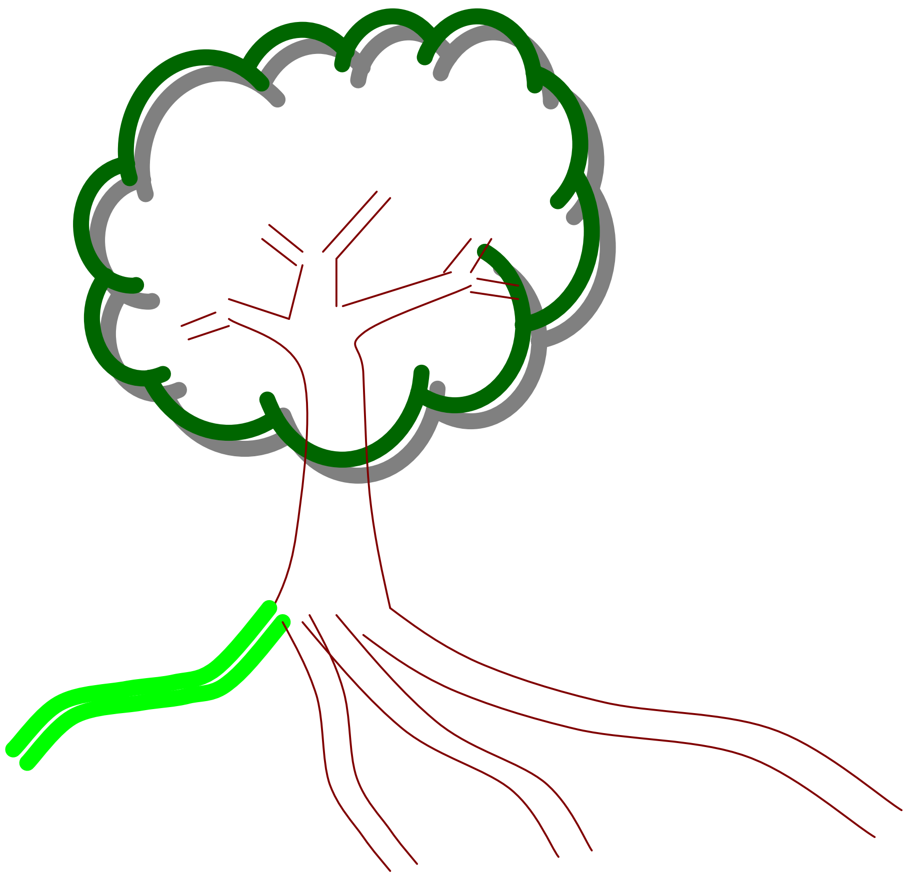
Ontario Bio-product Strategy

October 19th, 2004



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Executive Summary

This report outlines a proposed strategy for the development of a bioproducts industry in Ontario. This strategy is not aimed at the development of an industry that replaces or competes with our existing industries. Rather, this strategy is aimed at accelerating the incorporation of biological feedstocks into traditional industrial products and processes by traditional industries. We have chosen this approach for several reasons.

1.) The existing industrial infrastructure has been driven to evolve towards the lowest possible cost of production and the most efficient means of distribution by global pressure. Companies involved in the production of polymers from petroleum do not remove profit at intermediate steps. It is not possible to justify the capital expense of establishing an alternative supply chain for only a portion of the chemical path.
2.) The scale of production of chemicals and the implicit capital investment necessary to compete at this scale is too high a barrier for entry to start-up companies.
3.) In high volume, low margin businesses such as primary manufacturing, risk is more important than in other businesses. Company failure can be caused by minor deviations from product specifications.
4.) We must set our sites on the transformation of industry from the inside in order to maintain the competitiveness of the primary chemical manufacturing industry. We do not have the luxury of time to wait and allow others to take the risk.

The justification for an Ontario Bioproducts Strategy is that ultimately, the increased use of biomass in chemical manufacturing makes economic sense. The transition of industry from the capacity it has now, to one that includes increased use of fresh hydrocarbons will be difficult because it will require new approaches, new equipment, and the assumption of risk. There is a role for government to play in assisting industry to make this transition, as it is in the best interests of government to maintain the global competitiveness of Ontario's major employers and maintain the diversity of the Ontario economy. Given that there will be bioproduct opportunities that make economic sense, those geographies that capitalize on these opportunities first will not only immediately enhance their global competitiveness, but will also position themselves as leaders and winners in the ensuing race to incorporate more successful innovations.

This strategy is timely because the traditional manufacturing industry of Ontario is at a crossroads. The economic engine of Ontario has historically been composed of the entire industrial revolution value chain. Ontario has had significant capability in primary petroleum refining, intermediate chemical production, creation of polymers, and the use of these polymers to manufacture a wide array of products from automobile seats to construction material to plastic food wrappers. Our capabilities in this value chain have been eroding from the bottom up. In recent years we have seen the loss of manufacturing capability for the monomers necessary to make poly vinyl chloride, or polyurethane foams, or synthetic rubber polymers. The window of opportunity to address this erosion is closing just as the window to substitute biomass as a feedstock source is opening.

In this report, we characterize bioproduct opportunities in four broad categories, intermediate chemicals, renewable transport fuels, functional fibres, and forestry opportunities. Each of these sectors represent different opportunities and challenges.

Fibres:	A gap exists in the domestic value chain between production capability and end user specifications. To close this gap will require the commercial development of primary fibre processing facilities including an enzyme treatment plant.
Transport Fuels:	In the absence of competition the rising cost of petroleum can be passed on to end users without a loss of profit margin. The production of renewable alternatives has the potential to act as a competitive threat if the cost of production can be reduced. This is achievable through a combination of improvements to crop genetics, increases in fermentation efficiency, and increases in the value of co-product values.
Chemicals:	The price of certain intermediate chemicals has increased more rapidly than increases in the price of crude oil. These chemicals represent targets for biomass replacement as they are subject to higher demand than supply constraints than other chemicals. Efforts to produce these chemicals from biomass that allow prices that are competitive with existing chemicals will be embraced by Ontario's existing chemical industry.
Forestry:	Bioproducts developed from forest residue are becoming the basis for a mature industry globally. There is less of a need for innovation in the commercialization of these opportunities in Ontario, than there is for agriculturally based opportunities. A primary constraint to the development of forestry opportunities in this province revolves around issues of forest ownership and rights. Successful commercialization of forestry opportunities will be based on the removal of policy constraints, and the attraction of investment capital.

To address these opportunities we are suggesting two provincially led initiatives.

1.) The development of Bioproduct Opportunity Networks

We propose the development of clearly defined networks across all regions of Ontario, with clearly defined leadership. Separate networks are proposed for each of the target sectors identified above. Each network will be responsible for accelerating development of bioproducts in the appropriate target industries by the following means;

- increased communication of industry driven market opportunities to public sector researchers
- increased public/private partnering for opportunity development
- increased access to industry facilities by public sector researchers under appropriate confidentiality agreements.

- clear pathways and hand-off points for economic developers working with industrial opportunities.
- enabling effective leadership in the facilitation of interactions among players in all aspects of the target value chains.

2.) The development of an Ontario Bioproduct Seed Fund.

We propose the development of sustainable seed fund aimed at enabling industry to adopt innovation locally. The fund will be established through initial, one-time, government support, and used to guarantee a portion of private investment in bioproduct commercial opportunities. The flow of revenue from successful opportunities will act as a trigger to liberate seed fund guarantees facilitating recycling of funds into other opportunities. To be successful in our objective of using this fund to accelerate the incorporation of bio-based feedstocks in Ontario industry, as a means of increasing the global competitiveness of our industry, there is a need to actively engage industry and private investment. Our strategy is aimed at achieving this through the creation of separate, industry driven Innovation Funds. These funds will be created through the allocation of equity positions to the Industry Innovation Funds in opportunities assisted by the Ontario Bioproduct Seed Fund. The first call on revenue received from these equity positions will be to maintain the level of the Ontario Bioproduct Seed Fund at, at least it's initial funding level. Revenue flowing into these funds over and above the need to sustain the seed fund will be disbursed by the Industry Innovation Funds at the discretion of industry coalitions, circumscribed by a binding general agreement with the province of Ontario. The overall funding strategy minimizes government investment, maximizes industry involvement and leadership, and requires the mobilization of private capital to be successful.

The essence of this strategy is to develop bioproduct opportunities in Ontario in order to increase the competitiveness of Ontario industry. The focus is on the commercialization of innovation regardless of the location of discovery. To this end, the strategy is aimed at mobilizing Ontario's public sector research capability towards reducing the cost of existing innovation. The successful delivery of this strategy will lead to increases in value in Ontario for agriculture, for forest industry, and for rural and northern economies. The focus however, is on pulling this value into being through our existing industrial infrastructure rather than pushing it from our ability to grow and harvest biomass.

Background:

The Ministry of Economic Development and Trade coordinated the delivery of a province wide program entitled, "Biotechnology Clusters and Innovation Program" over the last year. As a result of this program, six regions in Ontario identified bio-products as of key interest in terms of economic development in their region. These regions were, Ottawa, Central and Eastern Ontario, the North, Guelph/Waterloo, the Golden Horseshoe, London, and SOBIN (or southwestern Ontario). As the regional processes were nearing completion, MEDT in collaboration with Ontario Agri-Food Technologies (OAFT) requested NeoBio Consulting to develop a provincial strategy weaving these regional interests together into the opportunities that exist in the province.

To perform this task, we have visited each region and reviewed all the documents submitted as part of the BCIP process. In addition, we have explored the potential for Bio-product opportunities in four broad categories throughout the province. Those four categories are;

Chemicals
Renewable fuels
Functional fibres
Forestry Products

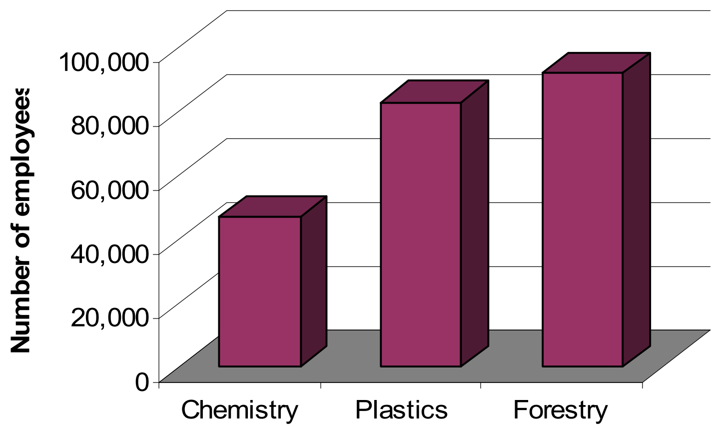
A list of individuals whom we interviewed and based our understanding of the nature of bioproduct opportunities in each of these four sectors is provided in Appendix "A".

Justification for a bioproducts strategy:

The economic development of Ontario has been based in large part on the development of two separate industries, forestry and petroleum based manufacturing. The Ontario chemical industry comprises 631 total companies including 23 of the 25 largest chemical companies in the world. The Ontario chemical industry supports the 2,250 plastics companies in this province directly employing 83,000 people.

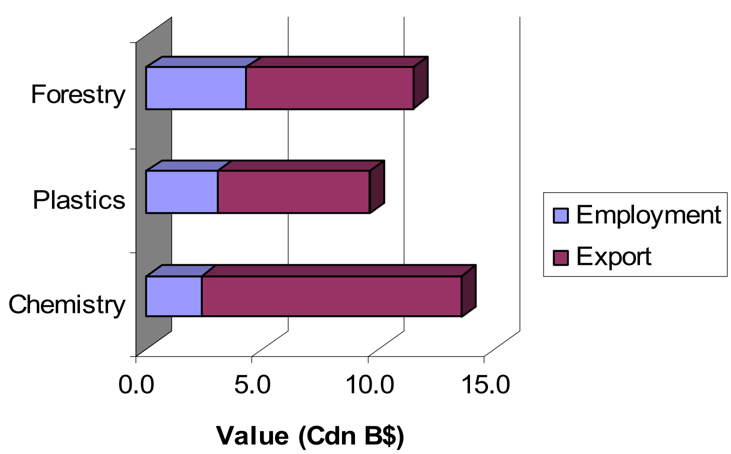
The target industries for bioproducts are a major employer of high value jobs in Ontario.

Figure 1: Number of employees in bioproduct target industries in Ontario.



These industries continue to be key contributors to value in Ontario both in direct salaries earned, and exports.

Figure 2: Value of employment in bioproduct target industries in Ontario.



These three core industries have been central to the growth of the Ontario economy, are crucial to it's success now, and will continue to be a key driver for economic growth in the future. These industries are in need of renewal however. The chemistry industry in Ontario is eroding from the bottom up. In the last five years we have lost the ability to manufacture a broad range of chemical intermediates. We no longer manufacture vinyl chloride monomer, propylene oxide (precursor of polyurethane), and butyl rubber. The Ontario industry is supporting continued growth of demand in the Ontario plastics sector by acting increasingly as a distributor of polymers manufactured in the U.S.

This represents both a challenge to the health and existence of the industry, and an opportunity for bioproducts. Intermediate chemicals manufactured from biomass within Ontario represent an attractive potential replacement for imported chemicals. We will not need to displace or cannibalize existing manufacturing capacity. The accelerated adoption of bioproducts will lead to an increase in our balance of trade, by directly reducing reliance on exports.

The Ontario forestry industry is suffering from a decrease in the quality of forests available for harvest. The Ontario industry was built on hardwood lumber, and the proportion of these trees in regenerated forests and existing forests is significantly lower than the proportion in most of the forests harvested. The industry and the northern economies supporting it could use a shot in the arm in terms of economic viability. Bioproducts derived from forest industry co-products and forest residue may represent the added value necessary to not only maintain present levels of forestry investment, but to grow economic development. The processing of biomass into feedstocks appropriate for bioproducts and/or the development of bioproducts directly represents an opportunity for northern communities to diversify their economies.

The agricultural economy of Ontario is also struggling in a global environment of low commodity prices produced by high agricultural subsidies in Europe and the U.S. Farm profit margins continue to dwindle as a result of increasing costs, and stable revenue. Efforts in the past have focused on increasing production more rapidly than input costs. Bioproducts represents an opportunity to increase demand, thus increasing price, without affecting production level, or input costs. The development of industrial varieties within existing commodity crops has the potential to increase the need for local users of grain to compete for farmer's decision as to what varieties to plant.

Overview of Strategic Approach:

Without question, bioproducts represent an opportunity to improve the profitability and the sustainability of a broad range of Ontario industrial sectors. At what cost though? Are there bioproduct opportunities that represent competitive cost structures to existing feedstocks? What technical constraints exist to the development of opportunities in Ontario? What effect does existing government policy have on the development of these opportunities?

An Ontario Bioproducts Strategy has to be based on the answers to these questions. This strategy was developed as follows;

1.) We performed an analysis of the existing price/cost flow of existing feedstocks through Ontario industry in order to evaluate and identify the most promising opportunities for bioproducts.
2.) We evaluated the key constraints to bioproduct opportunity development and developed a set of recommendations to address these constraints. This strategy is aimed not only at government action, but also at researchers and target industries, therefore we address specific recommendations to each of these groups.
3.) We review the strengths and weaknesses of Ontario as a basis for focusing our strategy on developing a globally competitive approach to bioproduct opportunity development.
4.) We propose a strategy for the coordination of regional activities that will maintain regional interests in local development, while supporting the global competitiveness of Ontario.
5.) We propose a funding strategy that will create a sustainable fund from government seed contributions, mobilize private investment and directly engage target industries.

This document should act as a template to stimulate further discussions as we work together to develop a dynamic provincial bio-products strategy that will satisfy the needs of all stakeholders. We have chosen to be specific in our recommendations in the hopes of stimulating specific feedback, and discussion. As a document our work is meaningless, it only acquires meaning as the vision is shared broadly across the provincial community, and as it is acted upon.

Section 1: Opportunity Evaluation

In this section we will attempt to answer the following questions:

What are the target industries for bio-products in Ontario?
What do the target points look like in terms of volume, price and value?
Where are the entry points for new bio-products?

Introduction:

We have two routes open to us for the development of an Ontario bio-products strategy. We could attempt to build a bio-based economy, based on the development of new industries that are advantaged over the existing industrial infrastructure through their operating synegies, their sharing of co-products, and their sharing of energy. This is a beautiful model on paper, but it suffers from severe constraints in the real world. In most theoretical exercises to move from point A to point B is independent of how point A came into being in the first place. This is not the case in terms of commercializing innovation. How point A came into being is material, because it represents capital investment, the development and existence of industrial cultures capable of commercializing innovation, and the existence of the infrastructure and relationships implicit in established product distribution systems. All of these factors carry momentum into the creation of point A. If this momentum is not considered, then the movement to point B may not be realized.

An approach to the development of Bio-product opportunities in Ontario that capitalizes on the momentum of existing industry has a higher probability of success. This may mean redefining point B in collaboration with existing industry. Our strategy is based on the premise that successful commercialization of innovation must be based first on meeting the needs of industry, rather than the needs of the consumer. Nylon was commercialized prior to WWII in response to rising prices and decreased availability of silk. The mass production of kerosene and asphalt from petroleum reduced the cost of gasoline resulting in the development of automobile engines based on gasoline combustion. We need to understand the direction the industry is heading in, and identify those existing constraints that are going to continue to threaten profitability.

To avoid having to characterize all of the industrial operations in Ontario we will focus on those industries that are targets for bio-product opportunities. To do this we must first define what we mean by a bio-product. We define bio-products as materials derived from biomass that are not immediately ingested by animals.

We have divided Bio-product opportunities into four broad categories:

Transport fuels:	Ethanol and bio-diesel
Fibre:	Hemp and flax fibre
Forestry:	Wood residue, forestry industry co-products
Chemicals:	Simple monomeric carbohydrates, including those derived from polymers.

These categories provide us with a basis to define target industries in Ontario and begin to understand the needs and economic drivers of these industries.

This means focusing on the commercialization of innovation that leads to a solution of the target industries most pressing need. In the course of performing the analyses that form the basis of this strategy, we determined that these market drivers may be completely different for different target markets. Some, existing target markets are capable of passing increased prices on to consumers without a fear of losing market share to foreign competition. The fuel market provides an excellent example of this type of market. The technology and feedstock base relied on by the Ontario fuel industry infrastructure is not at competitive risk vis a vis, more efficient technology, or fuel derived from lower cost crude oil entering the domestic market through other channels. The absence of this competitive risk is not based on trade barriers but on the global liberalization of crude oil prices, and the lack of a technological competitive advantage in any geography.

In Ontario, the majority of the primary chemical industrial processes and the secondary plastics manufacturing industry is at competitive risk versus other geographies who have access to lower cost feedstocks, technological parity, and lower energy costs. This industry requires lower feedstock costs in order to survive in the long term, thus while increasing market share through the introduction of increased value remains of interest, a larger opportunity exists to maintain the global competitiveness of the industry as a whole.

The target market for functional fibres presents a third type of opportunity. the competitive market risk faced by the primary chemical industry is less relevant for this industry. If nylon fibres can be purchased for less from elsewhere than North America, or Ontario, this represents a change in feedstock purchasing strategy, and not a constraint to individual competitiveness within a market, or global competitiveness of the industry. If a bio-based fibre can provide sufficient added value to increase returns through increased market share, then the innovation necessary to realize this added value will be achieved. This market sector is also increasingly driven by economic models that are based on the concept of the manufacturer leasing the product to consumers. The economic drive behind leasing may well be increased dependence of the consumer on a particular supplier, and increased economic return from payments over time, rather than up front payments, but the existence of lease relationships creates an opportunity for increased value to be realized from recycling. If a bio-fibre enhance the recycling value of a product, then the necessary innovation required to commercialize bio-fibres in such products will be accelerated.

The final target market that we have defined as a basis for this strategy involves the use of non-functional fibre in composite material. These applications, also do not appear to be driven by a global threat in the form of lower feedstock costs elsewhere. The majority of these opportunities, composite lumber and composite plastics are driven by the added value of the product. Market share can be increased if the added value is perceived by the consumer as being greater than the added cost. This increase in market share is worthwhile as long as the profit margin of the manufacturer is equivalent or greater for the new product as compared to existing products. Added value can take the form of increased product life, as in the case of composite lumber decks and fences, or decreased weight, as is the case with composite plastics used in the manufacture of autoparts. In this case, decreased weight creates value by increasing fuel efficiency.

