



VISTA Science & Technology

The Fusion of Science and Business™



Bioeconomy Industry Development Opportunities for Niagara

Final Report

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Executive Summary

Key Findings

The ranking of the CSF suggests the presence of a nascent, but growing bioeconomy cluster in the Niagara Region. All nine critical success factors are present in the Region and influencing the development of the Niagara Bioeconomy. R&D and Entrepreneurial Culture were the two strongest CSF, while Effective Networking and Supportive Policy Environment were identified as the two weakest CSF. Increases in several indicators suggest that the bioeconomy in Niagara is developing and growing:

- # employed in Scientific Research and Development Services
- University and College education attainment rates
- LQ- Scientific Research and Development
- R&D funding support and activities levels in the public research institutes

Twenty-two (22) Niagara-based organizations were identified as active in the bioeconomy. Eighteen (18) organizations are private sector companies; while four are public sector organizations (Niagara College, Brock University, Vineland Research and Innovation Centre; and Agriculture and Agri-food Canada. Of the 18 private sectors organizations included in the Niagara Bioeconomy Inventory, 10 were classified as small (<100 employees); 2 as medium (100 – 499 employees); and 6 as large organizations (>500 employees), based on the size definition used by Statistics Canada.

All sectors of the bioeconomy (bioproducts, functional foods/nutraceuticals, biopharmaceuticals/biotherapeutics and environmental products) were represented in the Niagara Bioeconomy Inventory. The largest sector appeared to be bioproducts with 10 organizations: seven in bioenergy; seven in biochemicals and three in biomaterials. The other three bioeconomy sectors were almost equally represented: eight in biopharmaceuticals/biotherapeutics; seven in functional foods/nutraceuticals and seven in environmental products.

The most significant position in the value chain was R&D, with more than 80% of the organizations (17) in the Niagara Bioeconomy Inventory involved in various types of research and development. Fourteen organizations in the R&D position of the value chain are private sector companies.

The level and availability of biomass in the Niagara Region represents a competitive advantage. Further research is needed to determine the quality and quantity the biomass feedstocks available in the Region. Opportunities for collaboration among biomass producers should be explored. Already there is evidence that greenhouses and grape producers are recognizing the value of biomass for value-added opportunities. These organizations are listed in the Bioeconomy Inventory. The agriculture sector in Niagara represents substantial receptor capacity for a variety of bioeconomy opportunities based on the utilization of waste biomass. Waste to energy initiatives appear to be the most immediate and accessible opportunities at this time and should be pursued aggressively.

Recommendations for Critical Success Factors

Research & Development

Regional policy facilitating capacity building in R&D in the Niagara Region should be priority for the Regional, as well as Municipal economy development agencies. Mobilizing the resources and expertise

within the public sector research institutions to support and advance the R&D capacity within the private sector is crucial for the growth of this critical success factor. Strong linkages between the public sector research institutions and the private sector organizations will lead to significant opportunities for economy development and investment attraction. This collaboration should be facilitated by the GHBN and strongly supported by Niagara College, Brock University, Vineland Research and Innovation Centre and Agriculture and Agri-Food Canada. Together, these organizations should engage the private sector in meaningful dialogue around the needs of the private sector for supportive R&D.

Entrepreneurial Culture

The bioeconomy by its very nature is entrepreneurial and therefore this critical success factor shows some strength. The entrepreneurial culture in the Region is nascent, but growing. Strategic efforts to support and nurture the entrepreneurial culture are warranted. The City of Guelph has had some success in building an awareness for entrepreneurship through the Guelph Partnership for Innovation (GPI). An organization with a mandate to support the Niagara bioeconomy based on the GPI model is an initiative worthy of further consideration by the Steering Committee. The Golden Horseshoe Biosciences Network could take a lead role and incubate such an organization until such time that it could be “spun-out” as a self-sustaining enterprise.

Effective Networking

Building enhanced networking opportunities throughout the bioeconomy sectors is critical to growing the nascent bioeconomy cluster. An organization based on the GPI model could have significant impact on improving this CSF. Networking and collaboration among the public sector research institutions and the private sector enterprises are critical to continued growth and development of the Niagara bioeconomy.

Supportive Policy Environment

Development of policy to support the growth and development of the Niagara bioeconomy is a priority that should not be delayed. Within the context of this report, policy is broadly defined to include all endeavours (implicit or explicit) that demonstrate a commitment to facilitating the growth of the bioeconomy in Niagara. Given the unique characteristics of the bioeconomy, it is unlikely that traditional policy options will provide meaningful outcome. It will be necessary to explore novel approaches to policy development (e.g. R&D free trade zones). Investigating policy research or best practices in other jurisdictions may offer critical insights for policy options. The NEDC should take a lead role and engage the 12 municipalities of the Niagara Region to collaborate on the development of policy that clearly demonstrates the commitment of the regional and municipal stakeholders to grow and develop the bioeconomy in Niagara. Consultation with the other bioeconomy stakeholders (as identified in the Niagara Bioeconomy Inventory) is an essential element of the policy development process.

