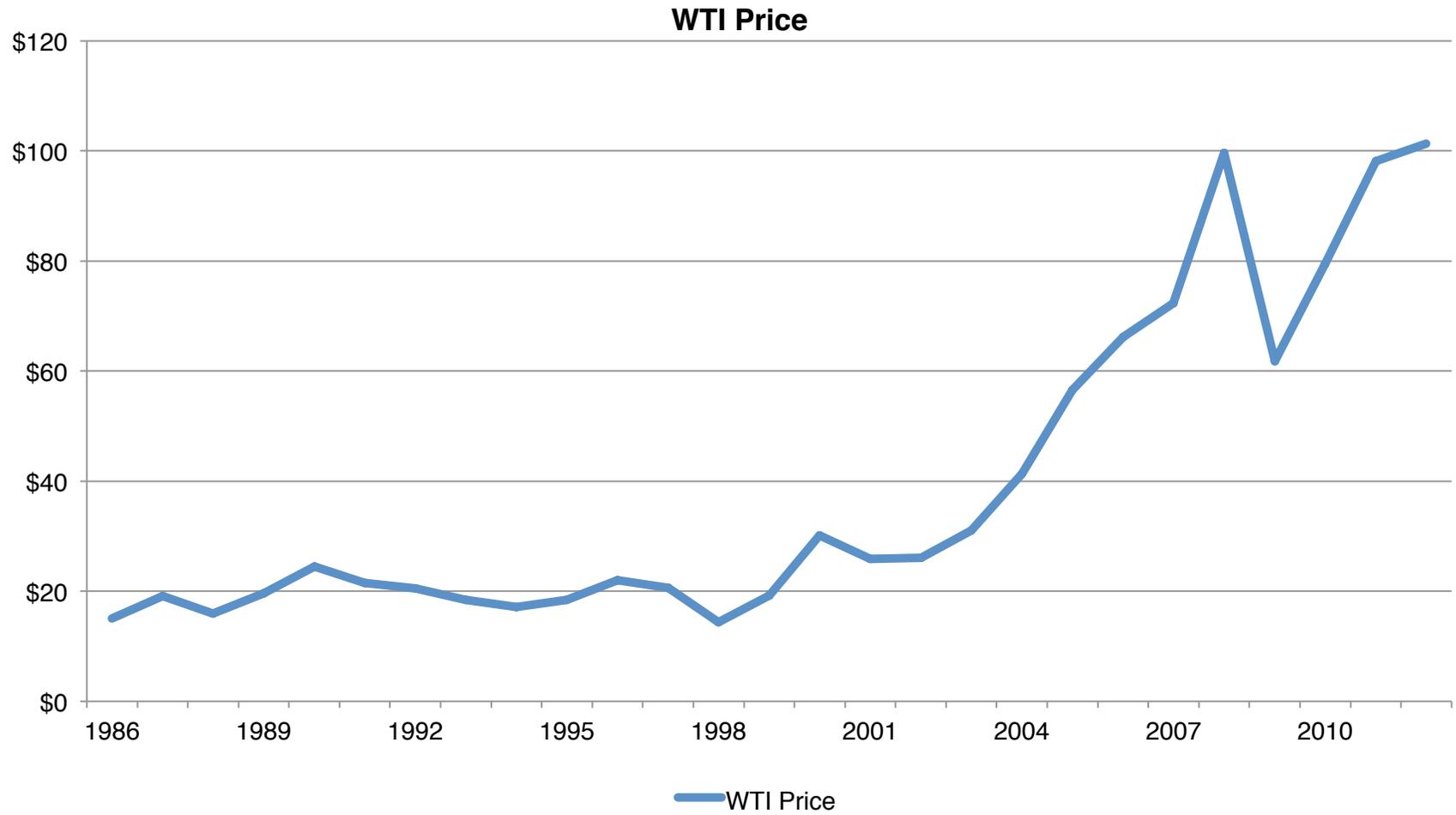
In spite of the dramatic growth described above, conventional oil production peaked in 1973 at 83 million cubic metres. Since 1995, the negative trend in conventional production has become considerably more pronounced. There is little unused capacity to respond to price movements (production kept declining through 2000–10 despite increases in price).

Unconventional oil sands production more than made up for the decline. In 1973, oil sands production was 19 million barrels. By 2010, production hit 533 million barrels, overwhelming the 355-million-barrel decline in conventional oil.

Unconventional oil from Alberta is heavy. Light oil, usually low in sulphur and more easily converted into high-value petroleum products, commands a substantially higher price. Trouble is, US light sweet crude production is growing dramatically and threatens to overwhelm US refiners.

³⁰ Canadian Association of Petroleum Producers. Tables 05-05A, B, C, D, E, F, and G. *Statistical Handbook*.

Exhibit 1: WTI price per barrel



Canada already refines US light oil. There is talk of sending it to Mexico too. But a glut of light oil, if sustained, will have important implications for future oil prices.

Suncor appears to be leading Alberta's response to this change, cancelling its \$11.6-billion Voyageur project and citing a downward narrowing of the price gap between heavy and light oil.

Bottom line for bioindustrial options

- Enhanced oil recovery (oil sands, tight oil, but more importantly recovery in conventional wells) is seen, by executives, as the transformative force in oil production. The chemical and mechanical means of stimulation are evolving rapidly. Corporate research and development is heavily focused in this area. Until processes get locked in, bioindustrial-based options are eligible.

2. Shift to Unconventional Gas

Peak natural gas seems like a silly topic these days. Supply overflows. Prices are ridiculously low.

Yet natural gas production in Alberta peaked in 2000 at 167 billion cubic metres. Production fell steadily to 132 billion cubic metres in 2010. Still, from January 2001 to December 2009, the average price was relatively strong at \$6.46 (with highs of \$13.62 in January 2001 and \$11.39 in July 2008).

It wasn't until 2010, as prices dipped to \$3.02, before falling further to \$1.95 in 2012, that we saw the impact of an explosion of new gas resources coming online. Adopting tight gas technologies made the US a potential net exporter of natural gas. Incredible.

Even still, Alberta production continues to decline.

Bottom line for bioindustrial options

- Unconventional gas wells produce less than conventional wells. More wells means more drilling, more flooding fluids, more chemicals, and more waste.
- One well per 10 square kilometres is standard in conventional gas production. Unconventional wells often require more than one well on a single square kilometre. Each well produces 100 to 500 tonnes of rock cutting³¹ and 100 to 20,000 cubic metres of drilling solution³² (of which 2% is chemical additives³³), all of which requires environmental treatments. Rough estimates based on interviews with Trican, data from the Petroleum Services Association of Canada, and Talisman Energy's Montney Shale play in British Columbia suggest 270,000 to 750,000 cubic metres of chemical solutions were used annually in unconventional wells in Alberta over the last five years. These chemical solutions already include bioderived inputs such as guar, methanol, biodiesel, and biocides.

3. What Now?

The shift to unconventional oil and gas makes for massive change.

- Enhanced oil recovery and tight, light oil in the US will reduce American demand for Alberta's production and create downward pressure on price.
- There is concern that "landlocked oil" sold into the US will face further discounts, converging on a lower light oil price if US supply is substantive. Executives talked to us about 17 per cent discounts. The media puts that figure at 50 per cent. Interviews with companies suggest that new pipelines to the US will do nothing to alleviate price pressure.
- Expanding oil production in Alberta and Saskatchewan and tight oil in North Dakota creates a glut in the US Midwest.

³¹ International Energy Agency. *Golden Rules for a Golden Age of Gas: World Energy Outlook Special Report on Unconventional Gas*. Paris, France: 2012.