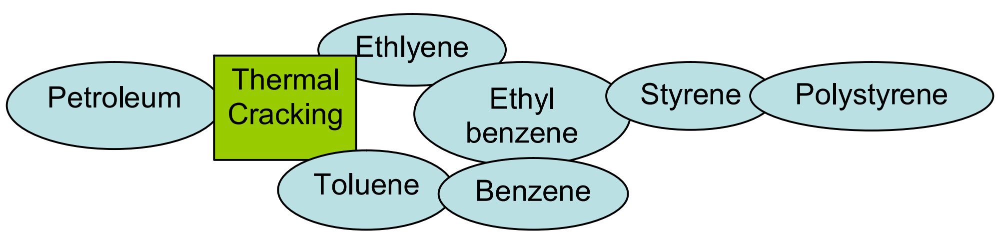
1.1 Chemicals:

We have focused our analysis of primary chemical opportunities to the major volume chemicals manufactured in Ontario.

1.) Polystyrene:

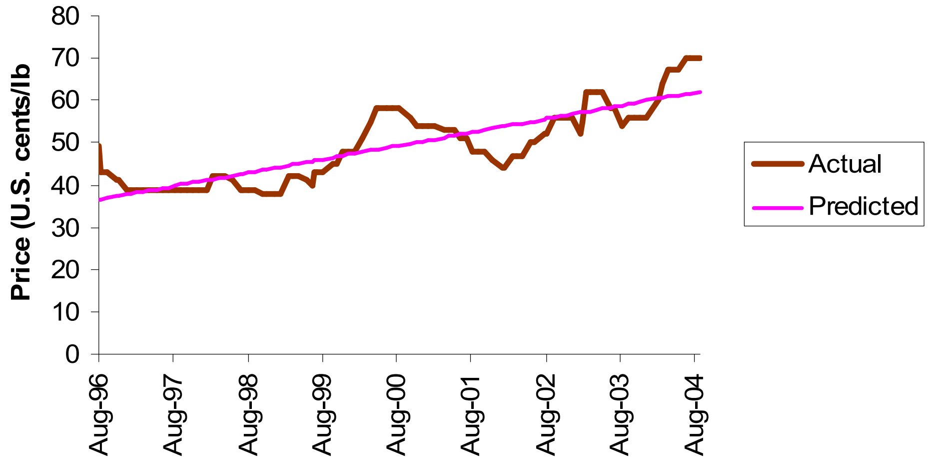
Both Dow and Nova manufacture styrene in Sarnia, Ontario. Nova ships the styrene for polystyrene production in Montreal and Massachusetts, while Dow completes the process within it's Sarnia operations. Both companies have capacity for manufacturing their own feedstocks. Ethylene and toluene are cracked from the light portion of petroleum using an energy intensive thermal process. Approximately 50% of the toluene isolated in North America is used to manufacture benzene through hydroalklation or disprortionation. This internal capacity to create a feedstock supply creates a potential for illusionary markets as benzene for polystyrene manufacture, is not commonly purchased on the open market, even though polystyrene manufacture represents slightly more than 50% of the total use of benzene in North America.

Figure 3: Product flow from petroleum to polystryrene.



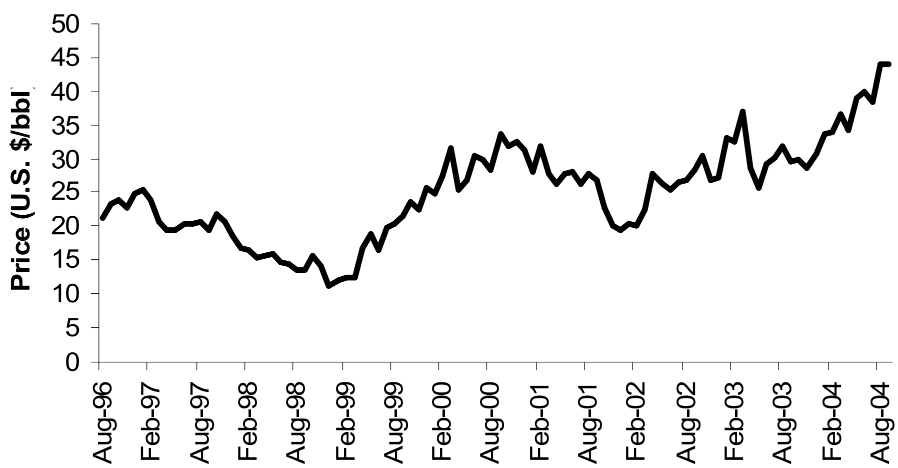
The price for polystyrene has increased an average of 3.18 cents/lb per year from 1996 to 2004. The current price for polystyrene of U.S. 70 cents/lb is substantially higher than either average or the eight year trend.

Figure 4. Polystyrene prices by month for the last eight years.



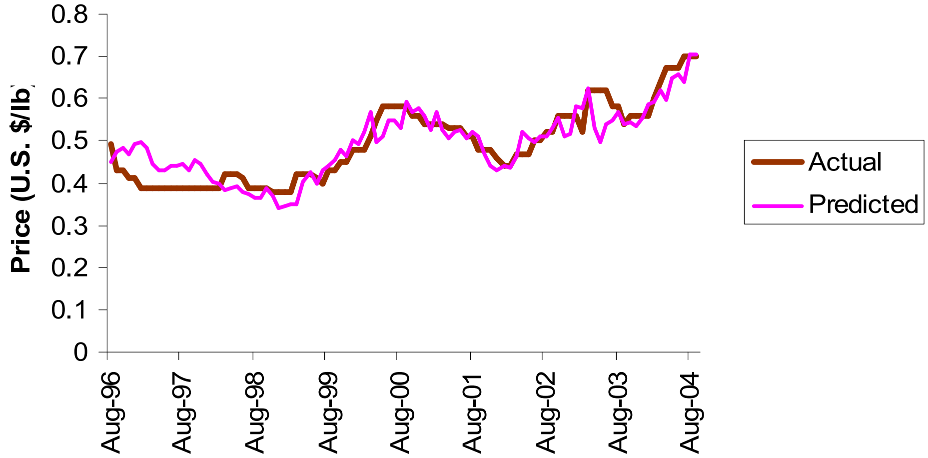
The feedstocks used for polystyrene production are derived from crude oil. Thus, the cost of the feedstocks is dependent on the cost of crude oil, and the cost of the energy necessary to refine them. Crude oil prices are globally determined and have demonstrated the same upward trend over the last eight years as observed in polystyrene prices.

Figure 5. Spot price for crude oil, U.S. gulf coast by month for the last eight years.



The price charged for polystyrene is based on these costs as well as additional manufacturing costs, and profit margins. Given the internal production process employed by most North American manufacturers, as well as those in Ontario, there is no profit taking between the cost of crude oil and the price received for petroleum. This is evident in the following graph demonstrating the relationship between crude oil price and polystyrene price in the time period analyzed.

Figure 6. Prediction of polystyrene price based on crude oil price alone.



In this analysis, we regressed the polystyrene prices against crude petroleum prices and obtained an r^2 value of 0.80. We used this regression analysis to predict the price of polystyrene based only on the crude oil price at any given time. The result is somewhat startling in it's accuracy. Polystyrene prices are almost completely based on crude oil costs. Variable costs due to labour and energy simply do not have much effect on the price charged for the product.

This means that the polystyrene manufacturing business is driven almost exclusively by feedstock cost. The apparent market cost of the feedstocks is rising faster than the price charged for the product.

Table 1. Cost/price structure of polystyrene production.

	Feb-02	Feb-04	% Change
Benzene	$0.09	$0.30	227%
Cost/lb ethylbenzene	$0.07	$0.22	227%
Ethylene	$0.24	$0.31	30%
Cost/lb ethylbenzene	$0.06	$0.08	30%
Ethylbenzene	$0.25	$0.32	27%
Feedstock cost	$0.13	$0.30	131%
Styrene	$0.35	$0.43	24%
Polystyrene	$0.44	$0.60	36%

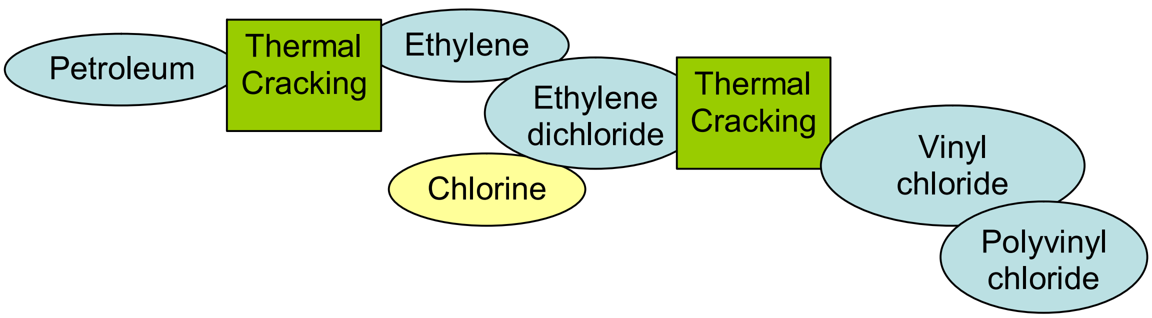
Market costs for feedstocks like benzene may not be indicative of real value, as the production of polystyrene in closed loop systems means that the majority of the market feedstock is not openly traded. However, this analysis indicates that the feedstock cost of polystyrene has risen more sharply than either the cost of crude oil, or the price received for the end product. This increase in feedstock cost has been driven disproportionably by the cost of benzene. Clearly, a market exists for a bio-based source of benzene at a price less than $0.30/lb.

Finding: *An opportunity exists for the commercial production of benzene from bio-based sources if the product can be produced for a lower cost than is currently available.*

2.) Polyvinyl Chloride:

Polyvinyl chloride is manufactured by OxyVinyls in Niagara Falls, and by the Royal Group in Sarnia. OxyVinyls has a PVC manufacturing capacity of 575 million lbs, while the Royal Group has a capacity for the production of 475 million lbs.

Figure 7: Product flow from petroleum to polyvinyl chloride.



Dow has announced that it is shutting down vinyl chloride manufacturing capacity in Fort Saskatchewan in 2005, while maintaining ethylene dichloride capacity. OxyVinyl and the Royal Group depend on external sources for vinyl chloride presently. The bio-based target market in Ontario for polyvinyl chloride is therefore not present in terms of providing an alternative feedstock. There is however a market opportunity targeted at the conversion of the vinyl chloride monomers to polyvinyl chloride. This conversion process involves the use of plastizers and it is possible to increase the bio-based portion of these catalysts. Alternatively, fibre reinforced plastics, either involving PVC, or involving other polymers have the potential to compete with PVC directly as a competitive product.

The polyvinyl chloride value chain has not been affected by a single element rising to a price that is not aligned with increases in other costs. Decreases in North American capacity for chlorine manufacturing have led to increases in prices as demand continues to rise. In 2003, 32% of the chlorine refined globally was used in the production of polyvinyl chloride.

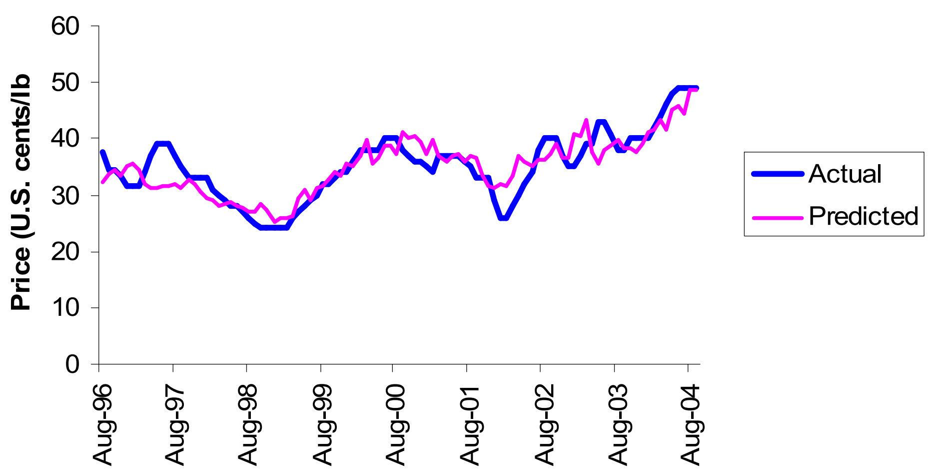
Table 2: Cost/price structure of polyvinyl chloride production.

	Feb-02	Feb-04	% Change
Ethylene	$0.24	$0.32	34%
Cost/lb ethylene dichloride	$0.07	$0.09	34%
Chlorine	$0.08	$0.14	77%
Cost/lb ethylene dichloride	$0.06	$0.10	77%
Feedstock cost	$0.12	$0.19	53%
Ethylene dichloride	$0.13	$0.21	62%
Vinyl chloride monomer	$0.20	$0.32	65%
PVC	$0.26	$0.41	59%

The feedstock cost as a proportion of the cost of the ethylene dichloride, the first committed step in the path towards PVC, has actually decreased from 95% in 2002 to 90% today. As was the case with polystyrene, this level of price dependency on feedstock is indicative of a closed loop, high volume industry. Profits appear not to be taken between certain points on the production chain, but rather on the production of polymers from monomers.

The price of crude oil provides an excellent basis for predicting the price of polyvinyl chloride even though chlorine contributes about 50% of the feedstock cost.

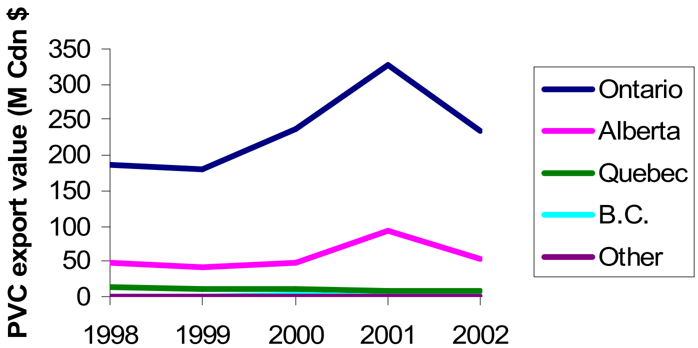
Figure 8: Prediction of polyvinyl chloride price based only on petroleum cost.



The predicted price for PVC is based on a regression against crude oil prices (r^2 = 0.73).

Ontario is the clear leader in Canada in terms of PVC manufacturing as this chart illustrating provincial share of the PVC export market demonstrates.

Figure 9: Provincial share of PVC export value.

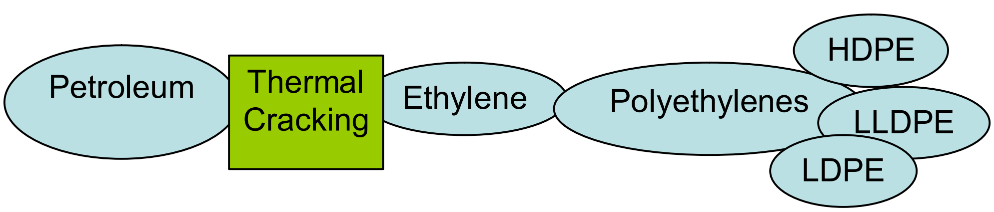


Finding: *Efforts in regard to the development of bio-based opportunities in the PVC market should be focused on the processing of vinyl chloride monomer to the polymer, including the use of plasticizers based on bio-products, and the increased incorporation of functional fibre and/or cellulose in finished products.*

3.) Polyethylene:

Polyethylene represents by far the most significant market in terms of volume and value for the Ontario petroleum industry. Dow manufactures low density polyethylene in Sarnia, Ontario. Nova has the capacity to manufacture 750 million lbs of polyethylene per year in Moore, Ontario (a combination of high density and low density) and additional capacity to manufacture 335 million lbs of high density polyethylene and 256 million lbs of linear low density polyethylene at the St. Clair River site.

Figure 10: Product flow from petroleum to polyethylene.



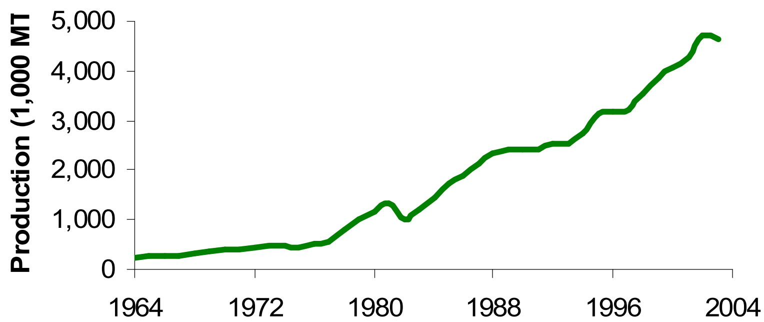
As we have already seen, ethylene is also key to the manufacturing of polystyrene and polyvinyl chloride. Approximately 54% of the ethylene produced in North America is converted to polyethylene. The following cost point analysis demonstrates that while the feedstock cost has increased over the last two years, manufacturers have been more than able to pass this increase in cost into final product pricing. This reflects a strong and growing final product market.

Table 3: Cost/price structure of polyethylene production.

	Feb-02	Feb-04	Change (%)
Ethylene	$0.24	$0.32	34%
HDPE	$0.31	$0.55	79%
LDPE	$0.44	$0.70	59%
LLDPE	$0.38	$0.64	69%

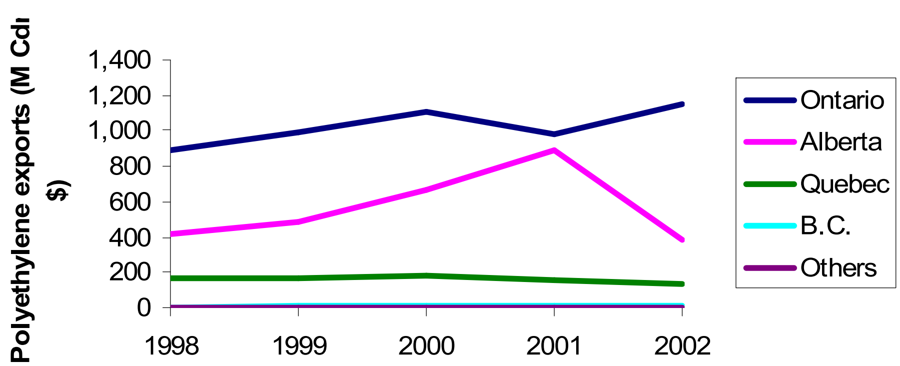
Ethylene production capacity in Canada has grown at a steady rate over the last forty years.

Figure 11: Historical ethylene production capacity in Canada.



Canada produces 1/6th the amount of ethylene produced by the United States. Alberta produces much more ethylene than does Ontario, but Ontario still leads in terms of polyethylene production and exports.

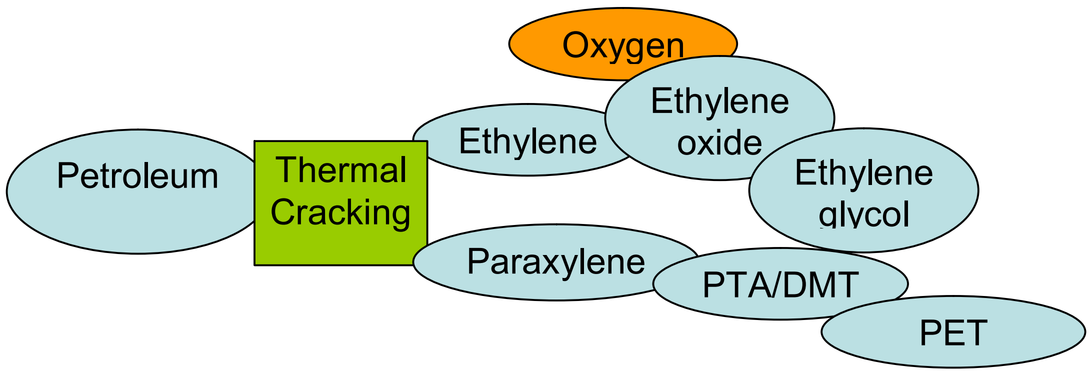
Figure 12: Provincial share of polyethylene export value.



Finding: *Polyethylene does not represent a bio-based market opportunity until the conversion of cellulose to ethanol becomes cost-competive with the cost of producing ethylene from petroleum. This is the key to focus on in regard to moving polyethylene markets into the bio-based opportunity camp.*

4.) Polyethylene terphthalate (PET)

Figure 14: Product flow from petroleum to polyethylene terphthalate.



Polyethlene terphthalate (PET) was manufactured by Eastman Kodak in Toronto until recently. PET is primarily used in bottles. The price points for certain of the intermediate feedstocks exhibit the same lack of alignment with the overall value chain as we observed earlier for benzene. Ethylene oxide used for ethylene glycol production is sold under market value. This is possible due to the closed loop structure of ethylene glycol manufacture from ethylene.

Table 4: Cost/price structure of PET production.