Opportunities for Niagara Bioeconomy

Building R&D Capacity in the Bioeconomy

R&D represents an opportunity for investment attraction and economic development in two ways: specific to the bioeconomy and as a corporate function across all economic sectors. Further exploration of R&D capacity and activity in other key sectors of the Region is warranted. Positioning the Region as a centre for R&D is a compelling strategy for long-term economic growth and transitioning employment in the Region to a knowledge-based economy. Better linkages and alignment among the public research

institutions and private sector would be necessary to realize the full potential of a long-term economic growth strategy based on R&D. Collaboration should be facilitated by the GHBN and strongly supported by Niagara College, Brock University, Vineland Research and Innovation Centre and Agriculture and Agri-Food Canada. Together, these organizations should engage the private sector in meaningful dialogue around the needs of private sector for supportive R&D.

Building the Capacity of Bioeconomy Receptors – Waste to Energy Opportunities

The volume of biomass waste from Niagara-based agriculture production was estimated at 700,000 tonnes. The amount of biomass in the form of algae in Lake Erie is unknown but substantial. As such, the agriculture production and processing sectors in the Region represent a strong receptor base for waste to energy technologies such as anaerobic digestion and pyrolysis. The waste to energy receptor base in the Niagara Region offers a compelling basis to attract waste to energy technology providers to the Region. Planet Biogas Solutions is an example of the type of company that would find a solid market in the receptor base in the Niagara. Funding and technical support for regional renewable energy projects is available through the Community Power Fund. The Ontario Sustainable Energy Association works with community-based groups to develop and initiate community-based power projects.

Bioeconomy Niche Expertise in Fermentation

The wineries, while outside the scope and definition of the bioeconomy used for this study, represent an opportunity for building on existing expertise to develop a bioeconomy niche. Fermentation is a biological process used to manufacture a diverse range of industrial chemicals, in addition to wine. There is considerable technical and operational fermentation expertise resident in the wineries, the public research institutes, especially CCOVI, and Jungbunzlauer in Port Colborne's "Carbohydrate Alley". Biochemicals derived from biomass are generally obtained through industrial fermentation processes that make efficient use of a broad range of microorganisms to produce high-value fine chemicals, bulk chemicals, enzymes for use in pharmaceuticals through biocatalysis, and a broad range of industrial chemicals e.g. pesticides, solvents, plastics, vitamins and food additives. Worldwide demand for industrial enzymes was expected to reach \$2.7 billion by 2007 with a compound annual growth rate of 12%.

Niagara's chemical industry anchored by three multinational chemical companies: PolyOne, Oxyvinyl and Cytech, in collaboration with the wineries, Jungbunzlauer and Brock University could form basis for an investment attraction strategy to expand the nascent biochemical subsector in Niagara.

Introduction

Concentrations of economic activities linked to a specific industry have been of interest to scholars and economic development officials for quite some time. In recent years there has been increasing interest in the role of location in regional economic development. There is no doubt that the concept of “clusters” has become one of the central policy paradigms in economic development during the past decade. The reason for the popularity of this concept is not difficult to grasp. The rise of such regions as California’s Silicon Valley and the Research Triangle in North Carolina has shown how a region devoted to a high degree of science-based innovation can succeed in creating sustained economic growth. Researchers at the London Business School explain that clustering includes the phenomenon of a critical mass of one sector of an industry developing in one place such that other firms in that sector are attracted to the location, and the force of attraction that a core sector of an industry has on auxiliary sectors of the same industry to that location.¹

Emerging trends in the bioeconomy sector are strong indicators for strategic opportunities. Market growth and innovation in the bioeconomy sector has been driven by rising petroleum costs; decreasing biomass costs; process technology advances; climate change and pollution concerns and regulations; and the need for rural economic development. The trends are supported by abundant access to biomass resources in Canada. Energy derived from agriculture and forestry residues and harvests are estimated to be equivalent to 27% of annual fossil fuel demand.² The promise of biomass to support the development of clean technologies has been driving the agricultural biotechnology segment, as has the need to deal with global food shortages and preserve environmental resources.³ The bioeconomy shows significant potential in bioenergy; biomaterials and biochemicals. Much of the innovation in the bioeconomy sector is being driven by SMEs.

Both the federal and provincial governments have identified the bioeconomy as a strategic sector for investment. The market for bioproducts is expected to reach \$150 billion by 2050, with 30% of the world’s needs for fuel and chemicals being met from biomass. In Canada, as much as 5% of transportation fuel and 10% of organic chemicals and plastics could be derived from biomass by 2010. Existing technology for bioenergy has reached demonstration or production stage. There is already more than 4 million gallons of annual bio-oil capacity in Ontario. Major barriers to the development of a Canadian bioenergy industry include feedstock uncertainty, difficulty economically transporting low-density feedstock, the need for reliable access to water to produce biomass, and heavy international investments in bioenergy R&D.⁴ The market for biofuels (corn ethanol, cellulosic ethanol, biodiesel) is expected to be significant. Sales of advanced biofuels are expected to reach \$15 billion by 2010. By 2017, advanced biofuels are expected to account for 5-10% of global fuel production. Canada is regarded as a top nation in biofuels technology development, with specific strengths in research into industrial feedstocks, such as lignocellulosic crops, oil seeds, cereals and grasses. Particularly strong opportunities for biofuels technology development are in

¹ Martha Prevezer, “The Dynamics of Industrial Clustering in Biotechnology,” *Small Business Economics* 9, 1997: 255.