³² All Consulting. *The Modern Practices of Hydraulic Fracturing: A Focus on Canadian Resources*. Tulsa, Oklahoma: 2012.

³³ Data gathered by Sift Every Thing from Halliburton, 2012.

Transportation and refining capacity is overburdened. The Energy Resources Conservation Board (ERCB) expects current infrastructure to tap out by 2014 (other analysts say even earlier). Enbridge's purchase, reversal, and twinning of the Seaway Pipeline is meant to take advantage of this situation. It and TransCanada (with its Keystone XL pipeline) would together move 300,000 barrels per day from Cushing to the US Gulf Coast.

- Abundant US gas supplies put price pressure on Alberta. But they also increase demand for drilling chemicals. Unconventional gas production requires more drilling than conventional production, and the process itself requires more chemicals.³⁴ We pick this up again further into this paper.
- Less gas through pipelines means less gas into the straddle plants. Alberta uses straddle plants to siphon off inputs for chemical production. Again, we talk more about this later.
- Productivity will fall as the energy sector shifts to new practices. Multifactor productivity declined by 6.1 per cent from 1997 to 2008.³⁵ Across Canada, the decline was 4.2 per cent, 6.4 in Saskatchewan, and 3.4 in British Columbia.³⁶ In 2010, it took twice the inputs to produce the same output in 2000. The shift away from conventional production requires higher capital and labour input.

³⁴ International Energy Agency.

³⁵ Statistics Canada. *Table 383-0022. Multifactor Productivity, Gross Output, Value-Added, Capital, Labour and Intermediate Inputs at a Detailed Industry Level, by North American Industry Classification System (NAICS) Annual (Index, 2002=100)*. CANSIM [database].

³⁶ The productivity data for oil and gas is pooled with mining at the provincial level. Mining represents a significantly larger part of the Saskatchewan and British Columbia economies, clouding the comparison.

B. Impact on Chemical Production

We hinted that unconventional oil and gas impacts chemical production. Let's discuss it here.

The petrochemical sector adds important value to oil and gas produced in the province. It accounted for \$12 billion in revenue in 2010. Based on 2007 data, petrochemicals (36%), fertilizers (38%), and resin and synthetic rubber (22%) manufacturing make up a majority of production. In 2011, exports were principally basic chemicals (ethylene glycol, polyethylene, and ethylene polymers together were \$2.6G), resins and synthetic rubber (\$3.3G) and fertilizer (\$1.7G).

Revenue is strong, rides substantial output price increases, and aligns with the broader manufacturing sector (around 6%). But real GDP is steadily declining. Between 2004 and 2010, revenue increased by 0.7 per cent per year. Real GDP fell by 4.5 per cent annually.

1. Basic Chemicals

Capital investment in basic chemical production has been spotty and inhibits industrial ecosystem growth. Nova, Shell, and BP each built plants between 1997 and 2001, together investing almost \$1 billion in construction costs.³⁷ From 1981 to 1983, annual investments averaged \$1.0 billion. Again in 1998 to 2000, investments jumped to \$1.4 billion, far above the average \$540 million per year between 1980 and 2006.

³⁷ Alberta Finance and Enterprise.

If we get a little bit fancy, we can compare coefficients of variation³⁸ of chemical industry investment against in oil and gas. At 74 per cent against 22 per cent, it's clear that steady investments in oil and gas helped grow the chemical industry and that volatile investment in chemical infrastructure inhibits the level of maturity in its downstream ecosystem.

Alberta's basic petrochemicals live on cheap ethane. It's extracted from natural gas. But Alberta's conventional natural gas is declining rapidly. In 2011, there was 109 million cubic metres left, down 4.3 million cubic metres from 2010. The ERCB expects demand for ethane to increase from 35,000 cubic metres per day in 2011 to 38,000 in 2015. If oil sand off-gas ethane is not used, demand for ethane from conventional gas will exceed supply this year.

Ethane flows along four primary channels. Marketable gas comes in from gas field plants. Ethane is picked out of pipelines, by straddle plants, before gas is exported to the US. Unmarketable gas, from field plants, runs through fractionation plants that push out ethane. Ethane is also pulled from oil sands off-gases.

2. Fertilizer

Fertilizer production in Alberta is based on ammonium. Ammonia is applied directly as a fertilizer or upgraded to urea, urea ammonia nitrate, or ammonium nitrate. Nitrogen was 60 per cent of the total of crop nutrients applied globally in 2011. Like basic chemicals, ammonium comes from natural gas.

Alberta's GDP from fertilizer production peaked in 2004 at \$758 million and dropped to \$294 million in 2010—an annual decline of 7.6 per cent. The revenue data we can find puts revenue at \$500 million between 2005 and 2008.³⁹ Export data shows

³⁸ The coefficient of variation is a normalized measure of dispersion of a probability distribution. It's the ratio of the standard deviation to the mean. It shows the extent of variability in relation to the mean of the population.

³⁹ Alberta Finance and Enterprise. *Alberta Industry Sector Performance and Prospects*. PricewaterhouseCoopers, May 2009.

a peak in 2008 of \$1.4 billion that dropped down to \$1.1 billion in 2011. Urea dominates the mix, hovering around 75 per cent of exports. Ammonium sulphate and ammonium nitrates are each around five per cent.

3. Implications of Unconventional Gas and Ethane Shortages

Earlier we worked through a set of complicated events related to unconventional oil and gas. Potentially abundant tight, light oil could press down on the price of heavy crude, infrastructure bottlenecks are forcing a discount already, and the explosive supply of unconventional gas creates new paths for chemical producers and pervasive price pressure.

Alberta got used to cheap ethane based on cheap natural gas. Other jurisdictions made do by pulling ethane from longer carbon chains. These alternative sources correlate with the price of oil. Historically, this worked out fine. Crude oil traded at six to seven times the price of natural gas. Alberta was hugely competitive.

But, like everything else, this is changing. The multiple for February 2013 contracts was 26—four times the historical average.⁴⁰ The price is pushing other jurisdictions to seek alternative pathways. This openness to change is growing just as super-cheap unconventional gas comes online.

The ERCB warns that an increase in liquids-rich shale gas, and the divergence in the price of natural gas and oil, will increase opportunities for petrochemical industries outside Alberta to access ethane.⁴¹ This move would rapidly erode Alberta's historical price advantage.

⁴⁰ Pricing data from Bloomberg.

⁴¹ ERCB. *ST98-2012 Alberta's Energy Reserves 2011 and Supply/Demand Outlook 2012-2021*, 6-13.

Super-cheap US unconventional gas will slow Alberta's exports. But straddle plants use those same exports to pull gas to their plants. No exports, no ethane from straddle plants. And straddle plants produce 74 per cent of the ethane⁴² used in Alberta.

4. Impact on Chemical Use

World demand for oilfield chemicals is growing. Climbing 8.6 per cent annually, it's expected to reach \$21 billion by 2014.⁴³ Demand is closely correlated with drilling activity.

Stimulation, enhanced oil recovery, and lots of drilling creates strong demand for oilfield chemicals. In the US alone, chemical demand is expected to reach \$14 billion by 2015. Annual growth in US stimulation materials was 47 per cent in 2008, 66 per cent in 2010, and 52 per cent in 2011.⁴⁴

North America is the largest market and the most intensively drilled place on the planet.⁴⁵ The US represents 84 per cent of demand. With Mexico consuming six per cent, Canada only accounts for 10 per cent. Thirty per cent of total demand is for stimulation and enhanced oil recovery chemicals. The Freedonia Group expects this to grow and become the largest single demand source.