	2001	2004	Change %
Ethlyene	$0.24	$0.31	29%
Ethlyene/lb ethylene oxide	$0.15	$0.20	29%
Ethylene oxide	$0.60	$1.28	114%
Ethylene oxide/lb ethylene glycol	$0.43	$0.91	114%
Ethylene glycol	$0.22	$0.39	76%
p-xylene	$0.26	$0.34	32%
p-xylene/lb PTA	$0.13	$0.17	32%
PTA	$0.30	$0.26	-14%
DMT	$0.31		
PET	$0.65	$0.66	2%

The ethylene to ethylene glycol portion of this manufacturing chain is of more interest as a Bio-product target than the xylene to PTA portion of the chain. The xylene portion of this value chain appears to be in over supply versus the ethylene portion, this is potentially due to the co-production of xylene along with other processes including ethylene production, and the existence of significant manufacturing capacity for PTA and DMT in Asia. The majority of the p-xylene refined is used to create PET (77% in North America). More p-xylene is available to refiners in gasoline based on current North American gasoline refining capacity. A supply shortage for p-xylene is anticipated in the short term, as demand for gasoline continues to increase in the absence of increases in refining capacity.

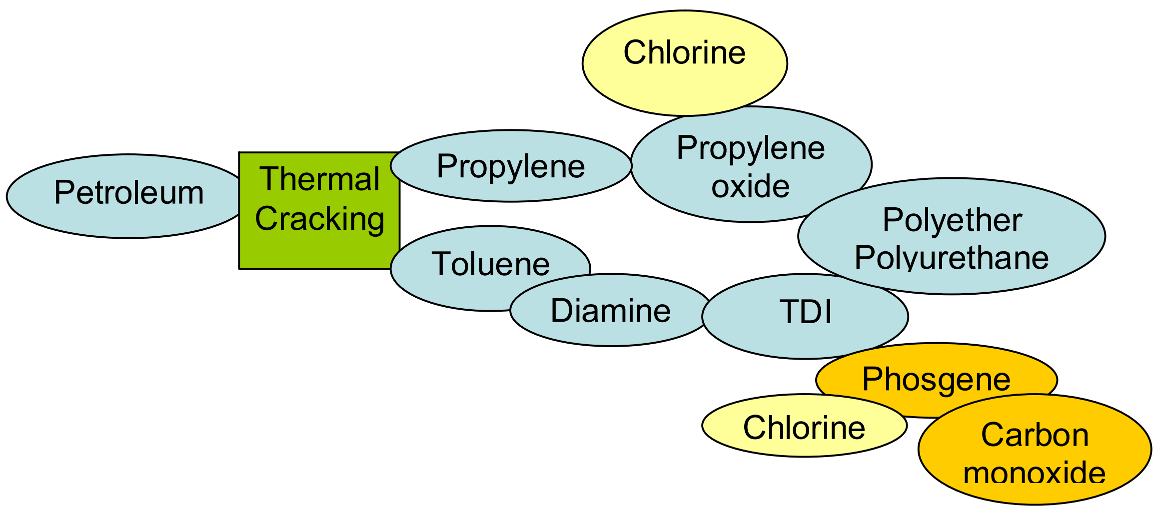
Finding: *Ethylene oxide and ethylene glycol are potential targets for bio-based substitutes.*

5.) Polyurethane:

There are two broad types of polyurethanes based on polyester or polyether chemistry. The polyester types are more commonly used in rigid foam or non-expanded applications, while the polyether types are used in flexible foams. Polyester based polyurethanes are predominantly produced through the use of propylene glycol, but a significant proportion are based on the use diethylene glycol.

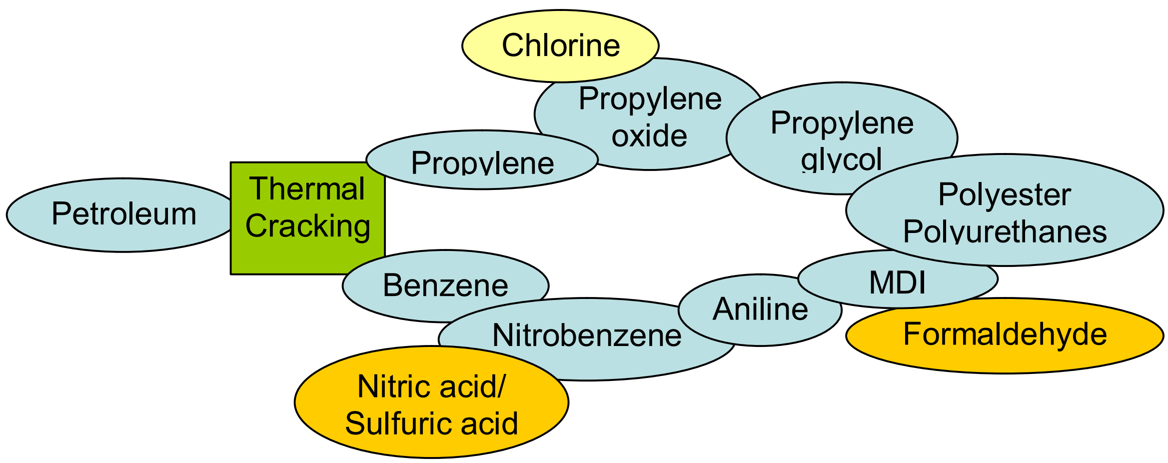
First for flexible foam applications the manufacturing process flows like this;

Figure 15: Product flow from petroleum to flexible polyurethane foams.



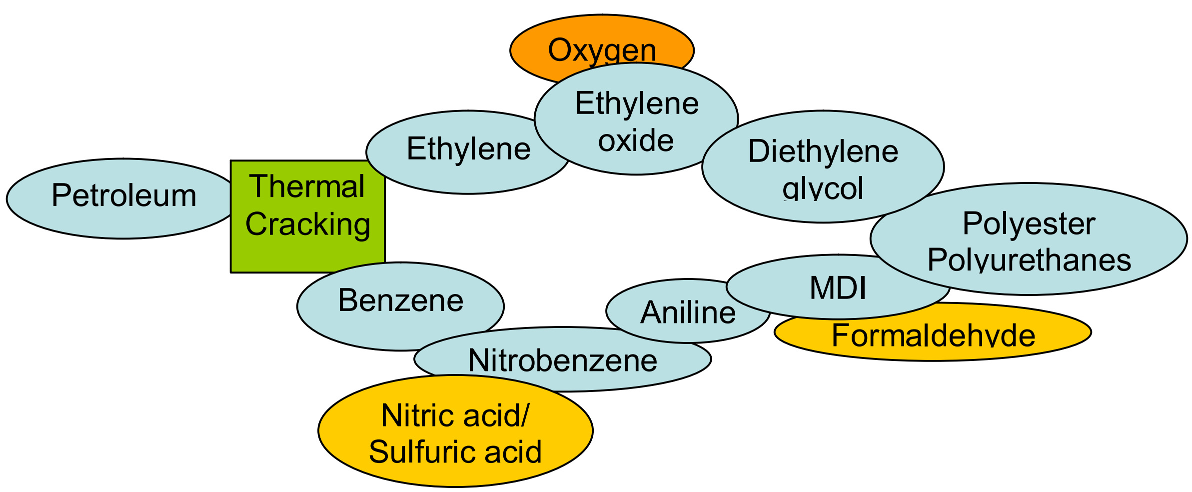
For polyester applications involving the use of propylene glycol the pathway looks like this;

Figure 16: Product flow from petroleum to rigid polyurethane foams through propylene glycol.



Alternatively, rigid polyurethane foams can be produced from polyesters through the use of diethylene glycol as follows;

Figure 17: Product flow from petroleum to rigid polyurethane foams through diethylene glycol.



The upper part of these pathways involving propylene oxide, propylene glycol and diethylene glycol are referred to as the polyol pathway. The lower part involving the use of methyldiphenyl diisocyanate or toluene diisocyanate are referred to as the diisocynate production pathway.

The polyurethane market has been remarkably stable in recent years. Recently an upward pressure on polyol prices has been noted, driven primarily by increases in the cost of propylene.

Table 5: Cost/price structure of polyurethane production.

	2002	2004	Change %
Propylene	$0.18	$0.35	93%
Propylene oxide	$0.64	$0.69	8%
Propylene glycol	$0.68	$0.73	7%
Toluene	$0.16	$0.23	46%
TDI	$1.15	1.15	0%
MDI	$1.10	$1.10	0%
Polyurethane			
Polyether	$2.39	$2.39	0%
Polyester	$1.78	$1.78	0%

Propylene oxide is more difficult to manufacture synthetically than ethylene oxide due to the lack of an effective metal catalyst for propylene (silver in the case of ethylene). This creates a significant opportunity for the development of biobased alternatives to polyols. The pressure on polyol price increases the significance of this opportunity. Alternatives to diisocynates would be even more attractive on a cost per pound basis, but more difficult to achieve technically.

Finding: *Polyurethane represents a key opportunity for bio-based targeting given the high cost of existing feedstocks. Polyols are particularly interesting given the recent upward trend in prices and their structural similarity to vegetable oils.*

Summary – Chemical Opportunities:

We have reviewed the technical and economic basis for the current market prices of several key chemicals. The chemicals that we chose to review were selected on the basis of their volume. There are a great deal more chemical pathways that could be explored, and that are not presented here. This analysis serves as a guide for the type of approach that is necessary in identifying targets for bio-based opportunities. To maximize the probability that innovation will be successfully commercialized it is useful to start with a thorough understanding of the target industry. We have shown that there are specific points in the chemical industry value chain where a bio-based alternative would be welcome. The inertia of the industry is such that the provision of an alternative source for an existing feedstock is much more likely to be supported than the development of a competitive product.

Key findings from chemical industry analysis:

1.) It is important to understand what stages of chemical processing are performed in Ontario.
    a. Vinyl chloride monomers are imported into Ontario.
    b. Probability of success is higher with bio-based opportunities focused on the processing of monomers to polymers in this case, rather than replacement of monomers.

2.) It is important to understand that certain chemicals may have market prices that are not directly related to their value to industry.
    a. Closed loop production of final products that involves the majority use of a given feedstock can lead to artificial prices in open markets.
    b. This is important to understand when targeting these feedstocks with bio-based alternatives.

3.) Certain chemicals are derived as co-products from value chains that have higher value.
    a. Propylene oxide can be produced as a co-product from the production of styrene from ethylbenzene.
    b. The development of processes that result in the production of co-products that can be used in other processes is a key innovation target in the chemical industry as a result of rising feedstock prices. We need to watch developments in this area as this is the key competition to bio-based alternatives.

4.) Certain feedstocks are used in a wide variety of chemical value chains.
    a. As prices increases, the opportunity for replacing these feedstocks with bio-based alternatives will be highest in the following value chains.
        i. Value chains where feedstocks are purchased across companies.
        ii. Value chains that provide lower overall profit margins
        iii. Value chains that are not core to a feedstock providers business.

5.) The chemical industry is driven by feedstock price.
    a. Competitive advantage in this industry will be driven by decreases in feedstock price.
    b. Innovation must be amenable to existing capital infrastructure, and must not lead to any sacrifices in product quality.

Recommendation*: Given that intermediate chemicals provide the most significant opportunities for cost competition between bio-based chemicals and synthetic ones, and given that certain intermediate chemicals are under more supply pressure than others, resulting in differential increases in prices we have the following recommendations;*

Research: *We recommend that chemical researchers engaged in the development of bio-based alternative intermediate chemicals focus on those chemicals that are either currently available in biomass, or are structurally similar to existing biological chemicals. Moreover, we recommend that alliances be built wherein chemical engineers identify useful chemistries, plant biochemists describe biosynthetic pathways that can be* *modified, and molecular biologists and plant breeders create industrial plant varieties capable of producing these chemicals cost-effectively.*

Government: *Given the high capital cost associated with globally competitive chemical manufacturing and the difficulty domestic arms of international chemical companies will face attracting capital investment from headquarters into Canada, in light of the existing capital investment made in Ontario, we recommend that the government of Ontario completely and immediately remove capital taxes for any facility that will create a bioproduct. This has the potential to act as a global incentive to the attraction of significant bioproduct production facilities in this province, and will demonstrate that this government is serious about working with the chemical industry to encourage innovation and renewal.*

Industry: *We recommend that the Ontario Chemical Value Chain Initiative continue to work towards building and delivering a sustainable innovation model for the industry that incorporates bioproducts.*

1.2 Fibres:

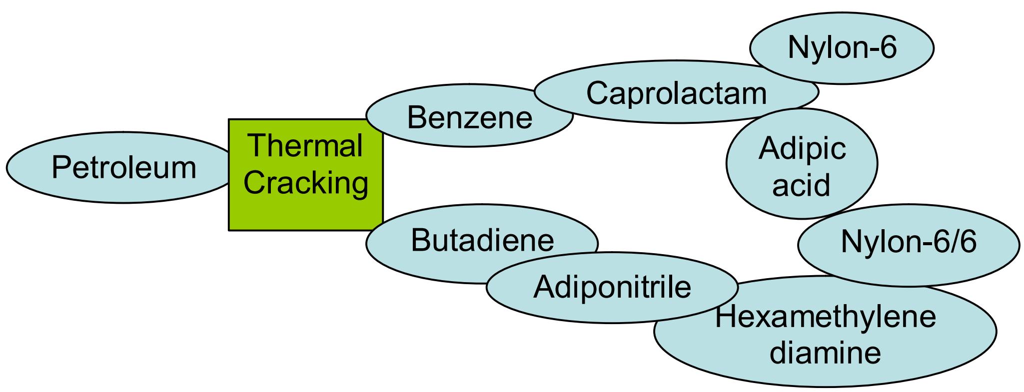
Introduction:

Bast fibre crops such as hemp, kenaf and flax produce a fibre that is considerably longer than those found in other crops. These fibres have been used for millennia in a wide variety of uses from rope to mummy wraps. Due to their high tensile strength and relatively low weight, they have the potential to replace fiberglass and/or plastic fibres either fully or in blends. First we will focus on characterizing the existing markets for fiberglass and plastic fibres in Ontario. Then, we will explore the potential for bio-fibres as an alternative, and identify the constraints to moving these opportunities forward.

Nylon:

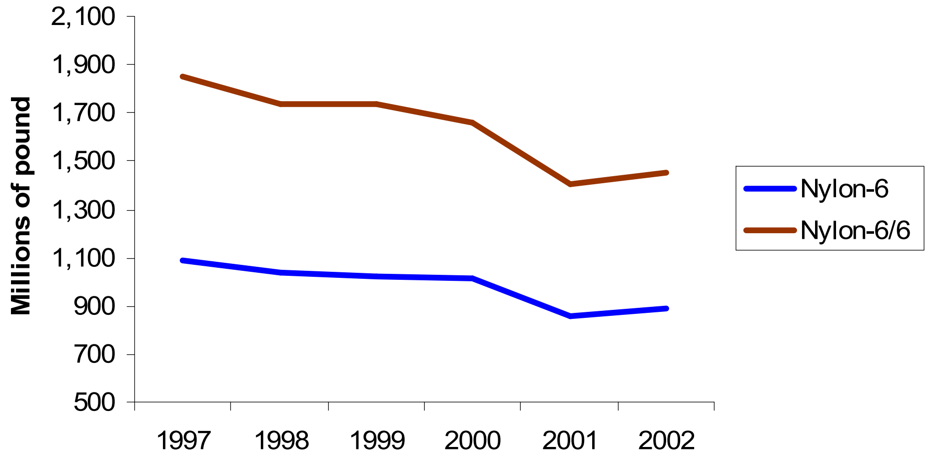
Nylon is manufactured in two basic types of fibre, nylon-6, and nylon-6/6.
Nylon-6 is manufactured by combining caprolactum with water, whereas nylon-6/6 is produced by combining adipic acid with hexamethylenediamine.

Figure 18: Product flow from petroleum to nylon.



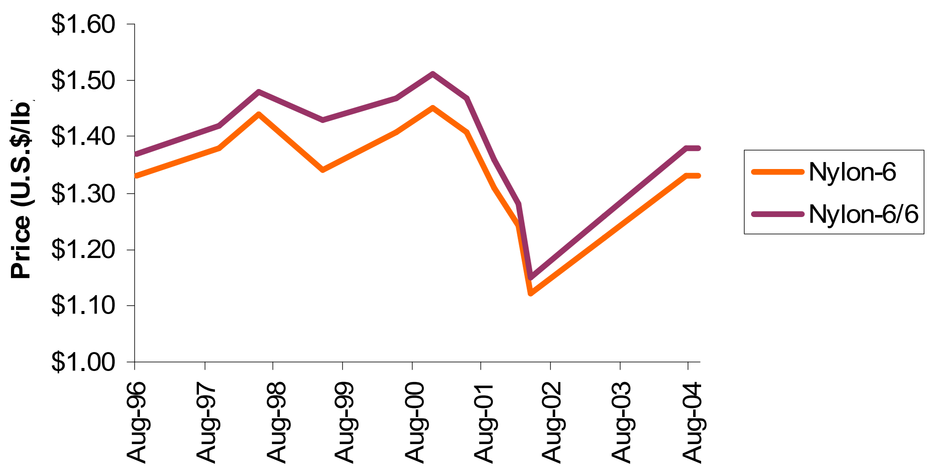
Market demand for both types of fibre have declined in recent years, but appear to have stabilized.

Figure 19: Historical production demand for nylon in North America.



Prices in 2001 reflected this decline in demand, but have since stabilized at traditional levels as well.

Figure 20: Historical nylon prices in North America.



Caprolactam is produced by only three manufacturers in North America, all in the U.S. The manufacturing facility formerly owned by Dupont in Maitland, Ontario has a capacity for the production of 330 million pounds of adipic acid per year. Nylon is used primarily in clothing and in the manufacture of composite plastic autoparts. The use of plastics in automanufacturing is continuing to increase as engineers become more comfortable with their incorporation, and demands for increased fuel economy continue.

The feedstock prices for both types of nylon appear to be well aligned within the value chain, with opportunities for profit taking at each reaction step.

Table 6: Cost/price structure of nylon production.

	2004
Cyclohexane	$0.17
Caprolactam	$0.70
Adipic	$0.73
Nylon-6	$1.36
Nylon-6/6	$1.48

Finding: *The bio-based opportunity for nylon fibre replacement needs to be based entirely on increased functional performance. The use of nylon itself in carpets and automotive parts is well established. Industry is not in need of a lower cost alternative to nylon. Competitive advantages will be derived from higher value finished products, if the cost increase is reasonable, and less than then perceived added value.*

Fibreglass:

Fibreglass was successfully commercialized in a wide variety of uses in approximately the same time frame as nylon. Markets were initially developed prior to WWII, but it was not until after the war, that commercial usage really took off. There are two basic types of fiberglass, one made from short curly fibers, commonly bound to a common backing is used for thermal or acoustic insulation. The second type consists of long, straight fibres that are mechanically drawn from solution. These fibres have found widespread use in glass reinforced plastics.

Fibreglass comes in a variety of types, however the most common (90% of applications) is termed E-glass as it was initially developed for use in plastic composite electrical housings. The E refers to the poor ability of this type of glass to transmit electricity. Prices have remained relatively stable, for large scale applications ranging depending on the type from $0.81/lb up to $1.63/lb (U.S. $).

Polypropylene:

Polypropylene represents the most significant competition for market entry and market share in industrial markets targeted for functional fiber use. The use of polypropylene in the automotive industry has risen significantly due to similar reasons driving the use of natural fibres. Polypropylene represents a lower cost alternative to fibreglass and increased environmental friendliness. Polypropylene, as a thermoplastic can be recycled, thus providing an environmental option, as well as a potentially lower cost feedstock for the future. The use of plastics in auto parts has increased from an average of approximately 100 lbs/vehicle in 1977 to over 275 lbs/vehicle in 2003 (General Motors Corp. Detroit, February 23rd, 2004).

Polypropylene is produced from propylene which is a co-product of ethylene cracking from light petroleum fractions. The price for polypropylene extruded fibre thus tracks the price for ethylene over the last several years.

Table 7: Cost/price structure of polypropylene production

	Feb-02	Feb-04	Change (%)
Propylene	$0.20	$0.35	78%
Polypropylene	$0.29	$0.51	76%

Bio-based opportunity:

Opportunities exist for the use of functional fibre in a wide variety of products. In the automotive industry, functional fibres are used in compression molded parts. Opportunites also exist for non-functional fibres in injection molded parts, especially in combination with polypropylene. This is an industry that already exists as can be seen in the following table.