² Industry Canada, “The Promise of Bioproducts in Canada,” Industry Canada, [http://strategis.ic.gc.ca/epic/site/lsg-pdsv.nsf/vwapj/bioproducts-overview.pdf/\\$FILE/bioproducts-overview.pdf](http://strategis.ic.gc.ca/epic/site/lsg-pdsv.nsf/vwapj/bioproducts-overview.pdf/$FILE/bioproducts-overview.pdf), (accessed May 5, 2008).

³ Global Industry Analysts, “Local Agricultural Biotechnology Market to exceed \$8.0 Billion by 2009, According to a New Report by Global Industry Analysts, Inc.” PR Web, http://www.newscrafters.com/releases/agricultural_crops/biotechnology_seeds/prweb707894.htm, (subscription required) (accessed May 5, 2008).

⁴ Delphi Group and Stratros. 2008. Clean Technology/Bioeconomy. Ontario Ministry of Research and Innovation Public Consultation May 2008

cellulosic ethanol and biodiesel.⁵ The biochemical and bioplastics markets are already considerable. The biochemicals and bioplastics markets were forecasted to be between \$140- and \$210 billion by 2010.

Previous studies completed by VISTA and other stakeholders confirm that the Region displays the characteristics of an embryonic bioproducts sector. The purpose of the study was to expand on the previous studies and more clearly identify and define specific opportunities through in-depth local industrial intelligence that informs decision-making, strategic planning and attracts investor interest. The objective of the project was to examine the phenomenon of critical mass in the bioeconomy in the Niagara Region. Specifically, to determine if the Niagara Region has the appropriate infrastructure (i.e. critical success factors) in place to develop, grow or support a bioeconomy cluster.

Methodology & Approach

• Scope and Definitions

“Bioeconomy” implies that food/feed and non-food/feed biomass could be the basis for value-added activity in one or more markets, and could be part of competitive growth and prosperity strategies in a given region. The bioeconomy is an integral part of the larger economy and as such in the near term and perhaps for the foreseeable future, regional economic development strategies will need to reflect the integrated nature of the emerging bioeconomy. An expanded scope of the bioeconomy was adopted by the Steering Committee after careful consideration of the objectives and expectations of Committee members, and to remain consistent with current provincial and federal definitions. It was agreed that bioeconomy would include: bioproducts, further defined as biomaterials, bioenergy and biochemicals; functional foods/nutraceuticals; biopharmaceuticals/biotherapeutics and environmental products.

Bioproducts are defined as industrial products other than food, beverages, feed, and pharmaceuticals. Bioproducts are further classified as bioenergy, biochemicals and biomaterials (Table 1). Functional foods and nutraceuticals are classified as natural health products. Nutraceuticals are foods or active components of food that provide a medicinal or health benefit. Functional foods are foods that provide a health benefit beyond the nutrients normally contained in the food. Foods fortified with vitamins, bioactive compounds, herbs or nutraceuticals are considered to be functional foods. Omega-3 eggs are an example of an extraordinarily successful functional food; while omega-3 is an example of a nutraceutical. Biopharmaceuticals/biotherapeutics are drugs (Health Canada approved) that are manufactured through a biologically-based process such as fermentation or a plant that has been genetically modified to produce a specific compound. Another example of biopharmaceutical is the paclitaxel extracted from yew trees by Biolyse Pharma in St. Catharines. Environmental products are defined by a biomass waste or by-product feedstock, which is converted to a product that contributes to sustainable processes and production and reduces environmental footprint. Compost is a good example; however for the purposes of this analysis, the compost would have to be produced at a commercial scale.

⁵ Delphi Group and Stratos. 2008. Clean Technology/Bioeconomy. Ontario Ministry of Research and Innovation Public Consultation May 2008

Table 1. Types of Bioproducts

BIOENERGY	BIOCHEMICALS	BIOMATERIALS
Any form of energy produced from biomass/renewable feedstocks : steam, electricity, thermal	Specialty chemicals manufactured through a biological process such as fermentation and/or using a biomass feedstock	Industrial compound produced from biomass or composites that incorporate biomass/renewable components
Ethanol Bio-diesel Methane Syngas Hydrogen Bio-oil Bioenergy – energy feedstocks (e.g. ethanol, methanol, butanol, biodiesel, bio-oil, biogas, pellets, hog fuel), as well as the end products (e.g. electricity, thermal energy).	Industrial chemicals (e.g. cleaners, lubricants, sealants, solvents,), Intermediate biochemicals (e.g. ethylene) Chemical inputs/feedstocks for production of other products (e.g. oils, phenols, resins) Biotechnology products where at least part of the product is a biological organism or component (e.g. enzymes, molecular probes, microbes, yeast, bacteria)	Bioplastics, biobased blends, natural fibre composites, Biobased nanocomposites, biofoams, biorubber, biobased paints and coatings, Bioadhesives, and bioinks, and natural fibres, as well as the resulting end products (e.g. textiles, carpets, mats), rigid components (e.g. tiles, panels, beams and posts, tubes/pipes, casings, or other formed products), or granulated products (e.g. chips, pellets, dust).