Demand is expected to grow even though total oil and gas production is declining. North America accounts for half of oilfield chemical demand but only 20 per cent of production. The maturity of North American fields justifies the expense.

⁴² ERCB. *ST98-2012 Alberta's Energy Reserves 2011 and Supply/Demand Outlook 2012-2021*, 6-13.

⁴³ Freedonia Group. *World Oilfield Chemicals*. Freedonia Focus Reports. December 2010.

⁴⁴ Freedonia Group. *Well Stimulation Materials: United States*. Freedonia Focus Reports. March 2012.

⁴⁵ Freedonia Group. 2010.

Bottom line for bioindustrial options

- **Drilling fluids** are 38 per cent of the market.⁴⁶ Biocides, corrosion inhibitors, defoamers, emulsifiers, flocculants, lubricants, thinners and wetting agents can all be sourced from plants.⁴⁷ Biosurfactants have several advantages over synthetic alternatives. They are less toxic, biodegradable, and often more effective across a wide range of pH and temperature levels.⁴⁸ But production costs usually far exceed the cost of \$1 per pound for synthetic options.
- **Cementing and stimulation chemicals** are 30 per cent of the market. Xanthan gum and guar gum are regularly used as friction reducers/viscosifiers. Bioindustrial alternatives to guar would interest companies. The price of guar is volatile and makes up a big part of drilling costs,⁴⁹ and 80 per cent comes from India.⁵⁰ Bioindustrials that gain viscosity in high-temperature environments (as a cement additive), biocides, and fluid-loss-control additives are also attractive.
- **Oil production chemicals** are used at all stages of production, from well bore to the delivery of crude to the refinery. In 2010, total demand was \$991 million. Production chemicals are 18 percent of total oilfield chemicals. About half of this percentage is corrosion and scale inhibitors and demulsifiers. Biodiesel works as a solvent degreaser. Grain-derived polymers are used for water treatment.⁵¹ Other bioindustrial applications could include biocides, corrosion inhibitors, and scale dissolvers.
- That said, one of the top players in the specialty chemicals space (at least in Canada), which claims to lead adoption of bioindustrial inputs, says its total feedstock demand is less than \$5 million annually. Of course, the sale of the chemical solutions is where the value is added. These are worth more and make up about 30 per cent of this leading company's revenue. But, to put this in perspective, raw material demand for US oilfield chemicals was \$3.8 billion in 2010. Polymers (natural gums, cellulose, and polyacrylamides) represent 15 per cent of demand.

⁴⁶ Freedonia Group. 2010.

⁴⁷ Sift Every Thing executive interview with specialty chemical company, January 30, 2013.

⁴⁸ R. Makkar, S. Cameatra, I. Banat. "Advances in Utilization of Renewable Substrates for Biosurfactants Production." *AMB Express* 1.5 (2011).

⁴⁹ Sift Every Thing executive interview with well service and drilling company. November 17, 2012.

⁵⁰ H. Hylton/Austin. "Why the US Fracking Industry Worries about the Weather in India." *Time*. July 17, 2012. <http://world.time.com/2012/07/17/why-the-u-s-fracking-industry-worries-about-the-weather-in-india/>.

⁵¹ Sift Every Thing interviews.

- Canadian companies warn that American chemical producers dominate the market, are highly efficient, invest deeply in new products, and use patents to lock out competitors. If Alberta wants to compete, the province will need to invest in building new products with provincially based companies. If this is done, it's important to realize that the benefits will only accrue to a few players—not the entire industry. But this is the best path to creating a competitive ecosystem.

C. Manufacturing

Manufacturing matters. It represents a significant portion of the economy and produces key inputs to the resource extraction sectors. Manufacturing, excluding chemicals, contributed \$16 billion to Alberta's GDP⁵² in 2011 (6.0%). It employs almost seven per cent of the workforce⁵³ and pays above the Canadian average⁵⁴ (\$25.83 versus \$22.58 an hour).

Like chemical production, the rest of manufacturing tracks oil and gas. Of course, food and wood products manufacturing isn't as tightly correlated as the rest.

Exhibit 2 shows the relationship between the petroleum industry, machinery manufacturing, and fabricated metal manufacturing. A bit of economic voodoo shows that the correlation coefficient between net cash expenditures in petroleum and revenue in machinery is 0.96. For fabricated metal manufacturing, it is 0.93. In statistics, this is an extremely strong connection.⁵⁵ The

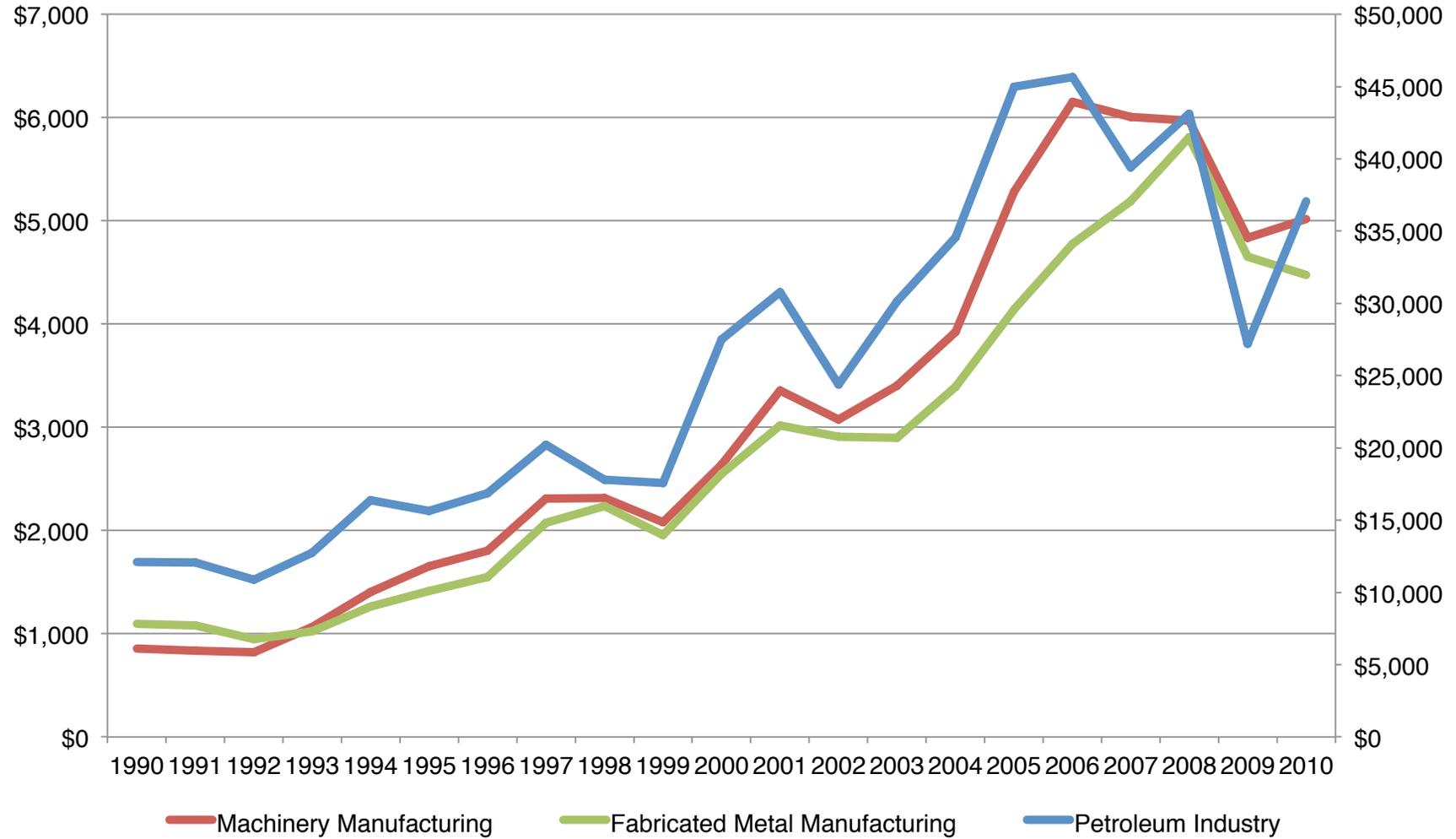
⁵² Statistics Canada. *Table 379-0030 - Gross Domestic Product (GDP) at Basic Prices, by North American Industry Classification System (NAICS), Provinces and Territories, Annual (Dollars)*. CANSIM [database].