Table 8: Fibre use in auto parts

Existing products	Weight (lbs)
Front door liners	3.3
Rear door liners	2.5
Trunk liners	4.4
Developing products	
Seat backs	4.0
Sun roof sliders	0.9
NVH material	1.1
Headliners	5.5
Total	21.7

Industry Canada estimates that the potential use of natural fibres in the automotive industry in North America could exceed 145,000 T by 2008. On the downside, it appears in Europe that increased use of functional fibre has been at the expense of previous use of non-functional fibre such as wood filler. The use of wood filler in the automotive industry in Austria and Germany decreased from 60,000 T in 1996 to 35,000 T in 2001. This represents a sharper decline in the use of wood fibre than was observed in terms of increased use of agricultural fibre.

Hemp fibre that has been physically processed sells for $0.35/lb (U.S.). This is definitely competitive with the prices that we have reported for all other types of fibre, including polypropylene. This price does not however, take into account the potential need for sizing of the fibre prior to application. In composite components the interaction between the fibre and the surrounding matrix is of crucial importance. This interaction is fundamentally driven by the surface characteristics of both components. The surface characteristics of the matrix are defined, it is necessary to ensure that the surface characteristics of the fibre are in maximum alignment with the particular matrix used. In functional fibre processing this step is usually referred to as retting. This is a process that involves enzymatic treatment of the bast fibre, creating a uniform surface for interactions.

The primary difference between the European functional fibre industry and the Ontario industry is our lack of resident retting capability. Retting adds a significant cost to the fibre processing process, such that it remains to be seen whether hemp or flax fibre produced in Ontario will remain cost competitive when it is fully refined.

Key constraints to the development of a domestic functional fibre industry:

1.) Variability of supply

End users must be assured of excess of supply at stable prices and consistent quality prior to the committing to the commercial development of products. The bridge towards building this assurance may be in partnering with existing European functional fibre processors. As the North American demand grows, a local processing industry will be able to compete effectively with the higher transportation, and higher production costs of European imports.

2.) Appropriate quality

Our discussions with industries potentially interested in using functional fibre in Ontario consistently identified a need for enzymatically sized fibre. Tests performed by Interface Flooring with hemp fibre based carpets demonstrated that hemp fibre that was only processed physically failed their wear tests. Similar tests performed on enzymatically treated fibre passed this test.

3.) Consistent quality

Manufacturers need to be assured that functional fibre will not vary in quality depending on when or where the crop is grown. This level of quality control is likely not possible without increased emphasis on fibre processing.

4.) Competitive price

Initial attempts to stimulate the increased use of functional fibres in Europe focused on providing subsidy support to farmers to support crop production. This served to create an excess of functional fibre production, without industry acceptance. Recent efforts have focused on the implementation of subsidy support for natural fibre processing. These subsidies create an artificially low price for natural fibre. Analysts of the European experience project a shift in market demand from domestically grown fibre from crops like hemp and flax, to lower cost foreign imported fibre like kenaf and jute. To maintain a competitive price for functional fibre in Ontario it will be necessary to increase yield and agronomic performance of the crop. The genetic and agronomic development of the crop is as important a route to the future success of this industry as improved processing capability.

Summary – Natural fibre opportunities

The natural fibre industry in Ontario is potentially posed for substantially growth. This opportunity could be a leading bio-based success story in the near term. The most immediate constraint to the development of this industry is a gap on the value chain. We have farmers who are capable of growing the crop, and processors who are building the capacity to separate primary and secondary fibre from the straw. We even have end use industry interested in using functional fibre in carpets and auto parts. We are missing a commercial retting facility. It is beyond the present analysis to fully detail the business case for such a facility. However, if a compelling business case cannot be established, then the development of this industry in Ontario will be limited.

The genetic and agronomic development of the crop are crucial to long term commercial success of this bio-based industry. If an enzyme processing facility makes business sense, then increased focus and effort on functional fibre variety development also makes sense.

Recommendation: *Given that functional fibres are being imported into Ontario after enzyme processing in Europe, and that the National Research Council of Canada has made a breakthrough in the area of enzyme treatment of fibres, we recommend the following;*

Research: *There is a need to understand how functional fibre can be applied in a wide variety of products. This understanding should be based on functional performance, cost-effectiveness, product manufacturing issues, and the interaction of fibre composite products with existing products. We recommend that the value chain approach that Dr. Mohini Sain has pursued in this sector be extended to include a broader range of products.*

Government: *We have identified a significant gap in the Ontario functional fibre value chain with the absence of an enzyme processing facility. We recommend that the Ontario government work to actively stimulate the closure of this gap by persuading investors to create a facility, or attract a foreign company to locate in Ontario.*

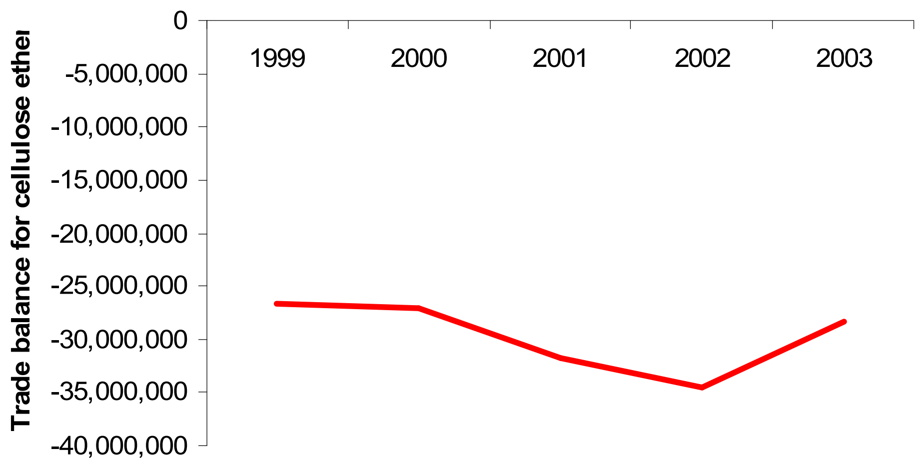
Industry: *We recommend that existing functional fibre companies in Ontario join forces with the government to work to develop an enzyme treatment facility in Ontario.*

1.3 Forestry Products:

The forestry industry is more advanced in the development of bio-product opportunities than the agriculture industry. Cellulose, and lignocellulose harvested from trees have become an important industry alongside lumber. One of the learnings from this industry, is to capitalize on the inherent strengths of an existing natural chemical rather than to try to transform it into something of lower value. Cellulose ethers have long been used as value added, texture enhancing additives to a wide variety of food products. Significant global markets exist for cellulose based fabrics like rayon. Cellulose is used in absorbent products such as diapers, and cellulose derivatives such as nitrocellulose have mature and significant markets. The forestry industry has commercialized the extraction of chemicals such as phenolic resins, MDI, and formaldehyde from co-product streams. Lignosulfonates derived from timber have been successfully commercialized as concrete admixtures, and as a source of carbon black.

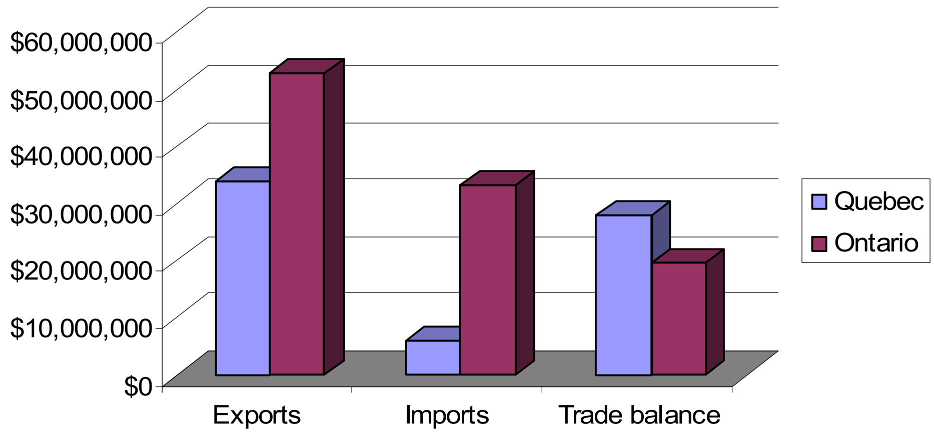
The following chart shows that the province of Ontario has a stable, negative trade balance in regard to cellulose ethers.

Figure 21: Ontario cellulose ether trade balance.



The phenolic resin market is a market that is, or can be impacted by forestry products. Quebec has developed a greater trade balance in this market than Ontario.

Figure 22: Comparison of Ontario and Quebec trade balances for phenolic resin (import/export).



North American demand for formaldehyde is approaching 10 billion lbs/year, at a current price of $0.21/lb (U.S.). Canada currently has the capacity to produce 1.8 billion lbs, how much of this is being sourced from the forestry sector remains unclear.

Bio-oil:

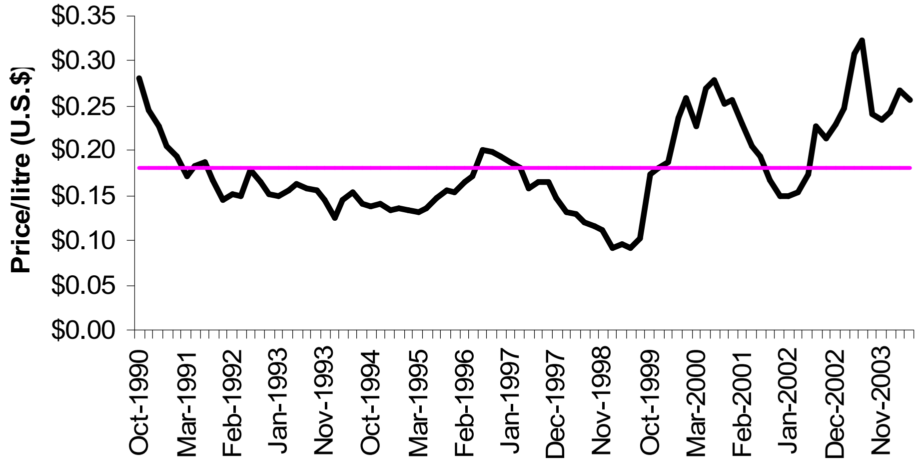
There are three companies in the province that are exploring opportunities to convert cellulosic feedstock into bio-oil using fast pyrolysis, Ensyn, Dynamotive and GreenEnergy. The increasing price of electricity and the need for the province of Ontario to increase both base and peak load capacity have created a potential market demand for this product. On a weight basis the heating value of bio-oil is only 40% that of diesel, while on a volume basis the heating value is 55% that of diesel. Bio-oil can be combusted in the same turbines used for diesel firing.

Table 9: Comparison of bio-oil to fuel oil.

	BioOil	Light Fuel Oil	Heavy Fuel Oil
Heat of combustion BTU/lb	7100	18200	17600
Heat of Combustion MJ/litre	19.5	36.9	39.4
Viscosity (centistokes) 50°C	7	4	50
Viscosity (centistokes) 80°C	4	2	41
Ash % by weight	<0.02	<0.01	0.03
Sulphur % by weight	Trace	0.15	0.5
		to 0.5	to 3
Nitrogen % by weight	Trace	0	0.3
Pour Point °C	-33	-15	-18
Turbine NOx g/MJ	<0.7	1.4	N/A
Turbine SOx g/MJ	0	0.28	N/A

The cost of heating oil has varied with the cost of crude oil, however the average wholesale cost of home heating oil in the U.S. has averaged $0.18/litre (U.S.).

Figure 23: Historical cost of heating oil.



The cost of bio-oil is highly dependent on the cost of the feedstock. Current pricing we have received for bio-oil is equivalent to $0.159/Litre (Cdn), or $0.127 (U.S.) Historically this means that bio-oil given that it only provides 55% of the heating value of diesel fuel, has been slightly more expensive than heating oil ($0.008/1,000 Btu/hour versus, $0.007/1,000 Btu/hour). If we look at current prices the story is quite different however.

Table 10: Comparison of heating prices for various feedstocks with bio-oil.

	Cost/unit	Btu/unit	Operating cost (1,000 Btu/hour)
Natural gas	$0.361/m^3	35,500	$0.010
Propane	$0.627/L	24,000	$0.026
Fuel oil	$0.559/L	36,000	$0.016
Electric heat	$0.104/kWh	3,400	$0.031
Hardwood	$213/cord	29,000,000	$0.007
Wood pellets	$206/T	16,500,000	$0.012
Bio-oil	$0.159/L	21,134	$0.008

Bio-oil is presently half the cost of heating oil, and substantially less expensive than natural gas. The only feedstock that comes close in price is the direct combustion of hardwood, which is not practical in the majority of commercial applications.

In regard to electricity generation, the comparison is also intriguing. We have estimated the current, large contract user cost of natural gas generated electricity is paying $0.32/m^3 of natural gas or $8.76/gjoule, or $0.03/KWh. The corresponding cost for bio-oil at $7.00 to $8.00 per gjoule is lower, but does not include transportation costs. Transportation costs will become a key element if the bio-oil production facility is in the north, and the electricity generation is in the south. Clearly, bio-oil production needs to be located in physical proximity to a secure, low cost feedstock. Early applications of this technology appear to be more suited to electricity generation in the north.

Key constraints facing the development of a bio-oil industry:

1.) End user reluctance to invest the necessary capital to build a liquid combustion turbine rather than a gas fired turbine.

This constraint could be overcome with the development of co-fired, liquid/gas turbines. Research in this area should be encouraged.

2.) Secure access to low cost feedstocks.

The Forestry industry in Canada leases the timber rights for forestry operations. This can lead to a lack of clarity over ownership of slash. In addition, this system makes it difficult to predict where forests will be harvested. These variables lead to uncertainties in the volume of feedstock supply and the cost of feedstock supply. Uncertainty of this type creates significant difficulties in obtaining investment capital.

Finding: *Commercial bioproduct opportunities are being developed globally in the forestry industry because they make economic sense. The opportunity exists to expand this development into Ontario.*

Summary – Forestry Industry

The Ontario forestry industry lags behind Quebec in Bio-product development, primarily because the lead company in this area, Tembec, has focused more of these manufacturing opportunities there. Several markets and processes for forestry based bio-products have a mature market presence. The challenge for us is not necessarily one of introducing innovation to industry, but attracting investment in bio-based opportunities into the Ontario forestry industry. We have strong and respected research leaders who have recently been appointed to positions of bio-product champions in the north, including Errol Caldwell, and David Deyoe.

Recommendations: *Given that forestry bio-product opportunities have been commercialized in a broad range of applications globally;*

Research:
That research on forestry opportunities be focused on existing commercialized products.
That research focus on the added value possible within the Ontario forest germplasm base. [Example/ Work such as the identification of terpene composition of Ontario tree species undertaken at the Great Lakes Forestry Centre, be aligned with commercial applications of these terpenes.]
Significant efforts need to be exerted building meaningful relationships in regard to bioproduct development with leading forestry companies such as Tembec.

Government:
The ownership of provincial forests, and in particular the ownership of the residue remaining from forest harvesting operations serves as a key constraint to the commercialization of forestry based bioproducts. We recommend that the Ontario government form a task force mandated to develop a solution to this problem.

Forestry based bioproduct opportunities are more mature than agriculturally based opportunities. We recommend that the Ontario government use existing northern economic incentive programs to attempt to aggressively attract investment in forestry bioproduct manufacturing in the north.

Industry:
The existing Ontario chemical industry has not investigated the potential of the forestry industry as a source of intermediate chemicals. We recommend that industry associations form research teams assigned to explore the potential of these opportunities.

1.4 Renewable transport fuels:

Introduction:

The renewable fuel industry in Ontario is a leader in Canada with 150 M litres of ethanol production capacity by Commercial Alcohols in Chatham, and the announcement of a 60 M litre biodiesel facility in Hamilton by Biox. The provincial and federal governments have stimulated the development of this industry by exempting renewable fuels from retail fuel tax. The province of Ontario has exempted ethanol fuel from their $0.147/litre fuel tax, and biodiesel from their $0.143/litre fuel tax. There is concern that this tax exemption has not delivered enough incentive to the industry to encourage further private investment. Clearly, the economics of ethanol and biodiesel fuel are not compelling enough to cause a race on the part of the existing petroleum industry, or private capital to invest. In part, this reluctance to invest in the industry is a function of an oversupply of domestic refining gasoline refining capacity. Existing capital investment is being underutilized, thus eroding desire to invest in incremental infrastructure.

1.) Biodiesel:

The development of any fuel industry is based primarily on feedstock cost. For biodiesel manufacturing technological breakthroughs achieved at the University of Toronto have broadened the prospective feedstock supplies to almost source of fatty acids.

Table 11: Comparison of biodiesel prices based on different feedstocks.

	Oil price ($/lb)	Fuel price ($/L)
Soybean oil	$0.32	$0.64
Palm	$0.19	$0.37
Canola	$0.43	$0.86
Inedible tallow	$0.21	$0.42
Edible tallow	$0.27	$0.54
Yellow grease	$0.20	$0.39
Diesel		$0.49

Based on this technology and including an operating cost for biodiesel production of $0.11/litre, biodiesel manufactured from palm oil, inedible tallow and yellow grease is competitive with the current cost of diesel fuel when we consider the federal and provincial tax exemptions on biodiesel in Ontario. In 2006, the Canadian government has proposed introducing a new diesel fuel standard mandating ultra low sulphur content. This change has the potential to stimulate the biodiesel industry as a 2% biodiesel blend provides the necessary lubricity that sulphur currently provides. The feedstocks listed as commercially viable above do have high melting points, however this is not seen as a concern in 2 to 5% blends.

Canada consumes an average of over 22 billion litres of diesel fuel annually for transportation purposes. A 2% blend of biodiesel in all this fuel would amount to a market for 440 million litres of biodiesel annually. This is an industry that Ontario is well positioned to lead given the presence of animal fat rendering facilities, large quantities of yellow grease, and proximity to major diesel refineries and distribution centres.

Processing technology has advanced to the point where close to a 1:1 transformation of fatty acids in feedstocks are converted to methyl esters. Given that biodiesel production is not based on enzymes, or microbial fermentation, there appears to be little room for further process improvements. For every 10 litres of biodiesel manufactured, 1 kg of glycerin is produced. At present, glycerin has maintained a market value of approximately $0.50/lb. In 2000, the North American demand for glycerin exceeded 450 million pounds, at a price of $0.60/lb. This market is being supplied by chemical manufacturers who are primarily extracting glycerin from fats and oils without creating biodiesel. The price may drop as a function of oversupply from biodiesel manufacturing, but if so, it is probable that the existing chemical operations will close down before the biodiesel operations do, thus relieving the oversupply pressure.

2.) Ethanol:

Ethanol production from corn starch is currently the most cost-effective means of production. Significant efforts are underway to develop corn hybrids that produce higher levels of ethanol. Ethanol production is based on fermentation, and while the existing facility in Chatham is among the most efficient in North America, there is room for improvement. The presence of ethanol in the fermentation chambers reduces the life expectancy of the resident yeast colonies, and directly inhibits the enzymatic process. Chemical engineering as well as in vitro enzyme evolution research capabilities present in the province have been under engaged in attempts to increase the efficiency of this process.

The ethanol from corn starch value equation, including the co-product, dried distillers grains and solubles works out to $0.68/Litre (Cdn).

Table 12: Value of ethanol production including co-products.

Ethanol value		
Value/litre gasoline	$0.39	$/L
Subsidy support/litre	$0.15	$/L
Total value/litre	$0.54	$/L
DDGS yield	17	lbs/bu
DDGS yield	0.69	kg/litre ethanol
DDGS value	$200.00	$/T
DDGS value/Litre ethanol	$0.14	$/Litre
Total value	$0.68	Cdn$/litre ethanol

This does not include a consideration of costs however. The capital cost of an ethanol production facility has been estimated as close to $1.00/litre of annual production capacity. This is four times the capital cost implicit in a biodiesel manufacturing facility ($0.25/litre of annual production capacity).

Table 13: Cost of ethanol production.

Cost of production		
Capital cost	$0.44	$/gallon
Capital cost	$0.10	$/litre
Feedstock cost	$4.39	$/bu
Ethanol yield	2.50	Gallons/bu
Ethanol yield	11.37	Litres/bu
Feestock cost/litre of ethanol	$0.39	$/litre
Operating cost	$0.04	$/Litre
Total cost of production	$0.52	$/Litre

This rough estimate of costs versus value results in a positive operating value, that is almost exactly equal to the tax exemption in place. The future of this industry, in the absence of a government mandate, will only be secured by process improvements that lead to at least a 25% increase in efficiency.

Ethanol production from cellulose, hemicellulose or other forms of 1,4-β glucose to glucose bonds are being pioneered by Iogen. The forestry company, Tembec currently produces 18 M litres of ethanol for conversion to acetic acid and commercial application as vinegar in Quebec. The primary constraint facing cost competitive cellulose conversion to ethanol is the cost of the enzymes used to degrade cellulose. Great advances are being made in this area, and there is no reason to believe that cellulose based ethanol production cannot become a cost effective alternative to starch in the future.