- Value Chain Model

Based on the concept of value chain theory, closely aligned collaboration among organizations and companies that focus their collective resources to produce a product will lead to improved competitiveness for all stakeholders involved.⁶ Value chain analysis is a powerful tool for identifying strategic capacity and opportunities within a localized industry. A preliminary Niagara Bioproducts Value Chain (NBVC) was compiled by VISTA in 2004 to support earlier initiatives in building the Niagara bioproducts industry. The revised Niagara Bioeconomy Value Chain model was designed to reflect the expanded scope of the bioeconomy (Figure 1).

⁶ Martin Gooch, Value Chain Management: Drivers and Critical Success Factors, George Morris Centre, September 2005

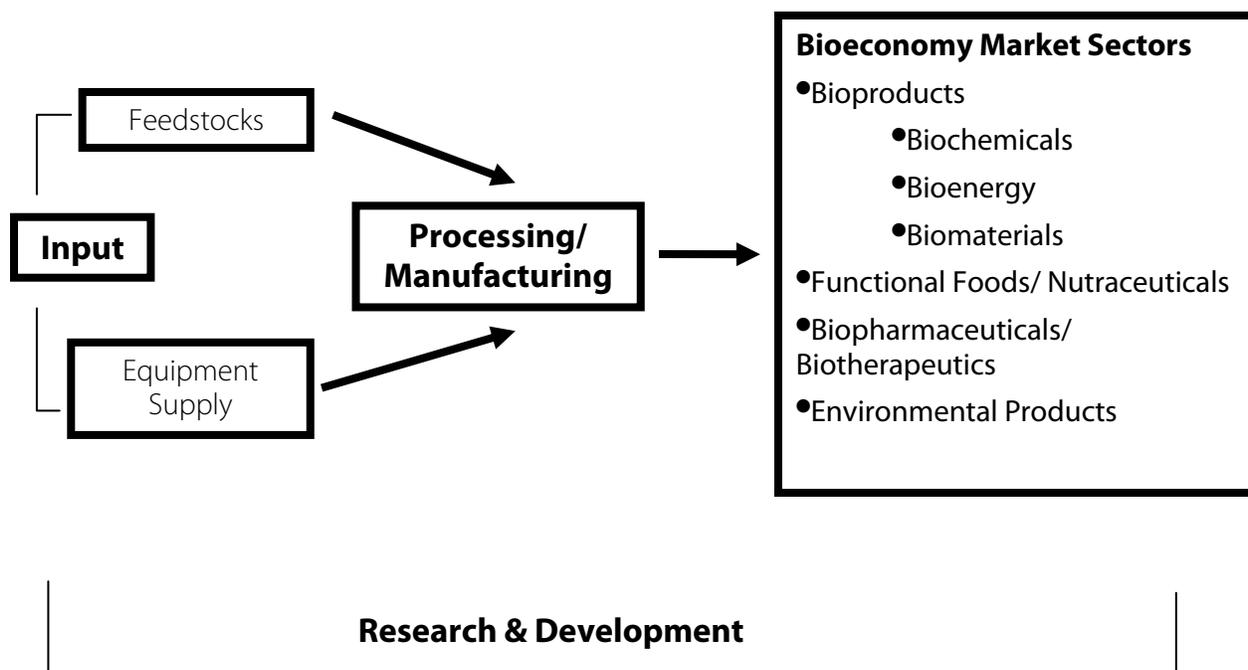


Figure 1. Bioeconomy Value Chain Model

The input position of the value chain is comprised of two distinct inputs: feedstocks and equipment (Figure 1). Feedstocks are defined as biomass intended for use in and subjected to some form of processing to prepare the biomass for use in manufacturing or energy generation processes. Residuals from conventional agricultural crops (including food crops) are considered a potential source of biomass feedstock for bioproducts. Other feedstocks could be bioenergy co-product streams such byproducts from lignocellulosic biofuel industries or paper and pulp industries, crude glycerol from emerging biodiesel industries, distillers' dried grains with solubles (DDGS) from corn ethanol industries, soy meal and canola meal (from soy/canola oil industries), food processing waste streams, and energy crops like hemp or miscanthus. The feedstock position of the value chain involves the production of biomass feedstock or the diversion of waste biomass byproduct specifically for processing or producing a product that belongs to one or more of the bioeconomy sectors: bioproducts, nutraceuticals/functional foods; biopharmaceuticals/biotherapeutics; and environmental products. Simply producing biomass such as growing grapes or livestock production does not meet the criteria for inclusion in the feedstock position of the value chain. Consistent supplies of biomass feedstock are certainly an advantage to a region interested in building a bioeconomy and therefore quality and quantity of biomass produced in the Niagara Region was considered in the critical success factors benchmarking. The equipment supply position of the value chain includes organizations that provide technology, equipment and/or components for processing and manufacturing. These organizations include distributors or re-sellers of equipment and full service firms who design, build and operate bioprocessing/manufacturing systems.