⁵³ Statistics Canada. *Table 301-0003 - Annual Survey of Manufactures (ASM), Principal Statistics by North American Industry Classification System (NAICS)*. CANSIM [database].

⁵⁴ Statistics Canada. *Table 281-0030 - Average Hourly Earnings for Employees Paid by the Hour (SEPH) for Selected Industries Classified Using the North American Industry Classification System (NAICS), Annual (Current Dollars)*. CANSIM [database].

⁵⁵ The t-statistics for machinery manufacturing and fabricated metal manufacturing are 15.0 and 10.7. These are well above the five per cent, two per cent, and one per cent significance levels (with 19 degrees of freedom). P-values are less than 0.0001 for both. The estimates are highly significant.

Exhibit 2: Industrial manufacturing and petroleum expenditures (millions \$ - petro expenditures on right axis)



coefficient of determination⁵⁶ suggests 86 per cent of revenue variation in manufacturing is explained by variation in petroleum expenditures.

Exhibit 3 shows the relationship between manufacturing in general in Alberta and Canada, petroleum and coal product manufacturing, chemical manufacturing, machinery manufacturing, fabricated metal products, and non-metallic mineral products. They all track closely.

So, the point: where oil and gas goes, manufacturing will follow.

1. Machinery and Fabricated Metal Manufacturing

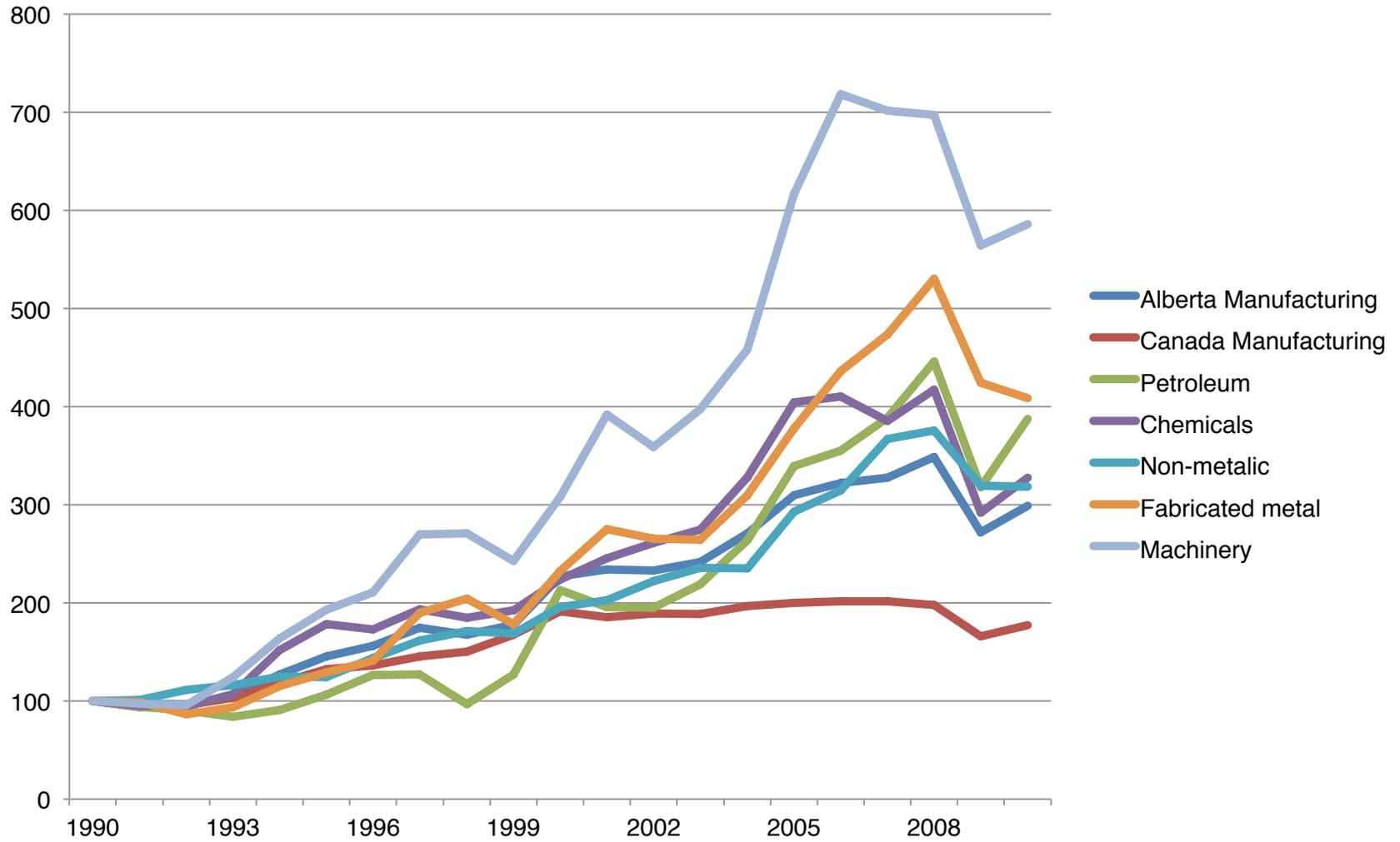
Given its proximity to energy, manufacturing enjoys strong revenue (\$48G in 2011). Machinery manufacturing earned \$5.0 billion in 2010. Fabricated metal, \$4.5 billion. Growth is strong (9.2% for machinery manufacturing each year since 1990, 7.3% for fabricated metal). The run-up to 2008 was incredible. The fall after 2008, precipitous. Between 2008 and 2009, revenue in machinery manufacturing fell by \$1.1 billion. In fabricated metal, it was worse (\$3G).

Clearly, tracking so close with energy has its risks. But manufacturing does a great job of mitigating risk by investing in assets. Asset investment is an important indicator of growing strength and future expectations. Since 1990, asset formation in machinery manufacturing increased 15 per cent annually.⁵⁷ For fabricated metal, the increase was 7.8 per cent. For the rest of manufacturing (including chemicals), it was 3.0 per cent.

⁵⁶ The coefficient of determination indicates the fit of data to a regression line. Close to 1 suggests good fit. Close to 0 is bad.

⁵⁷ Statistics Canada. *Table 031-0002 - Flows and Stock of Fixed Non-residential Capital, by North American Industry Classification System (NAICS) and Asset, Canada, Provinces and Territories, Annual*. CANSIM [database].

Exhibit 3: Index of Alberta manufacturing revenue (1990=100)



Alberta machinery manufacturing is particularly strong in world markets and is a great example of building on strengths. The sector competes internationally by investing in assets that reduce volatility, enable flexibility, enhance productivity, and improve global relevance.

Exports in 2002 were \$1.5 billion.⁵⁸ By 2011, they reached \$3.6 billion (increasing 138% in 10 years). Imports in 2011 were \$4.2 billion, putting the import/export ratio close to one.