Recommendations: *Given that the primary constraint to increased use of renewable fuels by the existing petroleum industry is their cost;*

Research: *Research efforts should be focused on increasing the efficiency of renewable fuel production. This means research that will lead to increases in fermentation efficiency, increases in co-product value, and improvements to germplasm that will result in more fuel being generated per bushel of grain. This latter aspect may also apply to the BDM biodiesel technology.*

Government: *The imposition of mandates without significant stimulation for renewable transport fuel manufacturers to use domestically produced commodities will lead to the importation of renewable fuels from other geographies. We recommend that the government of Ontario continue to work with the entire renewable transport fuel value chain, including the existing petroleum industry, renewable fuel manufacturers, and feedstock suppliers to create a framework that will sustain and encourage domestic innovation throughout this industry.*

Industry: *To be successful in the long term the petroleum industry should play a more significant role than as a purchaser and blender of renewable fuels. Ultimately, these companies have a greater capability to identify and commercialize co-product or alternative market opportunities derived from renewable fuels than start up companies. We recommend that the petroleum industry commission a study of the potential added value and cost savings that could be realized by the integration of renewable fuels manufacturing capacity into their existing manufacturing capacity.*

Section 2. Ontario's capacity to develop bioproduct opportunities.

2.1 Technology Innovation

Biodiesel:

Ontario is fortunate in being a world leader in several bioproduct enabling technologies. Dr. David Boocock at the University of Toronto was responsible for an innovative breakthrough greatly extending the range of feedstocks that are commercially available for bio-diesel production. The Biox Corporation obtained a license to this technology and in a continuing alliance with Dr. Boocock are in the process of commercializing the approach in a 60 million litre biodiesel production facility in Hamilton. This facility will be one of the largest in North America, and thus will go well beyond providing a working model demonstrating the efficacy of this technology.

Fast Pyrolysis:

Dr. Robert Graham and Barry Freel developed a process they termed Rapid Thermal Processing (RTP) starting back in the 1980's and leading to their first patent in 1991 issuing in 1991. Under the company name, Ensyn, they initiated commercialization of their process in 1989, and have succeeded in developing four operating plants to date. At present they are developing a fifth plant in Renfrew, Ontario. Ensyn currently markets 30 different products derived by RTP from biomass. Product applications range from food additives, copolymers/polymers, petroleum and natural chemicals. Ensyn has recently entered into a joint development program with Louisiana Pacific Corp (the leading wood product company in the U.S.) to develop adhesives from wood bark.

Oriented wood composites:

Dr. Frank Maines has led research efforts at PSA Composites in Guelph toward the development of second generation wood composites. PSA Composites has achieved a breakthrough by applying a pulling pressure on extruded cellulose fibre composites. This pressure increases the longitudinal orientation of the fibres while creating voids between fibres. This structure is similar to that of natural wood. Previous plastic lumber applications were limited due to the weight and cost of the products. PSA Composites has signed a joint development agreement with Green Forest Engineered Products LLC, Nevada, Missouri to create and market oriented fibre plastic wood. There are many commercial applications of Dr. Maines technology and he is actively pursuing similar development agreements with other major companies.

All three of these technologies represent innovations that occurred in Ontario. The latter two technologies either were, or will be commercialized outside of Canada first, due to a lack of domestic investment.

Finding: *We do not lack for opportunities or innovation in Ontario, we lack ability to mobilize capital for the domestic commercialization of industrial innovation.*

2.2 Provincial Capacity

1.) Forestry Industry

Ontario has a mature forestry industry located primarily but not limited to the north. Canada has a total land mass of approximately 988 M ha, of which slightly more than half, 51.2% is non-biomass supporting. The majority of the remainder supports forests (42%) while agriculture utilizes less than 7% of the total land mass. In Ontario, the proportions are similar. Ontario has a land area of 106.8 million hectares, of which 74% is forested. Of the forested area, approximately 77% is classified as productive (and thus potentially harvestable). In 1998, 220,503 ha of Ontario forest were harvested representing 23,600,000 cubic metres of logs.

Figure 24: Ontario forest harvest 1990-1999.

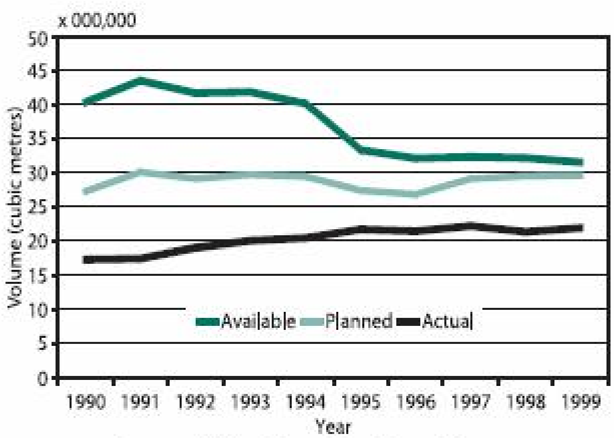


Figure 5.1.4b. Available, planned, and actual harvest volume, 1990-1999.

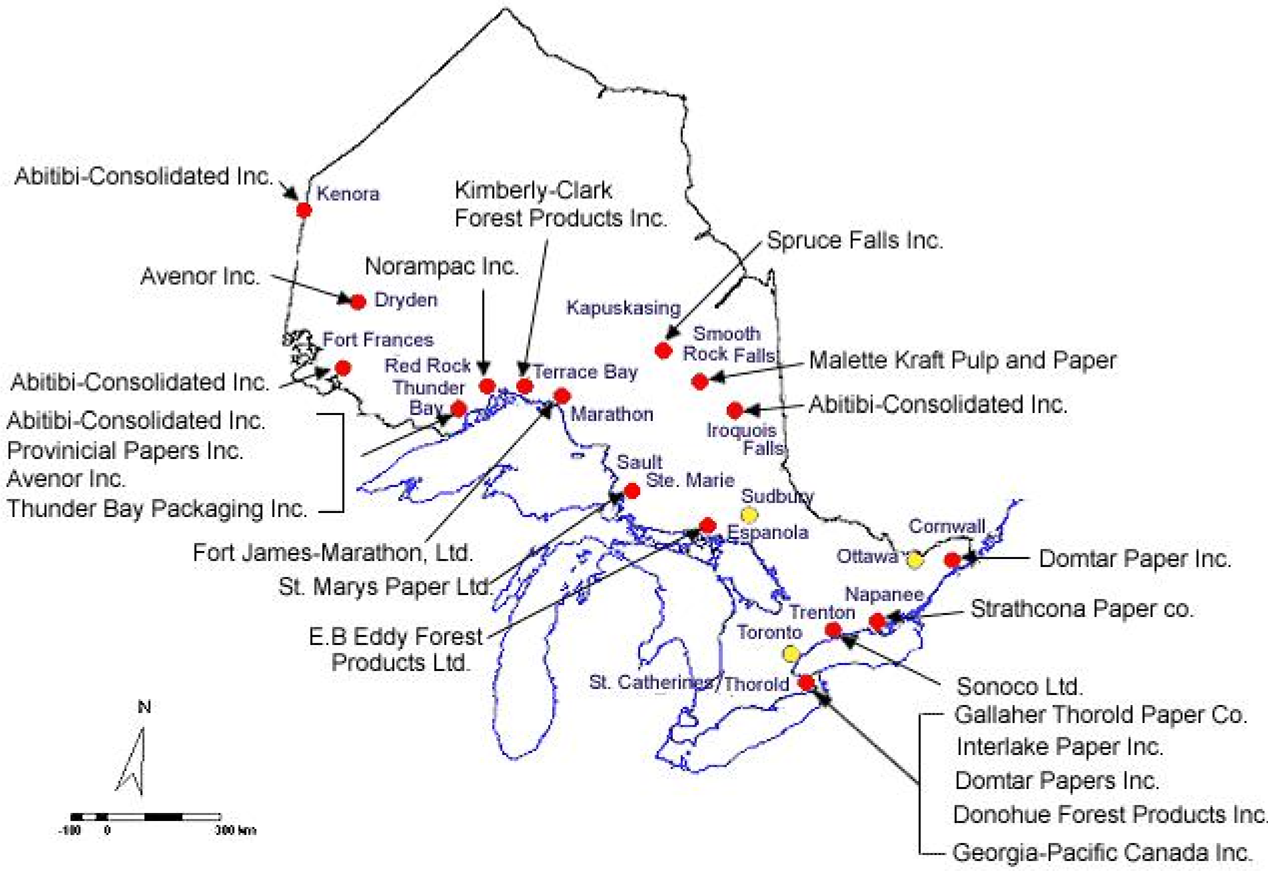
The average density of a log is 500 kg/m^3. Thus, the 1998 harvest resulted in the removal of 11.8 million tonnes of timber. It is commonly assumed that 50% of lumber by fresh weight is carbon, so the Ontario lumber harvest represents 5.9 million tonnes of carbon harvest per year. The net earnings of the Ontario forest and forest products industry in 1998 was $470 million. The following table provides an estimate of the net value of timber and forest carbon.

Table 14: Estimated net value of timber and carbon from Ontario forestry industry.

	Value
Cubic metre of timber	$20
MT of timber	$40
MT of carbon	$80

The forestry industry in Ontario is mature and is comprised of participants from a wide variety of multinational and Canadian companies.

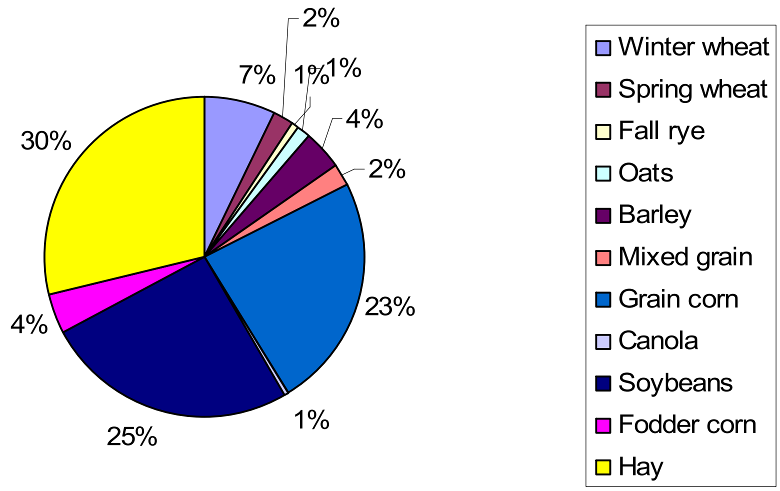
Figure 25: Geographic distribution of Ontario pulp and paper companies:



2.) Agriculture

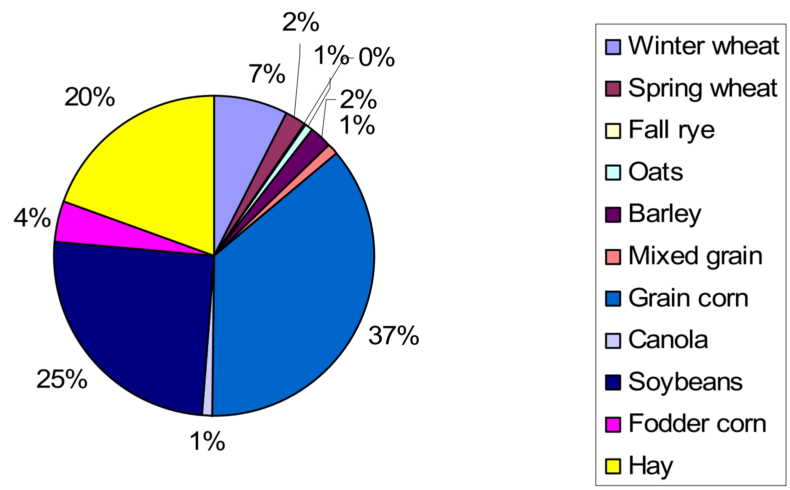
In Ontario it is possible to produce a wide variety of crops on the available 8,500,000 arable acres. Traditionally though, the primary crops grown are corn, soybeans and hay as seen in this summary of the 2002 growing season.

Figure 26: Distribution of crops in Ontario on a per acre basis;



The value generated from this production is important as this needs to be considered as the opportunity cost, were any of these crops to be replaced or supplanted by a crop or variety designed for bioproduct production. The proportionate values generated by each crop are roughly correlated with their acreage, with the exemption that hay production is of significantly lower value than other crops.

Figure 27: Proportion of total value for top crop species in Ontario.



For bioproducts it is more useful to think of this production in terms of useable carbon. Using standard calculation techniques (See Industry Canada's Biomass Availability portion of Canada's Bioproduct Innovation Roadmap for full documentation) we estimate the carbon available from these crops as follows;

Table 15: Total biomass harvested in Ontario from leading agricultural crops.

Crop	Hectares	Yield (ODT/ha)	Total yield (ODT)	Straw (ODT)	Available straw (T)	Total biomass (ODT)
Grain	580,713	1.88	1,091,741	1,419,263	709,631	1,801,372
Corn	904,456	6.42	5,806,604	5,806,604	2,903,302	8,709,907
Soybean	835,660	1.51	1,261,847	1,261,847	630,923	1,892,770
Hay	950,993	3.27		3,109,749	3,109,749	3,109,749

This results in estimates of carbon availability from grain and straw respectively from the province as follows;

Table 16: Total renewable carbon harvested in Ontario from leading agricultural crops.

	MT carbon grain	MT carbon residue
Grain	458,563	319,334
Corn	2,438,774	1,306,486
Soybean	630,923	283,916
Hay		155,487
Total MT carbon	3,528,260	2,065,223

These numbers can be used as a basis for determining the availability and cost of biomass for industrial purposes.

In consultation with the Ontario Corn Producers we have estimated the potential value equation for the collection of corn residue for industrial purposes as described below;

Table 17: Value of corn residue in Ontario.

Corn yield	115	bu/acre
	6440	lbs/acre
Residue available	2.94	MT/acre
Harvestable corn residue		
Shredded and raked	2.45	MT/acre
Raked	1.92	MT/acre
Baled after combining	1.40	MT/acre
Corn bale weight estimates		
Bale weight	1,100	Lbs
Bales/truck	30	
Maximum weight per load	14.96857	MT
Machinery costs		
Baler	$10.49	Cdn $/MT
Tractor use for shredding and raking	$43.86	Cdn $/MT
Raking	$6.67	Cdn $/MT
Shredder	$3.81	Cdn $/MT
Moving bales off field	$1.91	Cdn $/MT
Total	$66.75	Cdn $/MT
Transportation cost per MT	$0.36	Cdn $/MT/km
Transportation cost per load	$5.38	Cdn $/km
Farm cost to deliver corn biomass 50 km	$84.72	$/MT
Farm profit margin	$50.00	$/MT
Total cost	$134.72	$/MT
Cost per unit	0.06111	$/lb

This estimate of $134.72/MT is obviously much higher than the estimates for biomass cost from forestry. However, the biomass costs for forestry have not yet been subjected to analysis that includes added costs for collection, separation, storage, cleaning, and profit for handlers.

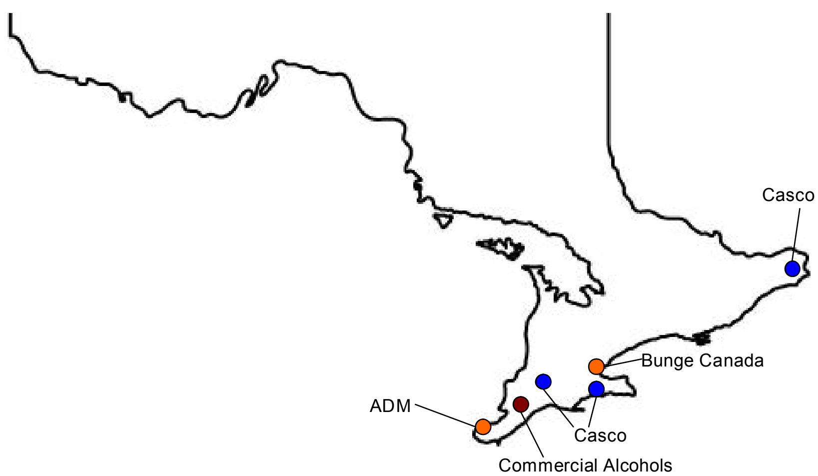
We provide these value estimates as a grounding basis only. Bioproducts will be manufactured from a variety of components within biomass, not simply carbon. The value added by biology in putting carbon together into molecules will be captured as these molecules will serve as the feedstock for manufactured goods. The values that will determine the feasibility of any given bioproduct opportunity will be the opportunity value of these molecules (fibres, oils, sugars, starches, and protein) in their existing food and feed markets.

Vegetable oil:

Soybean oil is the primary vegetable oil produced in Ontario, at two large crushing plants, Bunge Canada (Hamilton) and ADM (Windsor). Bunge Canada has a daily crushing capacity of 3,000 T, while ADM has a slightly larger capacity at 3,600 T/day. This represents an average annual oil production of 307,000 MT.

Approximately 40% of the corn harvested in Ontario is currently used for industrial purposes in wet milling operations at CASCO or Commercial Alcohols.

Figure 28: Grain processing capacity in Ontario.



2.3 Ontario Research capability:

The public sector research capability in Ontario represents a true strength with world class capabilities located throughout the province.

Figure 29: Geographical locations of Universities in Ontario:

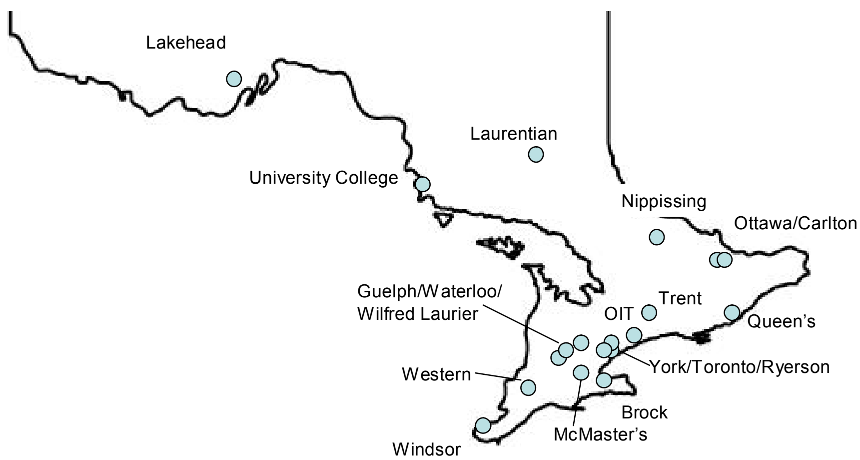


Figure 30: Location of Agriculture and Agri-Food Canada facilities in Ontario:

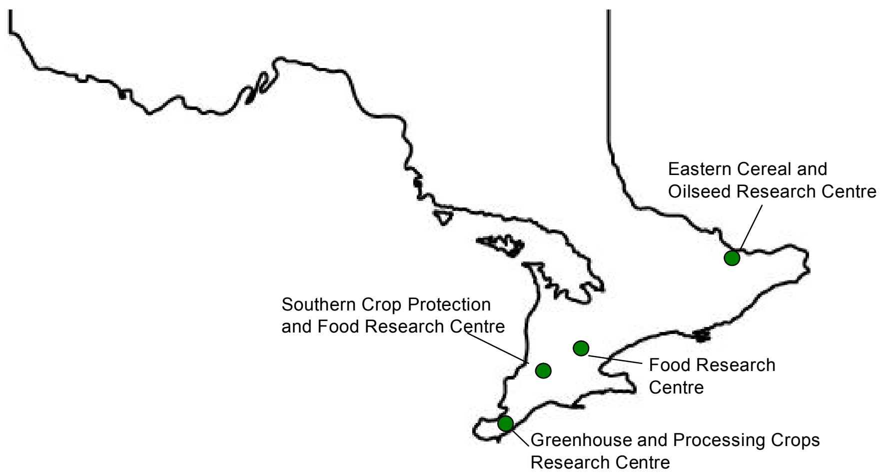
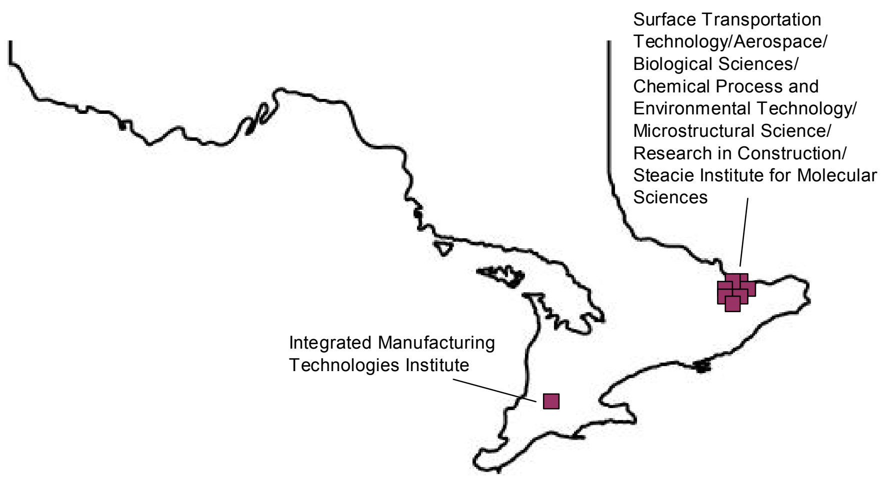


Figure 31: Location of National Research Council Facilities:



2.4 Summary of Regional Strengths and Opportunities:

Ottawa and eastern Ontario

This region has key strengths in the area of renewable fuel manufacturing with four companies being active in the area;

Topia is actively developing capacity to become Canada's first bio-diesel manufacturer. Topia has successfully opened two service stations in the Toronto area that were the first in Canada to provide bio-diesel fuel to the retail market. Topia has not committed to a geographic location for their manufacturing facility.