The processing position of the value chain includes organizations that process a biomass feedstock and/or use a biologically-based processing method. An organization that processes chicken manure by pyrolysis to produce bio-oil and/or specialty chemicals would be included in the processing position of the value chain. Alternatively, a company manufacturing an industrial chemical, such as an enzyme, through a fermentation process would also be included in the processing position of the value chain. Even though wineries use fermentation to process a biomass feedstock, the end product -wine- is not a bioproduct,

functional food, nutraceutical, biopharmaceutical, biotherapeutic or environmental product. On this basis, the wineries, on the basis of producing wine, are not included in the Niagara Bioeconomy Inventory. Processing/manufacturing includes biological, chemical, physical or thermal methods. In order to meet the criteria for inclusion in the processing position of the value chain, the organization had to operate on a commercial scale and serve an external market. A greenhouse using anaerobic digestion to produce energy to support its own operation would not be included in the inventory. A consortium of greenhouses that invest in an anaerobic digestion system to process greenhouse biomass and/or other biomass feedstock as a separate operation with the intention of generating revenues would be included in the inventory.

The R&D position of the bioeconomy value chain includes organizations involved in scientific research, technology, product and process development, as well as technology transfer and commercialization related to any position within the bioeconomy value chain or any of the bioeconomy sectors.

• Cluster Analysis

While the concept of clusters has achieved a status where it plays a role in describing how regional economies grow, there is still a degree of empirical uncertainty about when a given geographic-industrial arrangement has achieved cluster status and what role policy can play in creating, developing, and sustaining clusters. Assessing the strengths and weaknesses of clusters is an imprecise art. There is no definite determination of

- when critical mass is attained
- when effective knowledge transfer and networking is or is not taking place
- when sufficient financial support is present
- if a strong science base exists

Instead, most researchers tend to use proxies to assess the strength and weaknesses of clusters. More specifically, critical success factors (CSFs) have widely been used to determine whether or not the “right ingredients” are in place for cluster growth and development.⁷ It is important to note that many of the critical success factors are not specific to cluster growth and development but are also relevant to promoting regional economic development in general.

• Critical Success Factors

In the absence of valid statistical data that accurately defined the Niagara bioeconomy, accepted and recognized critical success factors for evaluating clusters were used in a qualitative benchmarking exercise to investigate the strengths and weaknesses of a Niagara bioeconomy cluster. The critical success factors were identified in a previous VISTA study on Clusters: strong science base, research and development support, entrepreneurial culture, availability of financing; business support services; effective networking; supportive policy environment; and physical infrastructure⁸. The nine CSF used in the study and the data used as indicators for evaluating the CSF are described in the Bioeconomy Critical Success Factors Benchmarking results.

⁷ E Hill, and J. Brennan, “A methodology for identifying the drivers of industrial clusters: The foundation of regional competitive advantage,” *Economic Development Quarterly* 14, 2002: 65.

⁸ VISTA, “Clusters,” April 2004.



Niagara Bioeconomy Inventory

Using the expanded scope and definitions approved by the Steering Committee, a variety of secondary sources (Table 2) were reviewed to identify those organizations based in the Niagara Region that met the selection criteria for inclusion in the Niagara Bioeconomy Inventory. Organizations were identified on the basis of activities related to any of the bioeconomy sectors: bioproducts, functional foods/nutraceuticals, biopharmaceuticals/biotherapeutics and environmental products. Under these criteria, wineries and greenhouse operations and other agricultural production were excluded from the inventory. In order to be included in the inventory, bioeconomy activity had to take place within the Niagara Region. Therefore, even though ADM Milling and Polyone are actively involved in the bioeconomy at a corporate level, the operations in the Niagara Region are not. Thus, these organizations were not included in the inventory. A separate list of organizations that did not meet the strict selection criteria for the Bioeconomy Inventory, but possess characteristics of potential to contribute to the development of the bioeconomy has been provided to the Steering Committee in a separate document.

Table 2: Secondary sources reviewed for inventory

Ontario Functional Foods and Natural Health Products Directory, http://www.marslanding.ca/useredits/File/Final%20Directory.pdf .
Ministry of Research and Innovation Bioproducts directory, http://mba.ebdata.com/mrio/search.jsp .
Niagara Economic Development Corporation Business Directory
Golden Horseshoe BioSciences Network Business Directory
Vista Science & Technology Database

Organizations identified on the basis of being active in one or more bioeconomy sectors were further classified by their position in the value chain (Figure 1). The input position of the value chain is comprised of two distinct elements: feedstocks and equipment. The feedstock position was defined as the production of biomass feedstock or diversion of a waste biomass byproduct specifically for processing or producing a product that belongs to one or more of the bioeconomy sectors: bioproducts, nutraceuticals/functional foods; biopharmaceuticals/biotherapeutics; and environmental products. Simply producing biomass such as growing grapes or livestock production was not a basis for inclusion in the feedstock position of the value chain. Consistent supplies of biomass feedstock is certainly an advantage to a region interested in building a bioeconomy and therefore volume of biomass produced in the Niagara Region is considered in the critical success factors benchmarking. Feedstocks are defined as biomass intended for use in and subjected to some form of processing to prepare the biomass for use in manufacturing or energy generation processes. Residuals from conventional agricultural crops (including food crops) are often referred to as ‘waste’ and are considered a potential source of biomass for bioproducts. Other feedstocks could be bioenergy co-product streams such as byproducts from lignocellulosic biofuel industries or paper and pulp industries, crude glycerol from emerging biodiesel industries, distillers’ dried grains with solubles (DDGS) from corn ethanol industries, soy meal and canola meal (from soy/canola oil industries), CO₂, food processing waste streams, and energy crops like hemp or miscanthus. The equipment supply position of the value chain includes organizations that supply technology, equipment and/or components for processing and manufacturing. These organizations can be distributors or re-sellers of equipment or full service firms who design, build and operate bioprocessing/manufacturing systems.