A ratio close to one suggests machinery manufacturing is a strong international force. It holds its own, trading its best against the best of others. Of course, this is all occurring in the midst of exchange rate and input cost pressures. It's really an important and unsung example of Alberta's strength.

Bottom line for bioindustrial options

- Bioindustrial producers positioned close to energy can learn from this sector's example. Invest in assets that preserve mobility and enhance global competitiveness.
- This sector is a gateway to energy. It uses materials, fluids, and chemicals that ultimately land in the energy field. Relevance in machinery and fabricated metal manufacturing will enhance options in primary energy production.

2. Refining Petroleum Products

The number of refineries in Canada peaked in 1974 at 42.⁵⁹ Today, there are 19.

⁵⁸ Industry Canada. Trade Data Online by North American Industry Classification System (NAICS). www.ic.gc.ca/eic/site/tdo-dcd.nsf/eng/Home.

⁵⁹ Canadian Association of Petroleum Producers. Table 07-04B. *Statistical Handbook*.

Total capacity remained relatively flat from 1980 (suggesting consolidation rather than lost relevance). Refining is evenly spread across Canada (630,000 barrels per day in Western Canada, 494,000 in Ontario, 395,000 in Quebec, and 504,000 in Atlantic Canada). The two important clusters are Edmonton (420,000 barrels per day) and Sarnia (358,000 barrels per day).

Exports and imports of petroleum products vary across Canada depending on relative market size and supply.⁶⁰ Total Canadian production was 697 million barrels in 2011. Of these, Alberta produced 177 million. Another 95 million barrels were imported. And 142 million barrels were exported.

The Canadian industry generated \$69 billion in revenue in 2010 and employed 13,000 workers (less than 1% of the workforce). In 2010, Alberta generated \$15 billion and employed 2,300 workers.

Revenues in Alberta increased significantly since 1990, riding price increases while production remained flat. Output of refined product is flat in spite of increasing oil production and historically strong prices. Clearly the industry operates at capacity, and indeed, the Canadian average utilization rate is 96 per cent.⁶¹

One of the unique characteristics of Alberta's refining industry is its vertical integration. Unlike the rest of Canada, refineries in the provinces are owned by the largest oil companies. Other companies operate in the rest of Canada but all are "independent." Also, upgraders are emerging which represent significant added value for petroleum. Finally, Alberta's refineries and upgraders own a majority of the refining-related intellectual assets in Canada.⁶²

⁶⁰ Statistics Canada. *Table 126-0001 - Supply and Disposition of Crude Oil and Equivalent, Monthly (Cubic Metres)*. CANSIM [database].

⁶¹ Conference Board of Canada. *Canada's Petroleum Refining Sector: An Important Contributor Facing Global Challenges*. October 2011.

⁶² Statistics Canada. *Table 031-0002 - Flows and Stocks of Fixed Non-residential Capital, by North American Industry Classification System (NAICS) and Asset, Canada, Provinces and Territories, Annual (dollars)*. CANSIM [database].

Consumption data suggests Alberta uses most of the refined petroleum products it produces. Sales in Alberta were 64 million barrels in 1990. They hit 121 million in 2011. Total refined petroleum production in Alberta in 1990 was 133 million barrels, with exports at 1.5 million. Everything else was going interprovincially (49% of total production⁶³). By 2011, increasing provincial demand pulled inter-provincial exports down to 31 per cent.

Bottom line for bioindustrial options

- If interested in refining-related inputs, bioindustrial producers can focus on Alberta's integrated companies—and leverage this integration to attract global players.
- One of Alberta's paths out of its market bottlenecks is to develop refining capacity. Bioindustrial producers need to take strong positions if this happens.

VI. FEEDSTOCK LOGISTICS

The trick with biomass feedstocks is that they're generally wet, bulky, and widely dispersed.⁶⁴ Large-scale applications, like most of the ones described above, require fairly sophisticated logistical operations. To make any sort of industry-wide applications, these logistical challenges are the main barrier.

Here we focus on residuals. The high-value components of forests and crops already have good uses inside substantial capital investments. The main market for these residuals is combination heat and power, biomass-based chemicals, and biomass-based fuels. Each of these options competes with conventional power sources, chemicals, and fuels.

⁶³ Statistics Canada. *Table 126-0001 - Supply and Disposition of Crude Oil and Equivalent, Monthly (Cubic Metres)*. CANSIM [database].

⁶⁴ Sift Every Thing interview with Geoff Clarke, ALPAC, 2012.

Conventionally sourced power, chemicals, and fuel are abundant, highly standardized, effective, and these days, unbelievably cheap.

So, to compete, large volumes are necessary to achieve economies of scale. Owing to the volume requirement, unconventional uses of biomass need to overcome knotty transportation costs and logistical challenges to be viable. The options are pretty scarce. There are two prerequisite parallel paths:

- Drying and concentrating biomass improves the cost-effectiveness of transportation. It usually creates a more homogeneous product. Achieving this result and overcoming the associated capital costs is one of the paths.
- The other path is stockpiling and transporting the biomass (concentrated or not) and getting the end product to market as energy, chemicals, fluids, or biocomposites.

Both paths are necessary and complicated.

Even if these logistical challenges are overcome, there is the reality that using biomass, concentrated or not, usually means adopting new technologies that further drive up barriers. Finally, it's easy to forget that these residuals aren't free. They have value as nutrients, fibre, and biomass on soils.

So, that's the pickle. Let's focus on the initial two paths.

A. Dry and Concentrate Biomass

1. Combined Heat and Power

In Canada, and around the world, biomass is burned for combined heat and power. In Canada, in 2008, more than 273,000 terajoules of heat and power were generated in the pulp and paper industry alone.⁶⁵ For scale, Canadian households used a total of 1.3 million terajoules in 2007.⁶⁶ Key biomass feedstocks are black liquor, bark, sludge, and other forestry by-products.

Alberta's generating capacity is 14,000 megawatts. It's predominantly based on coal and gas (83% of capacity). Renewables (such as wind) account for six per cent. Biomass is three per cent (409 megawatts).

Cheap gas and cheaper coal make biomass-based heat and power untenable. Stand-alone power facilities are rarely economical.⁶⁷ Chipped biomass from residuals is \$66–\$82 per oven dried tonne (\$2.80 to \$5.50 per gigajoule). Densifying and delivery costs are on top of this amount. The delivered cost of thermal coal is \$0.80 to \$2.90 per gigajoule. And current natural gas prices in Alberta are just above \$3.00. There's no contest.

⁶⁵ FPIinnovations. *Bio-energy and Bio-chemicals Synthesis Report*. 2011.

⁶⁶ Statistics Canada. *Households and the Environment Survey: Energy Use*. 2007. Catalogue no. 11-526-S.

⁶⁷ FPIinnovations. 2011.

Without government intervention, biomass combustion will struggle to displace coal and gas. But it is a viable option within a suite of renewable energy alternatives.⁶⁸ And it is readily used in contexts where it bolts onto existing facilities already using biomass, heat, and power (like mills).

The United States Department of Agriculture says the push by the European Union to supply 20 per cent of its energy needs from renewable sources generates significant demand for North American biomass, usually in the form of wood pellets.⁶⁹

2. Wood Pellets

The one significant yet successful unconventional use of biomass in Canada is wood pellets burned for heating. Canadian production is mostly exported (90%)⁷⁰ and shipped in bulk. Canada is the largest exporter to Europe (895,000 tonnes in 2010).⁷¹ American production reached 1.8 million tonnes in 2008. In Canada, it was 1.4 million tonnes. In 2008, utilization rates were 66 per cent in the US and 81 per cent in Canada.⁷² By 2010, the US was at 33 per cent and Canada fell to 69 per cent.⁷³ In 2010,

⁶⁸ C. Sampson, J. Agnew and J. Wassermann. *Research Report : Logistics of Agricultural-Based Biomass Feedstocks for Saskatchewan*. Prairie Agriculture Machinery Institute, May 2012.