Ensyn has developed and commercialized patented technology involving pyrolysis of biomass. They are currently building a manufacturing facility in the Renfrew area, and are focused on commercializing opportunities in the phenolic resin market.

Iogen caused a significant global stir recently by announcing the commercial sale of ethanol produced from cellulose. Iogen is headquartered in Ottawa, and has a history of working with the public sector on research driven solutions to their corporate problems. Iogen also has significant in-house R & D capability.

Seaway Valley Ethanol is a consortium of parties interested in developing a corn based ethanol production facility in the Cornwall area. This project has been progressing for a few years, but has gained steam recently with an infusion of federal capital and continuing support from the Farm Credit Corporation.

This region is eager to explore the concept of eco-clusters of companies as desirable and the region is committed to work with existing economic development opportunities through this mindset. Ottawa was an early mover in seeing and capturing value in the life science sector. They have established excellent communication networks, and are well positioned to bring additional players into their research and development communities. Ottawa is a leading centre in Ontario in terms of capacity for research in bioproducts. The presence of several National Research Council laboratories with expertise in chemistry, construction and manufacturing as well as biological sciences, in close proximity to agricultural research capability at Agriculture and Agri-Food Canada (ECORC) and at Kemptville College, and basic biology research programs at the University of Ottawa represent more of a critical mass in this area than elsewhere in the province. Mobilizing this critical mass across corporate barriers will be a challenge, but the current public sector environment is more supportive of bridge building than it ever has been.

The mobilization of the resident research capability will take a champion and/or a novel organizational approach. We see Ottawa playing a major role in a provincial innovation strategy by bringing the research capabilities of NRC/AAFC and Universities together to generate innovation that can be disseminated throughout the innovation network

Guelph/Waterloo

Key strengths within this region:

The University of Guelph by virtue of it's reputation, it's capabilities and it's $50,000,000 contract with the Ontario Ministry of Agriculture and Food, is the preeminent University agricultural research centre in Ontario. The president of the University has clearly declared that bioproducts is a key and central focus of the University in the years ahead. The region is positioning the University of Guelph as the focal point for the manipulation of germplasm for industrial uses. The University of Guelph is well equipped to bring capabilities in traditional breeding, molecular assisted breeding, physiology, and molecular biology to bear on understanding or creating the variability needed in crop species to meet the developing needs of industry.

The University of Waterloo is a leader in the province in terms of applied enzyme engineering, immobilized enzyme support analysis, fusion of enzyme supports with self-assembling systems, and *in vitro* enzyme evolution. These research skills will be central in building a competitive advantage for Ontario. In addition, the University of Waterloo has a centre for polymer chemistry, that is well positioned to link these skills in enzyme research to receptor industries, as well as polymer chemistry groups throughout the province. We see significant potential in forging more significant linkages between these research capabilities, and the research capabilities at the University of Windsor, as a key innovation driver in the network we are seeking to build.

Northern Ontario Biotechnology Initiative (NOBI)

Thunder Bay/Sault St. Marie

Substantial efforts have been made within the last five years to create the infrastructure necessary to attract and build life science based companies. Lakehead University is located in Thunder Bay, and has received a 100% increase in faculty funding since 1998, as well as the establishment of an Innovation Management Office in 2000. The Northwestern Ontario Technology Centre was founded in 1999, and Confederation College established a centre on Forest Excellence in 2003. Sault St. Marie has also developed an innovation centre. Sault St. Marie is home to Algoma University College, a college of Laurentian University, and the region is the site of the Great Lakes Forestry Centre, and the Ontario Forest Research Institute. Substantial forestry research capabilities exist throughout the region, that are globally recognized. Lakehead University has significant research capabilities in forestry, and is well linked through a forestry centre of excellence program to private companies, and private research facilities.

The key strengths in this region as we see them for the province of Ontario are as follows;

This region encompasses both ends of Lake Superior, and thus acts as a receptor for grain and forestry products from the surrounding region, and from western Canada. A key cost factor in the development of bioproduct opportunities lies in the collection cost of biomass. This region acts as a focal point for collection, and thus is positioned to add value to bioproduct value chains by becoming increasingly involved in further processing of biomass. The separation of components in Thunder Bay would facilitate more focused and thus more cost-effective distribution channels of bioproduct components to end users.

More analysis of these opportunities is required, but at first glance it appears that the bio-processing of grain products, and/or straw residue from western Canada may have economically competitive advantages over other regions of Ontario. More small grain cereals pass through these ports than are produced in Ontario. The abundance of forestry products, the existing research and development linkages, and the potential for the development of distribution channels to Ontario's industrial receptors clearly position the region well for forest biomass processing opportunities as well.

Sudbury/Timmins/North Bay

This region has significant University led research capability with Laurentian and Nipissing Universities. Basic chemistry and bio-processing are not current strengths at these institutions, however. Tembec, a private company has been an active leader in the development of bioproducts through the commercialization of resins, lignosulfonates, and ethanol (acetic acid). Tembec produces 570,000 MT of lignosulfonates per year globally. Lignosulfonates are used as binders in animal feed, fiberglass resins, clay bricks, pesticides, and ceramic tile. Lignosulfonates are also used as dispersents in concrete, drywall, textile dyes, and wax/water emulsions. Tembec manufactured resins are distributed exclusively through BASF and are primarily used for the manufacture of plywood, and particle board. Tembec also produces 18 million litres of ethanol via fermentation of biomass. Tembec spends approximately $75 million per year on research and development, of bioproducts. A key to success will be persuading Tembec to develop manufacturing capability in this region. Sudbury has significant strengths in mining and health research and delivery.

Southwestern Ontario

This region is the focal point for two of Ontario's major industries, chemical manufacturing, and auto manufacturing. Primary chemical manufacturing is centered around Sarnia with the presence of four Nova chemical plants, Bayer, ESSO, and Dow. The region contains most of the private research and development activities in chemistry and auto manufacturing.

Figure 32: Chemistry Research and Development in southwestern Ontario.

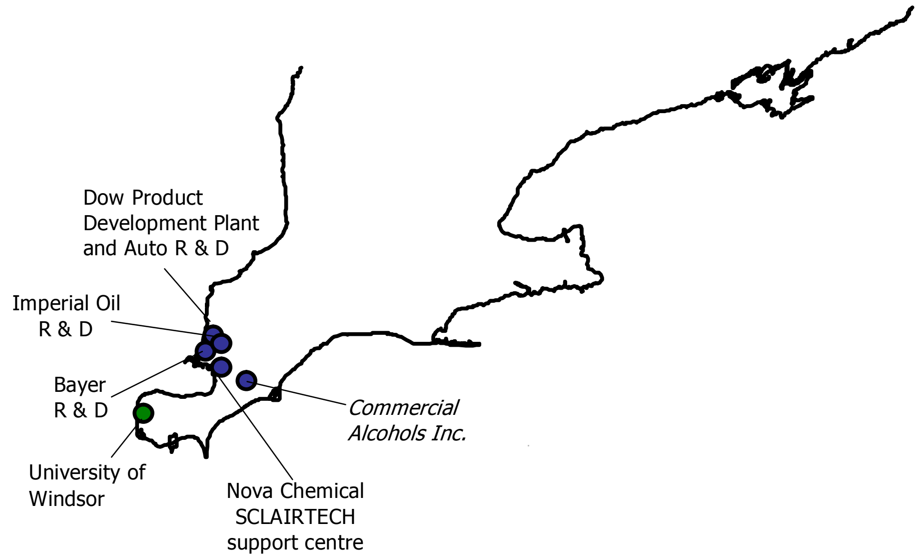
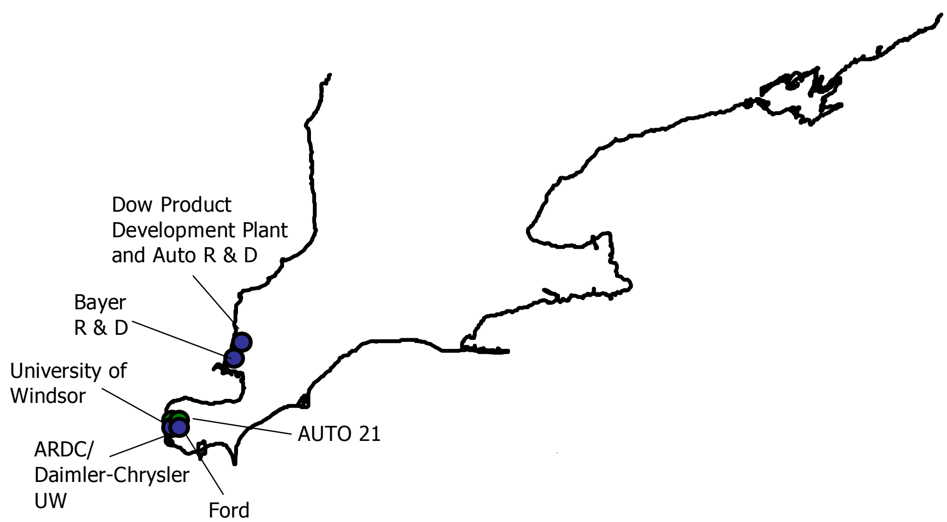


Figure 33: Auto manufacturing research and development in southwestern Ontario.



These research capabilities are linked to the lead U.S. activities in Michigan on an ongoing basis. The region is well served with public research capabilities with the University of Windsor, St. Clair College, Lambton College, and Ridgetown College

(University of Guelph). Ridgetown College is well positioned to work with developing opportunities in bioproducts in regard to research capabilities with agricultural product bioprocessing. Numerous private research and development facilities in crop development are located in the area (Monsanto, Pioneer, Thompson Seeds, and Syngenta).

Chatham has successfully nurtured the development of two bioproduct companies. Wellington Polymer manufacturers cedar shake like shingles from a mixture of flax straw and recycled tires. Wellington Polymer has just added a second production line in order to keep up with continued increases in product demand, and is planning to install a third line as soon as possible. Chatham is also home to the province's largest producer of ethanol with the Commercial Alcohols Inc. plant. This plant produces 175 million litres of ethanol from corn starch per year.

Within the OBIN region, Commercial Alcohols also operates a smaller plant in Tiverton capable of producing 22 million litres of ethanol per year, and Suncor has announced it's intention of building an ethanol plant in Sarnia in the near future.

Golden Horseshoe

Regional capabilities are strong in the area of chemical research at the McMaster's and Brock University as well as in enzyme engineering. The presence of an eco-industrial, co-product dependent cluster in Port Colborne is a strength that can be leveraged for further growth, as both participant companies (CASCO and JBL) are looking for growth opportunities. The region is home to a significant secondary manufacturing industry, particularly in plastics. This region also contains a healthy and growing greenhouse industry, primarily focused on flower production.

The Niagara region has a significant wine industry and the research and economic development capabilities of Niagara College. The wine industry represents a different biomass opportunity than those presented by other agricultural commodities. Grapes are processed locally, often by the growers themselves. This represents an opportunity in terms of flexibility and an eagerness to squeeze more value out of collected biomass, but a constraint in terms of focused capital infrastructure.

A consortium of parties has been successfully driving forward a plan to build an ethanol production facility in Brantford.

We see opportunities to garner more value out of the grape and greenhouse industries through the potential extraction of components as bioproduct feedstocks. The University research capabilities need to be explored further prior to building an understanding of how they can best be applied to a provincial strategy. The existing co-product value park in Port Colborne represents a significant opportunity as a catalyst for growth of bioproducts as an industry in the region and in the province.

London

The London region has the capacity to play a integral part in any strategy involving the delivery of bioproducts into industry. London has significant research capability at the University of Western Ontario, and with the Integrated Manufacturing Technology Institute. The development of a University of Western Ontario sponsored bioproduct research park in cooperation with Dow in the Sarnia area, represents an excellent opportunity for not only developing and commercializing bioproduct innovations, but also for building a linkage between this region and the OBIN region.

The London region contains a significant concentration of secondary plastics manufacturing companies, particularly in relation to auto manufacturing.

We see the London region as having the potential to be a knowledge generation centre in the interface between chemistry and bioproducts. We also see London as being important in playing a key role in the transfer of primary chemicals and innovation from the OBIN region into a broader secondary manufacturing community.

Central and Eastern Ontario

Kingston has a significant public sector research capability with Queen's University and private sector chemical research and development with the local presence of Dupont. KoSa and INVISTA are major primary plastic resin manufacturing companies, located in the region. Queen's University has strong capacity in molecular biology and chemistry. The presence of BIOCAP in the region, will provide an important tool for leveraging support, understanding opportunities, and building linkages broadly across Canada and the world.

The CEO region has a demonstrated history of being able to attract manufacturing companies based on their geographic location between Toronto, Ottawa and Montreal, with proximity to the U.S. and lower land prices than in the urban centres. This region along with the Ottawa region is also well positioned to interact with Quebec industry, especially the strong specialty chemicals manufacturing sector in Montreal.

The CEO region has been actively supporting the development of a natural fibre industry for several years. A significant amount of secondary agricultural land has gone out of production as commodity prices have not justified production of traditional crops. The presence of Bioniche in Belleville represents a focal point around which complementary industries could be added.

We see this region as an important player in the development of a provincial innovation network, in that the region has capabilities in all sectors of interest, but not overwhelming strength in any one area. The region has research capability, manufacturing presence, transportation infrastructure, primary chemical manufacturing capacity, and if we stretch Oshawa east, a substantial auto assembly plant. We see this region as an important player at the table in any discussion of how we build this strategy, and as a participant in all aspects.

Section 3: Proposed response to opportunities

3.1 Coordination of provincial bioproduct activities:

Need for coordination:

The business plans and SWOT analyses prepared by regions in Ontario with the support of the Ministry of Economic Development and Trade, represent a significant first step towards realizing bioproduct opportunities in Ontario. The opportunity analysis provided in this report was not based on regional boundaries, and clearly demonstrates that the value chains for target industries extend throughout and beyond the province. To effectively move regional opportunities into these provincial value chains will require the existence of supporting province wide infrastructure, not a series of disconnected regional networks. Individual regions will benefit by being able to reach into target industries in other regions, or facilitate target industries reaching throughout the province for alternative feedstocks and technology.

The historical economic development of Ontario has been based more on competition among regions rather than cooperation. Regions traditionally compete for site selection of large investment opportunities in auto manufacturing and chemical processing. The opportunities provided by bioproducts are different, and a competitive approach will hinder rather than accelerate delivery. Economic development derived from bioproducts has the potential to occur in two ways in Ontario. One, the adoption of lower cost feedstocks and/or technologies has the potential to improve the global competitiveness of industries that already exist throughout Ontario. Two, the development of companies engaged in bio-mass processing and bio based technologies to serve the needs of Ontario industry have the potential to develop in all regions. The primary constraint hindered the development of these industries will be linkage and effective early partnering with existing industries.

Ontario does not possess global advantages in terms of bioproduct research capability, manufacturing presence, population base, agriculture or forestry. However, Ontario does have a clear global advantage in that all of these factors are present at significant critical mass. This global advantage will only be realized if these elements can be coordinated in a way that enables effective response to opportunities. Bioproducts opportunities have been characterized as the third wave of the biotechnology revolution, following health and agriculture. Regional economic development throughout this province can and will, be based increasingly on small and medium sized technology development companies successfully commercializing biotechnological applications to traditional industries. Those countries or geographies who try to choose between the development of knowledge based economies versus manufacturing based economies are artificially stifling economic development. Companies, and geographies that realize that these two industries are different sides of the same coin will be better positioned to grow that coin than geographies who do not.

The emergence of biotechnology companies into the development of technology for chemical synthesis is instructive in terms of geographical location;

Lucigen	Middleton, Wisconsin
Codexis	Redwood City, California
Metabolix	Cambridge, Massachusetts
Diversa	SanDiego, California
Metabolic Explorer	Saint-Beazire, France
Bio-Technical Resources	Manitowoc, Wisconsin
Dyadic International	Jupitor, Florida
Athenix	Durham, North Carolina

The only clustering that appears to be occurring is that the majority of these companies are in geographies that are strong in biotechnology development. The other interesting note concerning these companies is their strong links to multinational chemical, pharmaceutical and agricultural companies including ADM, Dow, Dupont, GlaxoSmithKline, Pfizer, Novartis, Sundoz, and Eli Lilly. The existence of these companies, and their success in establishing linkages to large scale end users of their technologies provides a template for the development of a bioproducts industry in Ontario. Companies such as these can be developed in any region of this province. The key to their success will be their ability to bridge the gap between biotechnology discovery and primary manufacturing application.

Proposed Ontario Bioproduct Opportunity Networks

There is a need for regional interests to be balanced with provincial interests in order to sustain regional support of provincial strategies. Simply put, regions must have more to gain from collaborating broadly across the province, than by attempting to compete with each other. We have recognized this in our strategy by focusing interactions on regional strengths. We have also determined that an effective collaborative strategy must be built in a way that encourages industry to pull innovation rather than as a means to identify innovation and push it towards industry. To achieve this, we are proposing that the Regional Innovation Networks be linked to each other along lines of opportunity development rather than geography. We are proposing the formation of four provincial Bioproduct Opportunity Networks (BONs) corresponding to the four bioproduct opportunity sectors defined earlier (Functional Fibres, Renewable Transport Fuels, Forestry, and Chemistry). The function of these networks will be to establish clear and effective communication ties in regard to a specific bio-industry sector. These networks will be composed of public sector research facilities and Universities, economic development managers, government policy makers, target industries and existing bioproduct companies.

Opportunity networks that have fulfilled our vision will be effective in doing the following;

1.) Ensuring that commercial realities and opportunities are well understood throughout the network.

2.) Ensuring that researchers imaginations are challenged by the constraints industry faces in commercializing bioproducts in their sector.
3.) Marshalling commercial opportunities emerging in the province towards any and all appropriate channels of assistance.
4.) Championing Ontario as a location for international companies and investors involved in the sector.
5.) Developing public/private partnerships that work at understanding and developing opportunities together.

We have suggested specific individuals and institutions as leaders of these initiatives. These choices were made based on our visits to each region, and our objective understanding of who is most capable of leading each of these initiatives now. The establishment of these networks must achieve a balance between openness, flexibility and focus. To be effective it must mean something to be included in a network, and those that are not included at the outset should have an opportunity to earn inclusion.

Our vision for the roles of the respective components within each opportunity network is as follows;

Leaders:

Leaders of opportunity networks will be responsible for ensuring that the network vision is realized. They will be responsible for the initial establishment of the network. They will convene meetings between and among members of their network. They will be responsible for the development and maintenance of a database of capabilities within their sector. Leaders will become the key go-to points for opportunity development.

Public sector research

Public sector research participation in an opportunity network will mean that someone at each institute or University involved will take on responsibility for coordinating responses to opportunities within the sector. This means maintaining and communicating lists of research capabilities and sharing the general nature of research breakthroughs (in a manner that does not interfere with patentability) as rapidly as possible through the opportunity network. The public sector institutes involved will actively engage with target industries in their sector, with a view to comprehensively understand the technical nature of constraints to commercialization. Public sector institutes involved in opportunity networks will need to agree to encouraging direct physical interaction of researchers with industry. This means everything from site visits to the encouragement of leaves of absence and/or sabbaticals, of public sector researchers in private laboratories.