The processing position of the value chain includes organizations that process a biomass feedstock and/or use a biologically-based processing method. An organization that processes chicken manure by pyrolysis to produce bio-oil and/or specialty chemicals would be included in the processing position of the value

chain. Alternatively, a company manufacturing an industrial biochemical such as an enzyme through a fermentation process would be included in the processing position of the value chain. Even though wineries use fermentation to process a biomass feedstock, the end product – wine- does not fit into the bioeconomy sectors that define the scope of the project and therefore the wineries were not included in the Niagara Bioeconomy Inventory. In order to be placed in the processing position or identified as producing a product belonging to any of the bioeconomy sectors, the organization had to operate on a commercial scale. The processing and/or the end product had to be destined for a commercial market, rather than internal use. A greenhouse using anaerobic digestion to produce energy to support its own operation would not be included in the inventory. A consortium of greenhouses that invest in an anaerobic digestion system to process greenhouse residues and/or other biomass feedstock as a separate operation with the intention of generating revenues would be included in the inventory.

The R&D position of the bioeconomy value chain includes organizations involved in scientific research, technology, product and process development, as well as technology transfer and commercialization related to any position within the bioeconomy value chain or any of the bioeconomy sectors.

Twenty-two (22) Niagara-based organizations were identified as active in the bioeconomy (Table 3). Eighteen (18) organizations are private sector companies; while four are public sector organizations (Niagara College, Brock University, Vineland Research and Innovation Centre; and Agriculture and Agri-food Canada. Of the 18 private sectors organizations included in the Niagara Bioeconomy Inventory, 10 were classified as small (<100 employees); 2 as medium (100 – 499 employees); and 6 as large organizations (>500 employees), based on the size definition used by Statistics Canada. A Directory of the Niagara Bioeconomy is included in Appendix 3.

All sectors of the bioeconomy (bioproducts, functional foods/nutraceuticals, biopharmaceuticals/biotherapeutics and environmental products) were represented in the Niagara Bioeconomy Inventory (Table 4, Figure 2). The largest sector appeared to be bioproducts with 10 organizations: seven in bioenergy; seven in biochemicals and three in biomaterials (Table 4, Figure 3). The other three bioeconomy sectors were almost equally represented: eight in biopharmaceuticals/biotherapeutics; seven in functional foods/nutraceuticals and seven in environmental products (Table 4, Figure 2).

Table 3. The Niagara Bioeconomy Inventory

COMPANY NAME	LOCATION	DESCRIPTION
Abitibi-Consolidated Company of Canada	Thorold	Since 2002, Abitibi has been using biogas generated by Walker Industries to power 10% of manufacturing operations. In December 2003, the project was expanded to provide landfill gas for 25% of its steam requirements.
Agriculture and Agri-Food Southern Crop Protection and Food Research Centre (Vineland Research Farm)	Vineland	Research activity at Vineland supports development of improved methods of integrated pest management. It is the main site of fruit tree research.
Bee Biomedicals	St. Catharines	A small biopharmaceutical company involved in R&D of anti-viral, anti-inflammatory topical skin therapies based on the bioactive compounds of honey and propolis. Bee Biomedical works with industrial partners represented by the Canadian Honey Council and other government agencies to develop new value added products for biomedical/biotherapeutics
Biolyse Pharma	St Catharines	Biolyse conducts R&D in the production of natural-based medical products and chemical extracts. Also involved in harvesting and manufacturing of paclitaxel, a cancer fighting drug using technology that concentrates and purifies natural bioactive compounds.
Brock University	St Catharines	The Institute of Molecular Catalysis conducts research in design, synthesis, and characterization of new catalysts; application of these catalysts to chemical synthesis; biocatalysis and mechanistic studies. The Centre for Biotechnology is a joint venture between departments of biological sciences and chemistry. The Cool Climate Oenology & Viticulture Institute contributes to the regional research into wine making products.
Casco Inc.	Port Colborne	Casco produces corn-derived products — starches, fermentable sugars, sweeteners, feed and oil used by more than 60 different industries.
Clark Agri Services	West Lincoln	Clark Agri Services is an agriculture retail company. It conducts R&D for new product development and field trials of high yielding corn for ethanol production with major seed companies and also focuses on converting manure to novel products bioproducts.
Emery's Health Products	St Catharines	Emery's Health Products manufactures and sells an all natural herbal compound for the treatment of