A. Doukas, S. Kennet and M. Kennedy. *Green Energy Options for Alberta's Agriculture and Forestry Sectors*. The Pembina Institute, March 2010.

⁶⁹ Feedstock Logistics Working Group. 2010.

⁷⁰ H. Spelter and D. Toth. *North America's Wood Pellet Sector*. United States Department of Agriculture, Forest Service, Forest Products Laboratory.

⁷¹ IEA Bioenergy. "Task 40: Sustainable International Bioenergy Trade." *Global Wood Pellet Industry Market and Trade Study*. 2011.

⁷² Spelter and Toth. 2009.

⁷³ IEA Bioenergy. 2011.

alone, 15 new proposed pellet plants were estimated to add one million additional tonnes of capacity. RISI, a wood markets analysis company, estimates North American production will reach 16 million tonnes by 2017.⁷⁴

The average estimated plant capacity in Alberta was 49,000 tonnes per year in 2009.⁷⁵ In British Columbia, it's 129,000 tonnes (more mills to supply fibre). The US plants run around 100,000.

Sawmill residue provides 69 per cent of feedstock, 16 per cent comes from pulpwood and logging residues, 14 per cent is woodworking residue (from furniture and millwork factories), and the balance is waste wood and agriculture residue.⁷⁶ Because they are dependent on forest product cycles, pellet makers are vulnerable even though demand is fairly static (with pellets primarily being burned in home hearths).⁷⁷

If Europe moves to substitute five per cent of coal with pellets, demand could rise to 50 million tonnes by 2020.⁷⁸ Japan is committed to getting four per cent of its pellets from renewable, non-hydro sources by 2020. Several facilities are testing co-firing of wood pellets with coal. The market is estimated at 6.5 million tonnes.⁷⁹

⁷⁴ S. Walker. *North American Wood Pellet Markets*. Boston, Massachusetts: RISI, 2010.

⁷⁵ H. Spelter and D. Toth. *North America's Wood Pellet Sector* [Research Paper FPL-RP-656]. United States Department of Agriculture, 2009.

⁷⁶ Spelter and Toth. 2009.

⁷⁷ Spelter and Toth. 2009.

⁷⁸ FPInnovations. 2011.

⁷⁹ S. Walker. 2010.

Both Russia and the US are building capacity that could press down on prices (the US added about 164,000 tonnes between 2009 and 2010; Russia added 109,000 tonnes⁸⁰). Also, falling prices for natural gas create a clean, viable alternative to coal that is superior to pellets.

3. Pyrolysis

Pyrolysis is less successful than pellets, but there are some pilot and semi-pilot projects going.

Pyrolysis is the direct thermal decomposition of biomass in the absence of oxygen to obtain solid, liquid, and gas products.⁸¹ Depending on temperature and time, it can produce a high biochar yield (slow pace) or high yield of liquid products (rapid pace). Its neutrality on feedstock and use of the entire biomass make it attractive.⁸² The small footprint makes it eligible for farm-scale, regional, distributed systems.

Ensyn, a US-based company, uses fast pyrolysis to produce oil.⁸³ Its largest plant is in Renfrew, Ontario, with a capacity of 91 tonnes of dry residual wood per day. Nexterra, out of British Columbia, uses partial oxidation, pyrolysis, and gasification.⁸⁴ The company has five facilities, four in British Columbia and one in South Carolina. MaxWest, also in British Columbia, processes

⁸⁰ IEA Bioenergy. 2011.

⁸¹ S. Yaman. "Pyrolysis of Biomass to Produce Fuels and Chemical Feedstocks." *Energy Conversion and Management* 45 (2004): 651-671.

⁸² A. Boateng. *Pyrolysis Oil: An Overview of Characteristics and Utilization*. Wyndmoor, Pennsylvania: USDA-ARS, Eastern Regional Research Center, 2012.

⁸³ www.ensyn.com.

⁸⁴ www.nexterra.com.

biosolids and agricultural waste through a drying system, gasifier, thermal oxidizer, and power generation system.⁸⁵ PRM has several plants around the world that gasify rice hulls.⁸⁶ They have nine facilities in the US.

Capital costs range from \$12 million to \$52 million.⁸⁷ Daily operating costs run from \$129,000 to \$260,000 per day.

The products of pyrolysis are used for fossil fuel replacements (power and heat), catalytic cracking of fuels, specialty chemicals, binders, preservatives, de-icers and copolymers. The char is used for soil amendment and in carbon products.

4. Torrefaction

Torrefaction is a thermochemical treatment carried out at low temperatures, at near atmospheric pressure, and in the absence of oxygen.⁸⁸ Torrefaction initiatives in North America are less concrete than those in Europe.⁸⁹

All biomass resources are suitable for torrefaction. Studies suggest the physical and chemical properties of both woody and herbaceous biomass improve significantly after torrefaction.⁹⁰

⁸⁵ www.maxwastenergy.com; www.coaltec.com.

⁸⁶ www.prmenergy.com.

⁸⁷ T. Pytlar. "Status of Existing Biomass Gasification and Pyrolysis Facilities in North America." *Proceedings of the 18th Annual North American Waste-to-Energy Conference*. Orlando, Florida: 2010.

⁸⁸ P. Bergman and J. Kiel. *Torrefaction for Biomass Upgrading*. 14th European Biomass Conference and Exhibition. Paris, France: October 2005.

⁸⁹ C. Kleinschmidt. *Overview of International Developments in Torrefaction*. Arnhem, The Netherlands: 2011.

⁹⁰ T.G. Bridgeman, J.M. Jones, A. Williams and D.J. Waldron. "An Investigation of the Grindability of Two Torrefied Energy Crops." *Fuel Journal* 89.12 (2010): 3911-3918.

Torrefaction increases energy density from nine gigajoules per cubic metre to 18 gigajoules. This reduces transportation costs. The process also renders biomass hydrophobic, making storage outside and drying easier, and reducing logistical costs. It also increases the potential share of biomass when co-firing with coal (from 10% as wood pellets up to 100%).⁹¹

Thermya, Bioendev, Stramproy Green Invest, Topell, and Foxcoal were all expected to commission demonstration plants in late 2012 and early 2013. Vattenfall, in New Brunswick, is already focusing on production of torrefied pellets within its operations.

5. Preprocessing and Product Standardization

In addition to the processes above, preprocessing includes high-density balers and bale compressors, briquetting (with a press or screw), and cubing. These steps are expensive and inefficient, and they add little value.⁹² They reduce transportation, storage, and processing costs, but only by a little. It's the repeated loading, trucking, and unloading that make things very expensive.

Bottom line for bioindustrial options

- Wood pellets and combined heat and power are the most successful options for using dried/concentrated biomass.
- Torrefaction offers the most versatility in terms of feedstock. Feedstock flexibility reduces risk.

B. Move Biomass

Getting biomass from where it grows to where it's used is difficult. With the technologies above, we can address its wet and bulky characteristics, but it is still widely disbursed.

⁹¹ M. Deutmeyer. *Refining the Quality of Pellets: The Promise of Torrefaction*. 2011.

⁹² Prairie Agriculture Machinery Institute. *Logistics of Agriculture-Based Biomass Feedstocks for Saskatchewan*. Produced for ABC Steering Committee, Sask Power, and Natural Resources Canada. May 10, 2012.