Industry

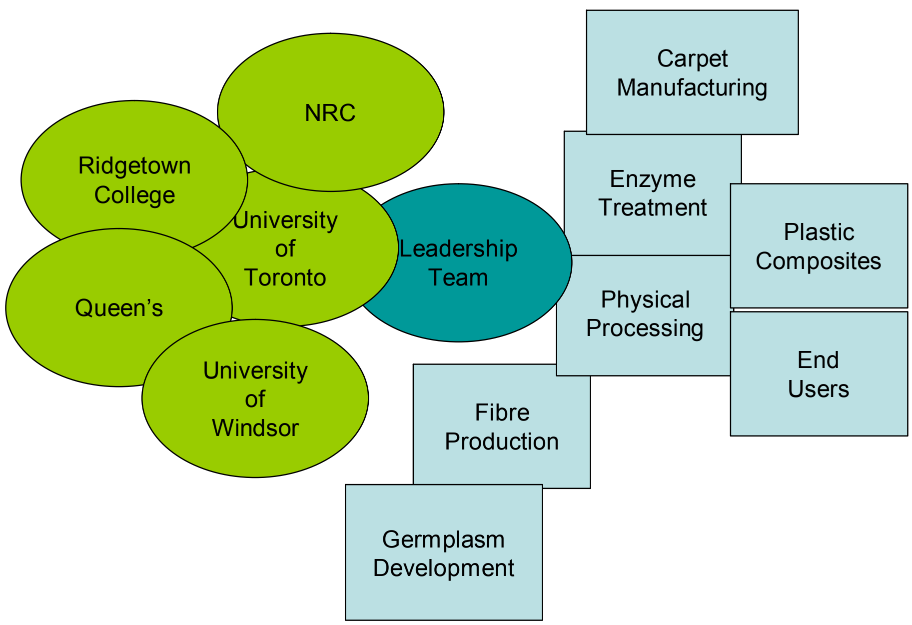
Industry involvement in opportunity networks will also carry with it certain minimum standards of engagement. Companies involved must be prepared to share published intellectual property, host site visits, and comment on economic analyses of opportunities. Companies should encourage their researchers to interact with public sector researchers, through adjunct status in Universities, or as a minimum through talks and discussions of technology platforms.

Government

There are several different levels and types of government involvement envisioned in the opportunity networks. Regional economic development offices will play a key role in bring opportunities to the networks, and shepherding their movement towards reality. Government policy makers should be engaged where policy acts as an active and artificial constraint to opportunity development. All levels of government can be actively engaged in assisting opportunities find public and private financial support as needed.

Ontario Bioproduct Opportunity Networks

Figure 34: Functional Fibre Network:

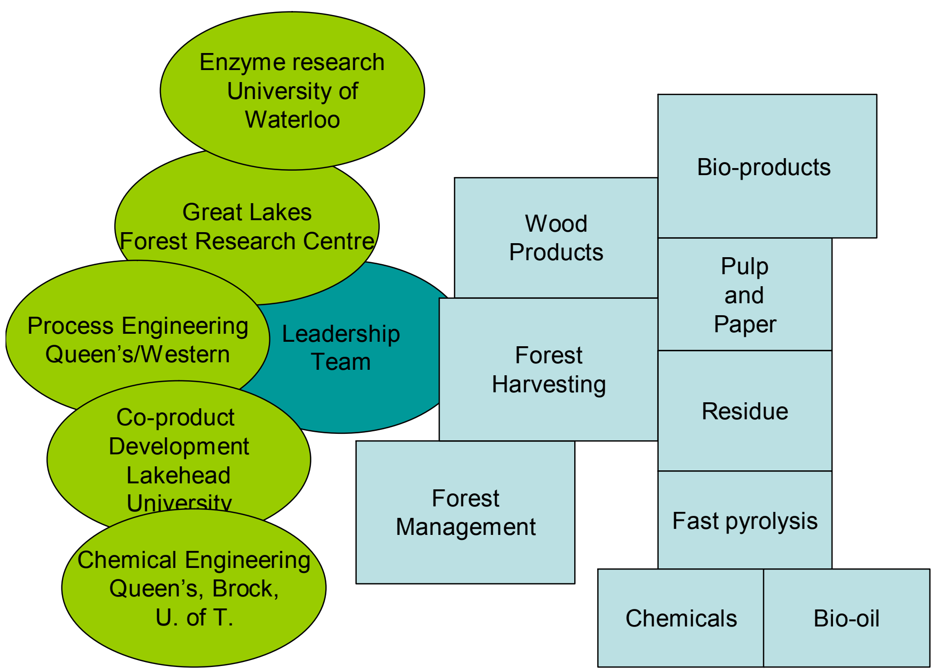


We suggest that the functional fibre leadership team be led by the Central Eastern Ontario region. Moreover, we suggest that given her leadership capability, and experience in the sector, Ms. Kathy Woods be appointed as the initial leader of this initiative. We have struggled to date in the development of this industry due to a lack of pull by end use industry. It is crucial that this network include effective linkages with the two primary end user markets, carpets and auto parts. We would suggest that linkages be established with Dupont Canada, INVISTA Canada and Interface Flooring in regard to carpet opportunities. In regard to autoparts, linkages should be established with OEMs, automotive chemistry suppliers, and plastic composite manufacturers. Peter Frise at Auto 21 would be of great assistance in building these linkages.

Dr. Mohini Sain at the University of Toronto has done a tremendous job of establishing a research network in functional fibres. His research network should be extended to include research at the University of Windsor on the interface between natural fibre composites and other auto components, and research on crop development at Ridgetown College and by John Barker in Belleville. There is an opportunity to engage the National Research Council, in particular the Integrated Manufacturing Technology Institute in London and the Aerospace and Research in Construction institutes in Ottawa.

Existing hemp companies such as Hempline, and Hempola should be included in this network and asked to play key roles in identifying gaps in knowledge and in the value chain that will need to be filled before this industry can be successful (Geof Kime and Greg Herriott).

Figure 35: Forestry Opportunities Network

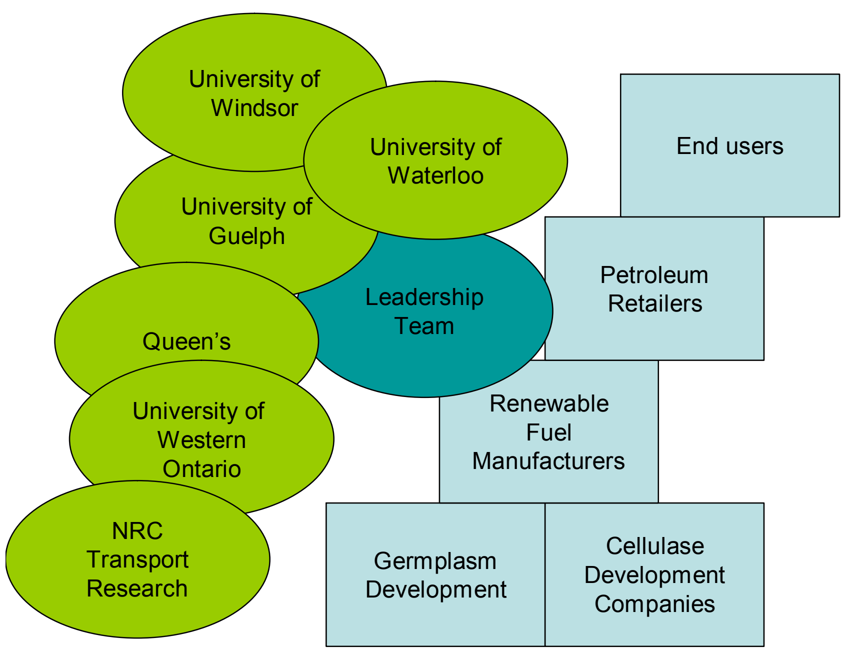


Northern Ontario should be responsible for building a leadership team around forestry opportunities. We suggest that the leadership team be initially composed of Errol Caldwell (Great Lakes Forestry Research Centre), David Deyoe (Ontario Forestry Research) and Leon Magdzinski (R & D Director, Environment and Technology, Tembec). This team will work towards identifying key opportunities to commercialize in Ontario through consultation with the existing forestry value chain. Technical constraints to opportunity development will be shared with the research linkages. Financial constraints to opportunity development will also be championed by this team through their interaction with the funding strategy (outlined later in this document).

The existing value chain will be asked to formally participate in this bioproduct opportunity network and would be invited to a workshop aimed at identifying and sharing ideas. We also suggest that the existing value chain be encouraged to work through the leadership team with the government of Ontario to develop a proposal that will alleviate the constraints currently imposed on bioproduct development by forest ownership issues.

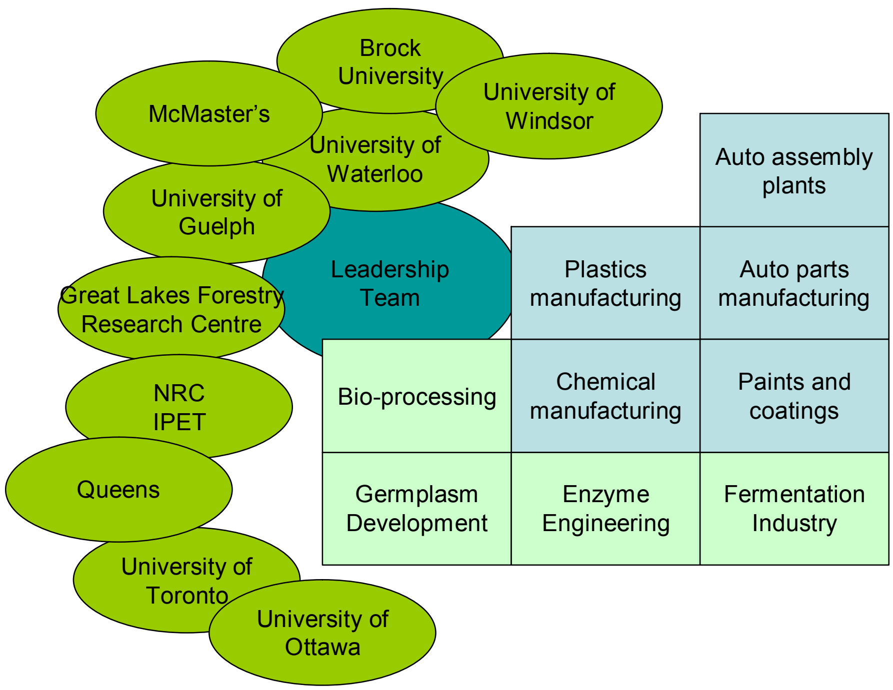
Fast pyrolysis represents an ideal business opportunity that is ready for development in the north. We suggest that the leadership team, in conjunction with researchers work with existing pyrolysis based companies such as Ensyn, Green Energy (ROI) and Dynamotive to identify and overcome barriers to success. The opportunities to create bio-based intermediate chemicals as substitutes for synthetic chemicals should be addressed by the public research community identified in the chart, and through the leadership team, by private sector researchers and product developers in the chemical industry.

Figure 36: Renewable Transport Fuels



The Renewable Fuels Leadership team should be established as a coordinated effort between Chatham, in the SOBIN region, and the Ottawa region. We suggest that appropriate leaders for this effort may both come from the private sector, Mark Schwartz (New Product Development Leader, Commercial Alcohols) David Jackson (Enzyme Plant Manager, Iogen) and Govindh Jarayaman (Senior Partner, President, Topia Energy Inc.). This leadership team will be asked to identify key constraints to increasing efficiency of their processes, and to share these key constraints, under confidentiality if necessary, with representatives from the public sector research institutes. By agreeing to participate in this opportunity network, companies will also agree to assist other start up companies access public information and support. This opportunity network should not exist as a funding channel for researchers. It exists to share information from the private sector to researchers such that their research directions can be in closer alignment with alleviating market constraints. It is not required for partnership in this network, but it would be extremely helpful if arrangements could be made that allow public sector researchers access to commercial facilities.

Figure 37: Chemistry



Clearly, the chemical bioproduct opportunity network is large and complex. We have included a significant number of public sector research institutes, each of the industries represented in the chart above also have significant in-house research capabilities. We are suggesting that this network be led by a group from southwestern Ontario. In particular, we suggest that a leadership committee composed of Keith Taylor (V.P. Research, University of Windsor), Allan James (Senior Automotive R & D Lead, Dow Canada), Richard Steevenesz (R & D lead, Lanexx (formerly Bayer)), Bernard West (Co-chair, Ontario Chemistry Value Chain Initiative), Vincento De Luca (Head, Chemistry Department, Brock University), Raymond Legge (Director, Biotechnology Research Institute, University of Waterloo), and Luc Duchesne (President, Forest Products Inc.). The formation of this leadership team, will in itself represent an important first step in bringing cultures and imaginations together.

The team will be charged with identifying a limited number of key opportunities, and identifying the constraints to commercialization. This process will serve as a sign post to industry, and to the research community, that these are opportunities that industry is serious about, and that circumvention of the constraints identified will lead to commercialization. The leadership group will be charged with the task of stimulating communication of opportunities within each of their respective communities, and acting as guide posts to channel not only their own interests but the interests of others. Participation in this opportunity network is conditional on the provision of industry wide support. It would be desirable if the industry partners in this opportunity network would provide site visits for participating public sector research scientists so that they can see operations up close. Public sector partners would be encouraged to take leave of absences or sabbaticals in private sector research facilities as a means of fomenting greater ties, and greater cross-fertilization of ideas.

Interaction with government policy:

It may be noted that a role for the government policy formation and interaction was not included in these charts. This is a key interaction between the opportunity networks and both provincial and federal governments. We did not include this in the charts as it is common to all opportunity networks. Think of this linkage extending into the space at a 90 degree angle from the paper you are reading.

Summary – Regional networking

A considerable amount of investment has already occurred or is occurring in regard to development of Bio-product opportunities on a regional basis. The Ministry of Economic Development and Trade's BCIP acted to galvanize activity in many regions in this regard. Region's are working with MEDT on implementation strategies derived from phase I of the BCIP process. We do not want to add infrastructure, or a need for resources over and above these regional efforts. Our proposal is based on maximizing existing resources by adding responsibilities that lead to increased synergy across regions. We are focused on developing these relationships along product opportunity lines, this is why we chose to establish clusters based on the opportunities. We have also taken the step of assigning leaders to each of these clusters. Assigning leadership to one group over another, has the potential to cause difficulty. This difficulty shrinks in comparison to the need to move opportunities and relationships forward. The best way to achieve effective teamwork is through effective leadership.

3.2 Funding strategy:

Overview:

We have reviewed a considerable number of strategies aimed at enhancing commercialization of innovation. A few key factors emerged in common across successful strategies.

1.) Methods of encouraging the engagement of private capital
2.) Methods that stimulate industry interaction with public sector research
3.) Strategies that are lead by industry rather than governments or Universities.

One of the most successful strategies reviewed was the Heznek Program from Israel. The government of Israel established a seed fund to act as a source fund to stimulate the creation of private sector funds and direct private investment. The government retained an equity position in opportunities in exchange for funding, but provided options for the private sector to buy them out at market prices.

Ontario Bioproducts Seed Fund:

We have several clear objectives underlying the creation and delivery of a bioproducts seed fund strategy. First among these is the creation of increased economic wealth in Ontario. Bioproduct opportunities must make compelling economic sense to justify capital investment. Increasingly international and local pressures have made the long term environmental sustainability of product and energy production a financial issue. We have before us a two pronged challenge to Canadian industry, increasing cost of petroleum based feedstocks and an increasing cost to greenhouse gas emissions. The future of the Canadian manufacturing and energy industry will need to compete globally in this changing environment. The goal of this strategy is to accelerate the ability of Canadian companies to develop and adopt innovative, sustainable technologies, and by so doing, increase rather than decrease their global competitiveness.

The government of Ontario has an interest in assisting Ontario companies make this transition to create a strong future for Ontario. The Ontario government has made and is continuing to make a significant investment in Ontario research capability in support of the development of life science and knowledge based industry development. The Ontario Bioproducts Strategy capitalizes on this investment by enhancing its' application to Ontario's industrial engine. The application of molecular biology, nanotechnology, and information management to primary manufacturing and energy production will occur globally. This strategy aims at leveraging Ontario's global advantage in diversity and scale of industrial development to create a leading edge in the new competitive realities of this century.

It would appear that while the motivation underlying the creation of an Ontario Bioproducts Seed Fund are shared by industry and government the means of creating are not. The government has limited resources, while the scale of the industrial transformation required is enormous. Ontario industry is willing to engage, but reluctant or unable to leverage funds from global headquarters for Canadian initiatives. Small companies are finding it difficult to raise the capital necessary to successfully penetrate large scale market opportunities. The Ontario private investment community has been slow to respond to bioproduct opportunities due to a poor appreciation of the relative risks involved, and a lack of enthusiasm over the scale of the potential returns. There is a need to persuade the investment community that their overall investment portfolios will be aided by the addition of bioproduct opportunities that make business sense. We cannot improve the potential return associated with these opportunities so we must concentrate on reducing the risk.

We have developed an innovative approach to a funding model that involves all three parties, government, industry and private investment. Our strategy supports the goals of all three parties in ways that will require them to interact and depend on each other for individual gain.

We recommend the creation of an Ontario Bioproducts Seed Fund of at least $10 M over three years. This fund would exist to stimulate specific bioproduct opportunities that pass the criteria established by an Ontario Bioproducts Seed Fund Management Board, and Technical Advisory Committee. Allocations from the seed fund would be limited in form to guarantees on a percentage of private funds invested in bioproduct opportunities. We are suggesting that a reasonable starting point for negotiations would be 50% of the principal of private funds invested, with a restriction that no more than $1 M will be guaranteed for any given opportunity (This means up to 50% of a $2 M investment).

The bioproducts seed fund guarantee would be placed in trust against the funds invested. Funds held in trust would only be liberated by revenue flow from the opportunity at a rate equivalent to the percentage of principal guaranteed. For instance if $500,000 was held in trust against a private investment of $1,000,000 in a bioproduct opportunity, then $100,000 in revenue generated by the opportunity would release $50,000 from the trust fund.

A definition of opportunity failure would be agreed upon prior to Ontario Bioproduct Seed Fund monies being placed in trust against investment. This definition of failure would include timeline performance milestones. If an investor chooses to declare that the opportunity has met the terms of the failure agreement, then that investor would receive the guaranteed amount back in full. The Ontario Bioproduct Seed Fund would receive all revenue generated by the opportunity until the guaranteed amount is repaid, and the private investor would be required to terminate any ongoing relationship with the opportunity that has the potential to provide financial benefit.

In return for the investment guarantee provided by the Ontario Bioproduct Seed Fund, investors and opportunity developers would also be required to provide an equity position in the opportunity being financed to a private industry fund that is relevant to the opportunity being pursued. This will require the creation of industrial funds within each of the four bioproduct categories that we defined earlier. Industrial organizations within each of these sectors have been contacted and are supportive of the development of such funds. We are recommending that the equity share in individual opportunities be equal to a minimum of 5% per million dollars of funds invested.

The industrial funds shall be limited to the development of innovation in their respective industries, and as such are titled Industry Innovation Funds. The first call on any revenue generated by these funds will be to reimburse losses incurred by the bioproducts seed fund in opportunities related to their sector. Thus, if a bioproduct opportunity fails, and the Ontario Bioproducts Seed Fund is required to pay $500,000 to an investor, the relevant industrial fund will be required to repay this $500,000 prior to obtaining any discretion over how it uses revenue. Moreover, funds acquired by the industrial funds may be dispersed to stimulate innovation within the relevant industrial sector according to criteria agreed upon between the Industrial Innovation Fund and the Ontario Bioproducts Seed Fund.

We have developed and are recommending this model for the following reasons.

1.) The Industry Innovation Funds will be able to take equity positions, and thus generate uncapped revenue from opportunities stimulated by the Ontario Bioproducts Seed Fund. This is the best approach to ensuring the sustainability of the seed fund, but it is an approach that a government sponsored seed fund would have difficulty fulfilling.

2.) The development of bioproduct opportunities will require the full fledged involvement of the relevant industrial sector. Our review of bioproduct opportunities has led us to conclude that development of this industry will in most instances require the engagement of existing industry. The creation of Industry Innovation Funds will lead to the implicit engagement of industry in innovation in Ontario.

3.) The government of Ontario cannot afford to create the necessary level of stimulus required to transform such a large and capital intensive industry. This strategy is aimed at improving the risk/reward equation enough to coax private investment away from real estate, and higher risk investments. This initiative cannot succeed without private investment, and currently private investment is not flooding into the bioproducts sector.

4.) The lack of actual entry of Ontario Bioproducts Seed Fund monies into opportunities greatly accelerates their return to the fund. The return of funds that enter into an opportunity imposes a financial drag on the opportunity. The approach that we have developed results in the liberation of Ontario Bioproducts Seed Fund investments in opportunities rather than the return thus increasing the rate at with which these funds can be reinvested in other opportunities. In this way, the initial $10 M investment becomes much greater than $10 M as funds are recycled over and over.