		onychomycosis (finger and toenail fungus).
Envirofix Corp	Niagara Falls	Envirofix is a multi-disciplinary remediation company providing services in site cleanup, restoration and remediation. The company offer a variety of remediation systems including dual phase extractions, activated carbon systems, bio-venting, vapor phase extraction, insitu-exsitu bioremediation systems, hydrocarbon degrading, bacteria implementation system, bio-augmentation and bacterial culture enhancement systems, sediment, sludge, groundwater and industrial sewage.
Joseph's Estate Wines Inc.	Niagara-on-the-Lake	Joseph Estate Winery produces a line of grape seed oil extracted from the grape pomace. The grape seed oil is rich in nutrients such as antioxidants and fatty acids such as linoleic acid. Through the second line of business: Vintage Flour Niagara Inc., a unique, nutritional and gluten free flour is manufactured from the grape skins. The flour can be used in any recipe where wheat flour is used.
Jungbunzlauer Canada Inc.	Port Colborne	Manufactures natural, biodegradable ingredients for the food, cosmetics and pharmaceutical industry. Some of the products include citric acid, gluconates and sweeteners. Citric acid is a natural occurring fruit acid produced commercially by microbial fermentation
Kare & Hope Inc.	St. Catharines	Kare and Hope Inc. is involved in research and marketing innovative health products based on black seed oil, garlic, and other aromatic herbs.
Niagara College	Welland	Niagara College is a member of the Colleges Ontario Network for Industrial Innovation (CONII), whose mandate is to help small companies solve technical problems, adapt new technologies, and develop or improve new products and processes. The College is invovled in several on-going applied research projects directly related to the bioeconomy.
Norgen Biotek Corp	Thorold	Norgen Biotek Corp., an innovative Canadian biotechnology company focusing primarily on advancing powerful tools for nucleic acid and protein purification and concentration. Expertise in biology, virology, and immunology.
Pharmetics	Fort Erie	Pharmetics is a full service private label and contract manufacturer of pharmaceutical products and efficient development of nutraceuticals, biopharmaceuticals such as proteins, peptides and monoclonal antibodies (MAb).

Planet Biogas Solutions	St. Catharines	PlanET Biogas Solutions designs, builds and installs anaerobic digester systems for use in greenhouses, poultry barns or factories that produce organic by-products. They are currently constructing their second digester at Vandermeer Greenhouses at Niagara-on-the-Lake. Their main focus is the Ontario market, however, they serve biogas customers throughout Canada and selected projects in the USA.
Redcoat Consulting	Ridgeway	Redcoat Consulting undertakes early stage IP development & technology transfer consultancy as the foundation for a privately operated business incubator working in collaboration with academic institutions and commercial partners
Sherwin-Williams Canada Inc.	Fort Erie	Sherwin-Williams conducts R&D and through its GreenSure Initiatives uses sustainable raw materials such as soy and sunflower oil in their paints.
Vineland Research and Innovation Centre (VRIC)	Lincoln	VRIC has an objective of developing a bio-active compound industry in the Niagara Region based on the extraction of individual molecular species from Niagara Peninsula crops, and/or processing co-products.
Vinifera For Life	Jordan	Vinifera For Life manufactures premium grape powders from grape skins and seeds. The grape powders, which contain high levels of fibre and polyphenols such as antioxidants and resveratrol are premium ingredients in gourmet breads, pasta and other other products.
Vista Science and Technology Inc.	Welland	VISTA Science & Technology Inc. works with organizations across the innovation value chain to maximize the outcomes of their investments in R&D. The bioeconomy is an area of special expertise.
Walker Industries Holdings Limited	Niagara Falls	Walkers Industries' is involved in several markets of the bioeconomy including bioproducts and environmental products. The company is active in several positions of the bioeconomy value chain: inputs- feedstocks, processing and R&D.

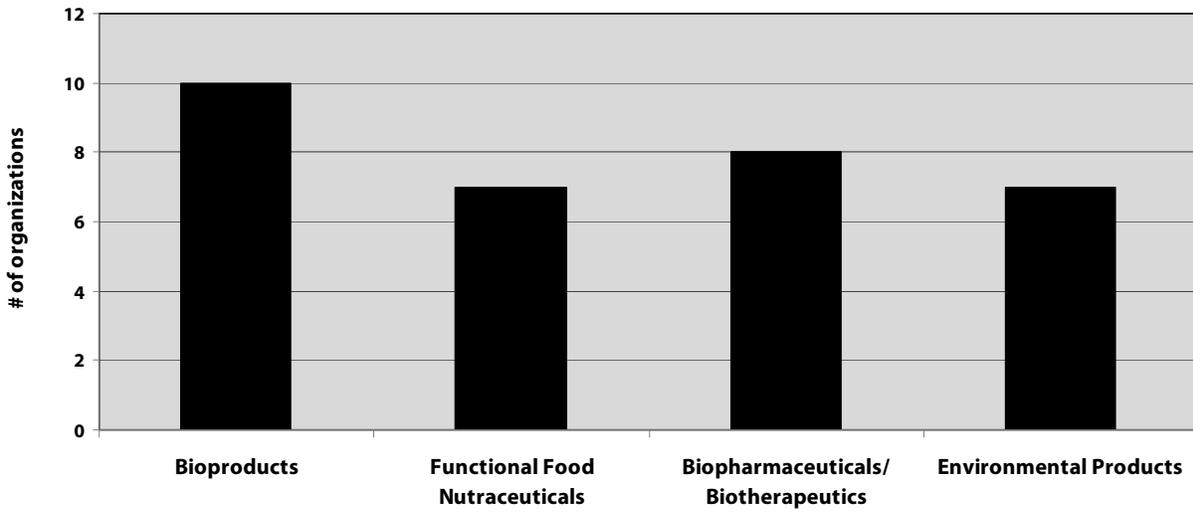


Figure 2. Distribution of Niagara organizations in the sectors of the bioeconomy.