Storing the biomass as inventory for the processes above requires significant space and creates critical liabilities. Biomass is a real fire hazard, a risk well known within the forest industry.

Transporting biomass to its intended use and its intended market poses the major challenge. Forestry mills and agriculture terminals are natural aggregation points but not without complications.

Transportation to aggregation points is expensive. In forestry, 65 per cent of production cost is collection, storage, preprocessing, and transportation.⁹³ The agriculture numbers are a bit different but still significant. The Feedstock Logistics Working Group of the United States Department of Energy says harvesting, transportation, and storage of US-produced corn ethanol is seven to 19 per cent of the total cost of production.⁹⁴ And, in either case, these are using the best parts of the plant. Most of the biomass-related options seek to use residual streams that are harder to collect, more heterogeneous, and less concentrated.

Doing this by truck is uneconomical. Costs are too high, and traffic congestion quickly becomes a problem. A road-only option would be to allow triple B-trains.⁹⁵ At the moment, this isn't permitted in the province.

Truck/train combinations have been explored because they offer important economies of scale. Unlike roads, where congestion begins to bottleneck the system, rails operate well at high unit volumes. Initial cost per dry tonne is high,⁹⁶ and the price

⁹³ Sift Every Thing interviews with forestry company executives, 2012.

⁹⁴ Feedstock Logistics Working Group. *Biofuel Feedstock Logistics: Recommendations for Research and Commercialization*. Biomass Research and Development Board, 2010.

⁹⁵ Sift Every Thing interviews with forestry company executives, 2012.

⁹⁶ H. Mahmudi and P. Flynn. "Rail vs Truck Transport of Biomass." *Applied Biochemistry and Biotechnology* (2006): 88-103, 129-132.

differential is too big. Executives tell us their models break at around 110 kilometres, which according to the Mahmudi analysis, costs about \$15 per dry tonne to transport. The rail cost of \$33 per dry tonne is well above this threshold.

Pipelines are also an option.⁹⁷ The economics are heavily impacted by the preprocessing and processing technologies deployed. And trucking to the pipeline inlet is still a constraint. Overcoming this input cost will require high economies of scale and high margins. Neither of these exist within today's market options.

Bottom line for bioindustrial options

- Resources for infrastructure investment will be scarce. Bioindustrial producers that integrate their needs with those of energy producers will be the first to get attention.
- If Alberta is serious about moving biomass into new markets, its position on triple B-trains is an important constraint.

VII. ENVIRONMENTAL MARKETS

The main pieces of legislation that historically drove and currently define biomass and environmental service markets in Alberta are the *Fibre Roadmap*, *Integrated Energy Vision*, *Nine-Point Energy Plan/Strategy*, *Land-use Framework*, *Climate Change Strategy*, *Timber Harvest Planning and Operating Ground Rules*,⁹⁸ and *Land Stewardship Act*.

Executives criticize the *Land-use Framework* for missing an opportunity to integrate agriculture, forestry, and energy. They understand that defining aggressive limits to water use, emission of pollutants, and biodiversity minimums is complex and that

⁹⁷ A. Kumar and M. Vaezi. "Biomass Logistics." *Biomass: Securing a Sustainable Supply*. Edmonton, Alberta: March 5, 2013.

⁹⁸ B. Waito and L. Johnson. *A National Scan of Regulations and Practices Relevant to Biomass Harvesting*. Forest Products Association of Canada, February 2010.

attaining consensus is difficult. But they argue that these are the only real mechanisms available for creating environmental markets.

The *Land-use Framework* could also drive integration of infrastructure. Such integration is critical if some of the challenges described above (particularly aggregation of biomass) are going to be addressed. It would also encourage agriculture and forestry to position themselves more credibly and proactively to address the reclamation, conservation, and stewardship interests of energy.

Alberta's system of policies and programs completely defines its environmental markets. This is why systemic competitiveness analysis is so important. Programs like the Upstream Oil and Gas Reclamation and Remediation Program create opportunities for new companies. The program takes abandoned assets, including 40,500 well sites and 24,000 kilometres of pipeline, and makes companies liable for reclamation.⁹⁹ It creates a market backstopped by the 213,000 active wells and 15,000 new wells drilled annually.

A. How Big Are Current Markets?

Guessing at the size of environmental markets in Canada is an arcane art. Heavily regulated and run by governments (and arm's-length agencies), existing programs are not transparent enough to estimate their size.

Canadian environmental markets are divided into three discrete playing fields: air and carbon markets, water markets, and biodiversity/habitat markets. Annual payments are between \$462 million and \$752 million.¹⁰⁰

⁹⁹ Alberta Environment and Sustainable Resource Development. "Program Overview." <http://environment.alberta.ca/02484.html>.

¹⁰⁰ Sustainable Prosperity. *Environmental Markets 2012: A Survey and Assessment of Environmental Markets in Canada*. Ottawa, Ontario: 2012.

1. Air and Carbon Markets

In Canada, there are nine air and carbon markets valued between \$170 million and \$190 million per year. Alberta's Greenhouse Gas Emissions Program accounts for \$125–\$144 million plus \$554 million in payments. It's easily the biggest program in the country.

The global carbon market is estimated at \$119 billion by Bloomberg.¹⁰¹ Voluntary climate markets were \$424 million in 2011.¹⁰²

2. Water Markets

Nine water markets exist in Canada, worth about \$31 million total. Alberta uses tradable water allocations in the South Saskatchewan River Basin valued at \$4.6 million. The Ontario Drinking Water Stewardship Program (\$5.2M) and Conservation Ontario watershed activities (\$13M) are also large programs in Canada.

Payments for watershed services and water quality were \$9.3 billion in 2008 (including in-kind contributions).¹⁰³ Australia's permanent and temporary trades of surface water allocations were estimated at \$1.4 billion in 2010.¹⁰⁴

¹⁰¹ Bloomberg New Energy Finance. *Global Carbon Market Expands 10% in 2011* [press release]. January 11, 2012. www.newenergyfinance.com/PressReleases/view/178.

¹⁰² Ecosystem Marketplace, *Voluntary Carbon Markets 2011*.

¹⁰³ M. Selman. "Water Quality Trading Programs: An International Overview." *WRI Issue Brief: Water Quality Trading 1* (2009).

¹⁰⁴ Australian National Water Commission. *Australian Water Markets Report 2010-11*. December 2011. <http://nwc.gov.au/publications/topic/markets/australian-water-markets-report-2010-11>.

3. Biodiversity/Habitat Markets

Biodiversity/habitat markets generate between \$260 million and \$530 million a year. Alberta is included in several federal programs, and it runs tradable hunting rights (\$0.5–\$3.4M) and Growing Forward (\$2.4M).

The best estimates put global markets at \$1.8–\$2.9 billion in 2010.¹⁰⁵ That figure was \$2.4–\$4.4 billion in 2011.¹⁰⁶

In 2011, there were 45 compensatory mitigation programs around the world. North America led the field with 15 active programs and four in development. The US aquatic compensatory mitigation and conservation banking programs account for \$2.0–\$3.4 billion and over 15,000 hectares (so basically, everything). The rest is scattered through another 172,000 hectares around the world.

a) US Programs

In the US, there are seven active programs. Payments run between \$1.5 billion and \$2.4 billion a year on 24,000 acres. The US wetland and stream program, driven by the *Clean Water Act*, is particularly important. The program creates offsets for disturbed wetlands and streams.

Offsets are created through creation (about 42% of total credits), preservation (22%), enhancement (19%), and restoration (17%).¹⁰⁷ Offsets are provided by the disturber, a mitigation bank with offsets for resale, and an in-lieu fee. In-lieu fees go into a compensation fund used to undertake offset activities.