The Ontario Bioproducts Seed Fund will need a board of directors to make funding approval decisions. We propose the following composition for this board of directors.

Chair	Industry leader
Director	Bast Fiber Cluster leader
Director	Forestry Products Cluster leader
Director	Renewable Fuels Cluster leader
Director	Bio-based Chemicals Cluster leader
Director	Provincial Government (MEDT)
Director	Federal Government (NRC)

In addition we propose that the Ontario Bioproducts Seed Fund create a technical committee with two tasks in mind. One, to provide technical support to the board of directors, and two, to develop research objectives that are aligned with Ontario business opportunities. The proposed composition of this technical bio-based opportunities expert panel is as follows:

Industry	Chemistry research leader
	Fibre company end user
	Tier one auto parts manufacturing representative
	Petroleum company
	Energy company
	Bio-lubricant company
	Forestry company
Public	Chemical engineer
	Enzyme engineer
	Chemical process engineer
	Fermentation researcher
	Germplasm development
	Forestry product research
	Energy research

This group could be added to or subtracted from over time. Membership in the group would be limited to a term of two years. Separate elements of the public sector research community including the National Research Council, Agriculture and Agri-Food Canada, Canada Forestry Service, Universities, and OMAF should be included in the public sector representation on the technical advisory committee.

Linkage between the Ontario Bioproducts Seed Fund and provincial opportunity development networks:

There is a need for the development of channels of communication between industry and the public sector research community. The results of public sector research efforts will be inherently more applicable to commercial opportunities if their initial direction is informed by dialogue with appropriate private sector partners. We propose using the alignment between the Industry Innovation Funds and the provincial opportunity development networks. We are recommending that this alignment be formally recognized through required engagement of opportunity development network leaders on the appropriate Industry Innovation Fund management board.

The creation of these formal links will enable public sector representatives to be party to the confidential discussions of industry priorities that lie at the basis of the Industry Innovation Fund decision making process. Presence and participation in these discussions will provide a basis for establishing trust between communities and between leaders in the development of opportunities. Grand strategies can be beautiful, but their effectiveness is entirely due to the efforts and abilities of the individuals who are involved in their delivery. By formally establishing linkages between the Industry Innovation Fund and public sector leaders, we are creating the infrastructure to enable individual leaders to be effective champions.

We also recommend that involvement in all management boards and/or technical advisory committees be compensated for on a similar basis to similar involvement in boards of directors in the private sector. This means that travel expenses, and payment for time expended be provided for these activities out of the Ontario Bioproducts Seed Fund. These expenses would be part of the value of the seed fund supported by the Industry Innovation Funds.

Summary – Ontario Bioproducts Seed Fund

A novel tripartite partnership for the development of bioproduct opportunities has been proposed. The proposal integrates the self interests of the government, industry and private investment in a way that results in the sustained stimulation of bioproducts opportunities in Ontario. To succeed we must mobilize private investment. To engage private investment a stimulus must be provided, as it is clear that there is a reluctance to invest in this sector now. The government has an opportunity to provide this stimulus through the provision of principal investment protection. The structure of the proposed fund maximizes the rate of funds returning to the bioproducts seed fund, thus increasing their power well beyond the initial government investment, by facilitating repeated recycling of funds. Finally the strategy actively engages industry through the development of industry driven innovation funds based on revenue flow.

3.3 Timeframe for action:

Consultant's report received	October 29th, 2004
Report reviewed	November 30th, 2004
Leaders of Bioproduct Opportunity Networks assigned	January 30th, 2005
Bioproduct Opportunity Networks plenary meetings	February to April, 2005
Bioproduct Opportunity Networks operational	May 1st, 2005
Bioproducts Seed Fund legal review completed	January 30th, 2005
Bioproducts Seed Fund structure finalized	May 1st, 2005
Bioproducts Seed Fund Board of Directors meeting	June, 2005
Call for Opportunities	Close September 30th, 2005
First Opportunities Financed	November 30th, 2005

Summary:

A bio-products strategy for Ontario must identify the opportunities to be addressed, propose a structure for mobilizing opportunities, and provide the means for stimulating opportunities. We have characterized targets for Bio-product opportunities in Ontario in four sectors, chemicals, renewable fuels, forestry, and functional fibres. Then we proposed a means of mobilizing existing regional infrastructure into a provincial model. Finally, we proposed a funding strategy that would be aimed at partnering with existing federal funding programs, to leverage funds for Ontario. All of these elements are necessary for the emergence of a successful bio-economy in Ontario.

Bio-product opportunities will only be successful if they make economic and technical sense. Why then, is there a need for a strategy? There would not be if there were not artificial barriers to the development of these opportunities. A Bio-product opportunity may make all the sense in the world, but still face constraints that an equivalent innovation within the existing industry would not face. These constraints are what this strategy is aimed at overcoming. The key constraint is probably the least tangible. We need to build trust and comfort across communities. We need to build trust for the introduction of novel Bio-product opportunities within the investment community. This same level of trust needs to be built within the decision makers of end use industry. The most important delivery target for this strategy must be to increase the level of trust across participants, and confidence in the opportunities.

Summary of Recommendations:

Opportunity Analysis:

1.1 Chemical Intermediates:

Recommendation*:* *Given that intermediate chemicals provide the most significant opportunities for cost competition between bio-based chemicals and synthetic ones, and given that certain intermediate chemicals are under more supply pressure than others, resulting in differential increases in prices we have the following recommendations;*

Research: *We recommend that researchers engaged in the development of bio-based alternative intermediate chemicals focus on those chemicals that are either currently available in biomass, or are structurally similar to existing biological chemicals. Moreover, we recommend that alliances be built wherein chemical engineers identify useful chemistries, plant biochemists describe biosynthetic pathways that can be modified, and molecular biologists and plant breeders create industrial plant varieties capable of producing these chemicals cost-effectively.*

Government: *Given the high capital cost associated with globally competitive chemical manufacturing and the difficulty domestic arms of international chemical companies will face attracting capital investment from headquarters into Canada, in light of the existing capital investment made in Ontario, we recommend that the government of Ontario completely and immediately remove capital taxes for any facility that will create a bioproduct. This has the potential to act as a global incentive to the attraction of significant bioproduct production facilities in this province, and will demonstrate that this government is serious about working with the chemical industry to encourage innovation and renewal.*

Industry: *We recommend that the Ontario Chemical Value Chain Initiative continue to work towards building and delivering a sustainable innovation model for the industry that incorporates bioproducts.*

1.2 Fibres

Recommendation: *Given that functional fibres are being imported into Ontario after enzyme processing in Europe, and that the National Research Council of Canada has made a breakthrough in the area of enzyme treatment of fibres, we recommend the following;*

Research: *There is a need to understand how functional fibre can be applied in a wide variety of products. This understanding should be based on functional performance, cost-effectiveness, product manufacturing issues, and the interaction of fibre composite products with existing products. We recommend that the value chain approach that Dr. Mohini Sain has pursued in this sector be extended to include a broader range of products.*

Government: *We have identified a significant gap in the Ontario functional fibre value chain with the absence of an enzyme processing facility. We recommend that the Ontario government work to actively stimulate the closure of this gap by persuading investors to create a facility, or attract a foreign company to locate in Ontario.*

Industry: *We recommend that existing functional fibre companies in Ontario join forces with the government to work to develop an enzyme treatment facility in Ontario.*

1.3 Forestry

Recommendations: *Given that forestry bio-product opportunities have been commercialized in a broad range of applications globally;*

Research:
That research on forestry opportunities be focused on existing commercialized products. That research focus on the added value possible within the Ontario forest germplasm base. [Example/ Work such as the identification of terpene composition of Ontario tree species undertaken at the Great Lakes Forestry Centre, be aligned with commercial applications of these terpenes.]
Significant efforts need to be exerted building meaningful relationships in regard to bioproduct development with leading forestry companies such as Tembec.

Government:
The ownership of provincial forests, and in particular the ownership of the residue remaining from forest harvesting operations serves as a key constraint to the commercialization of forestry based bioproducts. We recommend that the Ontario government form a task force mandated to develop a solution to this problem.

Forestry based bioproduct opportunities are more mature than agriculturally based opportunities. We recommend that the Ontario government use existing northern economic incentive programs to attempt to aggressively attract investment in forestry bioproduct manufacturing in the north.

Industry:
The existing Ontario chemical industry has not investigated the potential of the forestry industry as a source of intermediate chemicals. We recommend that industry associations form research teams assigned to explore the potential of these opportunities.

1.4 Renewable Transport Fuels:

Recommendations: *Given that the primary constraint to increased use of renewable fuels by the existing petroleum industry is their cost;*

Research: *Research efforts should be focused on increasing the efficiency of renewable fuel production. This means research that will lead to increases in fermentation efficiency, increases in co-product value, and improvements to germplasm that will* *result in more fuel being generated per bushel of grain. This latter aspect may also apply to the BDM biodiesel technology.*

Government: *The imposition of mandates without significant stimulation for renewable transport fuel manufacturers to use domestically produced commodities will lead to the importation of renewable fuels from other geographies. We recommend that the government of Ontario continue to work with the entire renewable transport fuel value chain, including the existing petroleum industry, renewable fuel manufacturers, and feedstock suppliers to create a framework that will sustain and encourage domestic innovation throughout this industry.*

Industry: *To be successful in the long term the petroleum industry should play a more significant role than as a purchaser and blender of renewable fuels. Ultimately, these companies have a greater capability to identify and commercialize co-product or alternative market opportunities derived from renewable fuels than start up companies. We recommend that the petroleum industry commission a study of the potential added value and cost savings that could be realized by the integration of renewable fuels manufacturing capacity into their existing manufacturing capacity.*

2.1 Ontario Bioproduct Opportunity Networks

Recommendations: *Given that there is significant positive value in regions and sectors working together to accelerate the commercialization of bioproduct opportunities in Ontario, we suggest that this be achieved through the formation of provincial Bioproduct Opportunity Networks.*

Researchers: *Participation in a Bioproduct Opportunity Network will not directly result in funding for research activities. We recommend that public sector research scientists engage in these networks as a means of increasing the focus and relevancy of their research efforts.*

Regional Innovation Networks: *We recommend that regional innovation networks view the Bioproduct Opportunity Networks as the playing field in which opportunities are developed. We suggest that the RINs become the eyes and ears, and operational element of the BONs. To achieve this, each RIN should compile and maintain contact lists and capacities broken out along the opportunity sectors that the BONs are based on. The BONs exist to facilitate the identification and acceleration of opportunities, the RINs exist to act as mid-wives in the birthing of opportunities in the real world.*

Government: *Given that it is crucial that organization does not tend to occur spontaneously, and that inertia will be required to develop the Bioproduct Opportunity Networks, and to maximize the effective integration of the RINs into this organization, we recommend that the provincial government continue to be responsible for the establishment of these networks. We suggest that the province act on the recommendation in this report relating to the formation of Bioproduct Opportunity Networks, by establishing plenary meetings of each network within the next six months.*

Industry: *Industry has consistently indicated that there is a need for increased interaction between themselves and public sector researchers in regard to the development of innovation. We recommend that industry engage in the Bioproduct Opportunity Networks as fully and openly as possible and use these networks as vehicles to facilitate this interaction. We suggest that for the BONs to be effective industry must act as full partners, and that the more information they provide, the more value they will receive from their participation.*

3.1 Bioproducts Seed Fund

Recommendation: *Given the following;*

- *that the target industries for bioproducts represent an integral part of Ontario's economy, and that shifts from complete dependency on petroleum based feedstocks are crucial to the long term global competitiveness of this industry,*
- *and that, the realization of bioproduct opportunities on a large scale will require large amounts of capital*
- *and that, the majority of companies resident in Ontario and capable of acting in this space, compete within their own conglomerates for project financing on a global basis*
- *and that, it is unreasonable to expect that governments provide all the economic stimulus required by industry to transform feedstock supply,*

We recommend that the province of Ontario provide an economic stimulus in the form of a seed fund, that is based on encouraging increased private investment in this sector, and that has the potential to mobilize capital investment on the scale necessary to make Ontario a globally competitive manufacturing base for the future.

Government: *We recommend the following actions on the part of the government of Ontario;*

- *that the government of Ontario establish a seed fund that guarantees up to 50% of the private investment in bioproduct opportunities.*
- *That the government of Ontario establish a board of directors for this seed fund, and provide payment for their participation on corporately competitive basis.*
- *That the government of Ontario establish a technical advisory committee to review opportunities to ensure that bioproduct seed fund monies are being prioritized in ways that maximize the fulfillment of government priorities.*
- *That the government of Ontario play an active role in ensuring that the Bioproduct Opportunity Networks proposed in this report, have a significant role in the operation of this fund.*
- *That the government of Ontario encourage industry participation in this sector through the formation of Industry Innovation Funds derived from opportunities financed through the seed fund.*
    - *That the existence of these Industry Innovation Funds be conditional on maintenance of the Ontario Bioproducts Seed Fund (first call on funds will be to maintain the level of the seed fund).*

Appendix A

Sector	Name	Position	Affliation	Address	Email	Phone
University	Dr. Raymond Legge	Professor of chemical engineering and director, Biotechnology Research Institute	University of Waterloo	Department of Chemical Engineering, 200 University Avenue West, Waterloo, Ontario N2L 3G1	rllegge@engmail.uwaterloo.ca	519 886 2913
Industry	John Baker	General Manager, Botanicals	Bioniche Botanicals	P.O. Box 1570, Belleville, Ontario K8N 5J2	john.baker@bioniche.com	613 966 0569
Industry	Mohamed Elrafih	Vice President, Manufacturing Operations	Bioniche Life Science Inc.	P.O. Box 1570, Belleville, Ontario K8N 5J2	melrafih@bioniche.com	613 966 8058
Industry	Mike Bryan	President/CEO	BBI International	701 Powerline Road, Brantford, Ontario N3T 5L8	mbryan@bbibiofuels.com	519 752 7680
Industry	Bernard West		Stuart Lammert & Co.	The Exchange Tower, 130 King Street West. Suite 1800, P.O. Box 427 Toronto, Ontario, M5X 1E3	bwest@stuartlammert.com	416 977 2800
Industry	Roger Goodman	Corporate Communications Manager and Executive Assistant	Dupont Canada Inc.	Box 2200, Streetsville, Mississiauga, Ontario, L5M 2H3	roger.h.goodman@can.dupont.com	905 821 5625
Industry	Robert Gallant	President/CEO	Commercial Alcohols Inc.	20 Toronto Street, Suite 1400, Toronto Ontario, M5C 2B8	rgallant@comalc.com	416 304 1700 ext. 226
Public Research	Thomas Noland	Research Scientist/Tree Biochemist	Ontario Forest Research Institute	1235 Queen Street East, Sault St. Marie, Ontario P6A 2E5	tom.noland@mnr.gov.on.ca	705 946 7421
Public policy	Genevieve Pickett	Program Officer	AAFC	Room 773-A Sir John Carling Building, 930 Carling Avenue, Ottawa, Ontario K1A OC5	picketg@agr.gc.ca	613 694 2522
Industry	Kathryn Wood	President/CEO	Natural Capital Resources Inc.	4297 Sills Bay Road, RR! Sydenham, Ontario, K0H 2T0	ncr@sympatico.ca	613 376 6006
Industry	Mark Lawton	Seed Quality Assurance Manager, Canada	Monsanto Canada Inc.	Research Park Centre, 307-150 Research Lane, Guelph, Ontario N1G 4T2	mark.b.lawton@monsanto.com	519 821 0790
Industry	Pesh Patel	Leader, Information Management	Nova Chemicals Corporation	2928 - 16 Street N.E. Calgary, Alberta, T2E 7K7	patelpg@novachem.com	403 250 0659
Public Research	Jamie Stephen	Research and Communications Coordinator	BioCap	BIOCAP Canada Foundation, Queen's University, 156 Barrie Street, Kingston, Ontario K7L 3N6	stephenj@biocap.ca	613 542 0025
Industry	Jeffrey Charuk	Chief Scientist	Larial Proteomics	3403 American Drive, Units 3 & 4 Mississauga, Ontario L4V 1T4	jeffrey@larialproteomics.com	905 405 2903
University	Murray Moo-Young	Professor	University of Waterloo	Department of Chemical Engineering, 200 University Avenue West, Waterloo, Ontario N2L 3G1	mooyoung@uwaterloo.ca	519 888 4006
University	Trevor Charles	Associate Professor	University of Waterloo	Department of Chemical Engineering, 200 University Avenue West, Waterloo, Ontario N2L 3G1	tcharles@uwaterloo.ca	519 746 0614
University	Christine Moresoli	Associate Professor	University of Waterloo	Department of Chemical Engineering, 200 University Avenue West, Waterloo, Ontario N2L 3G1	cmoresoli@cape.uwaterloo.ca	519 888 4567
University	C. Perry Chou	Associate Professor	University of Waterloo	Department of Chemical Engineering, 200 University Avenue West, Waterloo, Ontario N2L 3G1	cpchou@uwaterloo.ca	519 888 4567
Legal	Gray Taylor	Environmental Lawyer	Davies Ward Phillips & Vineberg	44th Floor, 1 First Canadian Place, Toronto Canada, M5X 1B1	gtaylor@dwpv.com	416 863 5533
Investment	Anjali Varma	Manager Applications	Sustainable Development Technology Canada	230 Queen Street, Suite 250, Ottawa, Ontario K1P 5E4	a.varma@sdtc.ca	613 234 6313
Industry	Christopher Neuman	President/CEO	Pheromone Sciences Corp.	443 King Street East, Toronto, Ontario, M5A 1L5	cneuman@pheromonesciences.com	416 861 9854 ext 226
Investment	Jom Aw	Managing Director	ICG/Transforma	255 Albert Street, Suite 500, Ottawa, Ontario K1P 6A9	eja@tranforma.ca	613 566 7011
University	Marti Jurmain	Director, New Product Development	Niagara College	Glendale Campus, 135 Taylor Road, R.R. #4, Niagara on the Lake, Ontario, L0S 1J0	mjurmain@niagarac.on.ca	905 641 2252
Investment	Blaine Kennedy	Manager, Screening & Evaluation	Sustainable Development Technology Canada	230 Queen Street, Suite 250, Ottawa, Ontario K1P 5E4	b.kennedy@sdtc.ca	613 234 6313
Industry	Dennis Barker	President/CEO	COSC	340 Bell Blvd, Belleville, Ontario, K8P 5H7	dennis@cosc.ca	613 969 2227
Industry	Rahumathulla Marikk	Director of Technology and Environment	Interface Flooring Systems (Canada) Inc.	233 Lahr Drive, Belleville, Ontario K8N 5S2	rahumathulla.marikkar@ca.interfaceinc.com	613 966 8090
Farmers	Nadia Carrier	Directrice generale	L'Union des cultivateurs franco-ontariens	2474 rue Champlain, Clarence Creek, Ontario K0A 1N0	ncarrier@lavoieagricole.ca	613 488 2929
Farmers	Harold Rudy	Secretary Manager	Ontario Seed Growers' Association	1 Stone Road W. Guelph, Ontario, N1G 4Y2	hrudy@ontariosoilcrop.org	519 826 4217
Legal	David Woolford	Lawyer, Opportunity Development	Cassels Brock & Blackwell LLP	2100 Scotia Plaza, 40 King Street West, Toronto, Ontario, M5H 3C2	dwoolford@casselsbrock.com	416 860 2911
University	Jesse Zhu	Professor	The University of Western Ontario	Faculty of Engineering, London, Ontario, N6A 5B9	zhu@uwo.ca	519 661 3807
Industry	Douglas Brown	Senior Account Manager	BSA Inc.	5288 General Road, Unit 6 Mississauga, Ontario, L4W 1Z8	dbrown@bas.ca	905 602 9639
Economic Development	Joseph Pavelka	Chief Adminstrative Officer	Municipality of Chatham-Kent	315 King St. W. P.O. Box 640, Chatham, Ontario N7M 5K8	joep@chatham-kent.ca	519 436 3241
Industry	Garth Hodges	Global Canola Business Manager	Bayer CropScience	#100, 3131 - 114 Avenue S.E. Calgary, Alberta, T2Z 3X2	garth.hodges@bayercropscience.com	403 723 7420
University	Louise Nelson	Vice President, Research	Okanagan University College	3333 University Way, Kelowna, B.C. V1V 1V7	lnelson@ouc.bc.ca	250 979 6437
Public Research	Lisa Buse	Technology Transfer Coordinator	Ontario Forest Research Institute	1235 Queen Street East, Sault St. Marie, Ontario P6A 2E5	lisa.buse@mnr.gov.on.ca	705 946 7405