¹⁰⁵ B. Madsen et al. *State of Biodiversity Markets Report: Offset and Compensation Programs Worldwide*. 2010.

¹⁰⁶ B. Madsen et al. *Update: State of Biodiversity Markets*. Washington, DC: Forest Trends, 2011.

¹⁰⁷ B. Madsen et al. 2010.

There are over 430 active wetland and stream mitigation banks, 180 pending banks, and close to 90 sold-out banks. In 2008, total area loss was 18,800 acres, and total compensatory area was 24,000 acres. Total payments were from \$1.1–\$1.8 billion.

b) Australian Programs

Australia's BushBroker program creates offsets for disturbed native vegetation.

Landowners can set aside land for preservation and management of native plants. The government assesses the land and determines the value of the offset. Credits are created through management, protection, maintenance, and improvement practices. Offset requirements ensure like-for-like conditions and proximity.

The unique program creates opportunities and cash flow for landowners and land managers. Between 2006 and 2009, 520 hectares were registered with an estimated value of \$11 million. The price per hectare ranged from \$16,000 to \$293,000. Today there are 3,400 hectares in the program, valued at \$34 million.¹⁰⁸

B. Build Better Markets in Alberta

If it is truly Alberta's intention to diversify its economy, there are few better opportunities than creating markets within the problems of its core engine. The energy industry is full of complex logistical, financial, ecological, construction, manufacturing, and risk challenges. Few are unique to Alberta. Most are global.

In weighing options, a few observations are relevant.

¹⁰⁸ A. Buchan. *Native Vegetation Offsetting in Victoria*. Victorian Department of Environment and Sustainability.

1. Companies Want Rules and Infrastructure, not Programs

Government's best tools for driving economic performance are taxes, infrastructure, resource access, and regulations. Policies that leverage these tools are usually better than specific program interventions.

In the interviews, many of the executives spoke of markets created by government regulations and resource access conditions. Gas flaring in Saskatchewan is a great example. Companies flared gas until government stopped them. Government intervention forced companies to pipe that same gas. Today, those companies enjoy new markets for a by-product they once threw away. None of the companies we interviewed saw this as a bad decision.

This is why Alberta's *Land-use Framework* is so important. It is a policy tool capable of driving corporate environmental performance and sectoral integration. But careful tailoring is needed to encourage these outcomes.

Too often, policies are ill designed and programs are introduced to fill the gaps.

2. Look for Global Relevance

Provincial energy companies rightly complain about excessive program and policy interventions. Their margins are getting thin. Any marginal increase in energy production costs will be aggressively contested.

So passing new costs to energy by imposing new regulations might not be the best plan. Alternatively, it's worth exploring the creation of tax advantages for companies that adopt bioindustrial opportunities. This would be particularly attractive if those bioindustrial alternatives were globally relevant.

Alberta is already a vigorous exporter of fracking and manufacturing expertise; it could do equally well in bioindustrial technologies that are relevant to world markets. The taxes regained by creating internationally relevant bioindustrial companies would offset the forgone energy taxes.

3. Dig Deeper for Root Causes

Alberta could create steps that stack to address its most significant liability issues, if those steps are carefully designed.

Instead of letting policy attention get captured by large-scale issues (tailings ponds and spill recovery), it's worth exploring options that source solutions from smaller problems. For example, using bioindustrial inputs in production processes would reduce the toxicity of tailings ponds. Encouraging the success of bioindustrial input providers would create capacity to develop solutions to larger-scale problems.

Executives tell us that there are small problems in energy that can stack to tackle large-scale issues. They also say that that attention and policy most easily flow to macro-scale concerns even though the source occurs at a small, more micro level.

4. Get behind the Mask

Alberta is concerned about its global image. It's also interested in preserving agriculture and forestry.

One of the ways Alberta has supported agriculture and forestry is by encouraging bioenergy production. In many ways this is a move that directly competes with the core strength of its economy. More than that, it does nothing to advance its existing advantages.

There are far more lucrative and viable opportunities to introduce bioindustrial products that benefit agriculture and forestry while driving further success in energy. This report is full of those options.

It's easy to let the activities of other countries define Alberta's options. International interest in energy security is, fortunately, not an immediate concern for Albertans. The right set of priorities in the US is not the right set in this province. Instead, those decisions can be an example of paths Alberta can take to deliver on its own needs.

Bottom line for bioindustrial options

- Alberta's *Land-use Framework* is one its most powerful policy tools. Enforcing the framework and ensuring it drives sector integration is critical.
- Other jurisdictions might worry about energy security; this isn't an issue in Alberta. Instead of pursuing bioenergy options, the province is well positioned to use forestry and agriculture as inputs to energy production and solutions for energy's environmental risks. There is a global market for these inputs and services.

VIII. PULL IT ALL TOGETHER

We've tried to summarize key points throughout this document. Here we want to focus on the next steps defined by this work.

A. Infrastructure Needs

Alberta needs to better understand its infrastructure gaps. These gaps go well beyond the couple of pipelines that are in the news.

Ongoing production continues to produce stranded by-products¹⁰⁹. Infrastructure bottlenecks are often the cause.

The province's roads are old and inadequate. Budget shortfalls will only exacerbate the issue.

Alberta needs an evidence-based plan to deliver on all its infrastructure needs, not just those few that capture media attention.

Our interviews, inside and outside government, say that the province has a lot of distance to cover before it can produce this clarity.

¹⁰⁹ Williams' off-gas upgrader is a great example of the opportunities this creates.

B. Simplify Programming; Embrace Policy

There are too many programs and not enough sophisticated, highly tailored policies. The policies that exist are often out of date and address issues that were long since resolved.

Alberta needs to comb through its historical positions and get rid of the programs and policies that no longer deliver results. It also needs to identify current issues and anticipate future needs as it develops new policies. It needs to instill government-wide discipline that produces programs in only the most unique circumstances. When programs are created, it's worth building in immovable sunset terms. The goal is tailored policies, not abundant programs.

C. Stop Supporting Agriculture and Forestry; Incentivize Energy

It's popular to support agriculture and forestry. These sectors desperately need help. But ongoing support does nothing to ensure their viability.

Policies that incentivize energy to adopt bioindustrial inputs (ideally through tax breaks but possibly as prerequisites for resource access) would create globally relevant products, help ailing sectors, and achieve important social outcomes.

D. Engage Successful, Mid-Size Companies

Everyone talks about SME strategies. These are really focused on entrepreneurial start-ups.

Start-ups are critical, but they aren't sufficient. Also needed, and in far shorter supply, are aggressive mid-size companies that have strong reputations among large corporations.

Other jurisdictions have stronger industrial ecosystems than Alberta and are better positioned to make use of new start-ups. That does not mean that we share their same needs.

Alberta's lack of mid-size companies is one of its most significant bioindustrial barriers. The province needs to do more to address this gap.

Mid-size companies need strong managerial capacity, access to competitive technologies, and the ability to engage Alberta's core engine. Because there are fewer of these companies, it becomes difficult to support them. Everything the government might do looks like direct intervention.

So policies that target mid-size players need to be sophisticated. And government needs to work harder to understand their needs. These companies don't often engage government. They are busy and successful.

E. Seek Niches

This analysis confirms the earlier work on bioindustrial options. There are no massive, economy-wide, sector-saving bioindustrial options. It's all niches.

Niches are never very attractive to policy and program designers. Big hits are where it's at. But there are no big hits here.

If government wants to drive bioindustrial options, it must accept that these are relatively small, disaggregate, isolated opportunities enjoyed by relatively few companies. There are important opportunities. But there aren't many.

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