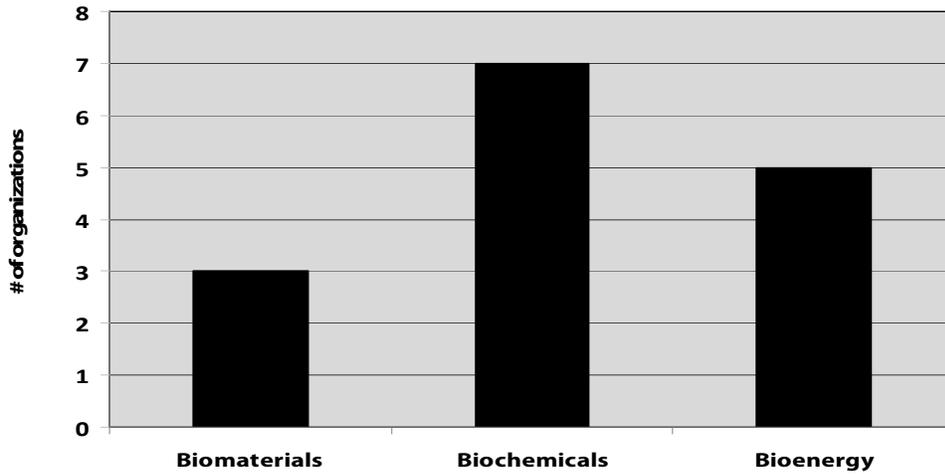


Figure 3. Distribution of the types of bioproducts in the Niagara Bioeconomy Inventory.

Six organizations were placed in the feedstock position of the value chain (Table 5). Within the feedstock position, four organizations produced agricultural biomass; one organization produced municipal solid waste; and one organization produced forestry biomass (Table 5). One organization was placed in the equipment supply position (Table 5). PlanET Biogas Solutions designs, builds and operates anaerobic digestion systems. They are currently involved in two such projects with Niagara-based greenhouses.⁹

Thirteen organizations were placed in the processing position (Table 5). The majority were active in bioprocessing (eight); five used chemical/physical processing of biomass and one used thermal processing.

The most significant position in the value chain was R&D, with more than 80% of the organizations (17) in the Niagara Bioeconomy Inventory involved in various types of research and development. (Table 5). Fourteen organizations in the R&D position of the value chain are private sector companies.

Interviews were conducted with nine of the private sector organizations placed in the R&D position of the value chain (see Appendix 3 for the interview guide). The purpose of the interviews was to gain a better understanding of the scope and nature of the R&D activities within the private sector. The focus and intensity of the R&D activity varied significantly among the various companies. All those interviewed confirmed that the R&D function within their organization in Niagara was permanent, with many indicating that there were plans to expand the R&D activities within the Region. Most of the R&D undertaken by the companies was focused on new product development. To a lesser extent, R&D was focused on operational efficiencies and manufacturing process development and optimization. One organization was doing feedstock-related research. Seven of the nine companies interviewed were in the natural health products market, including functional foods, nutraceuticals and biopharmaceuticals. Two of the companies were in the bioproducts market: biochemicals and bioenergy. Key challenges identified during the interviews included:

- Lack of financing/funding to support R&D and related activities
- Lack of suitable laboratory space
- Lack of trained/skilled employees

There did not appear to be significant collaboration or networking among the organizations active in R&D in Niagara bioeconomy. The focus of research at the public research institutions, especially those noted for early stage R&D appeared to lack alignment with the focus of R&D at the private companies. This could be a critical weakness for the Region, since public sector research is often cited as the source of innovations in the private sector and the driver of regional economic development. Cases studies have demonstrated that most clusters grow and develop using science and technology generated from local institutions.¹⁰

⁹ PlanET Biogas Solutions <http://www.planet-biogas.ca/news.html> (accessed October 28, 2008)

¹⁰ Ecotec Research & Consulting, "A Practical Guide to Cluster Development," <http://clusters.wallonie.be/federateur/en/surveys-and-assessments/at-the-international-level/a-practical-guide-to-cluster-development.html> (accessed October 28, 2008)

Table 4. Organizations in the Niagara bioeconomy market sectors

BIOPRODUCTS			FUNCTIONAL FOOD / NUTRACEUTICALS	BIOPHARMACEUTICALS / BIOTHERAPEUTICS	ENVIRONMENTAL PRODUCTS
Biochemicals	Bioenergy	Biomaterials			
AAFC-Vineland Research Farm	AAFC-Vineland Research Farm	AAFC-Vineland Research Farm	AAFC-Vineland Research Farm	Bee Biomedicals	Abitibi-Consolidated Company of Canada
Bee Biomedicals	Niagara College	Redcoat Inc	Joseph's Estate Wines Inc.	Biolyse Pharma	Clark Agri Services
Casco Inc.	PlanET Biogas Solutions	Vista Science and Technology	Kare & Hope Inc.	Brock University	Envirofix Corp
Jungbunzlauer Canada Inc.	Redcoat Inc		Pharmetics	Emery's Health Products	Redcoat Inc
Redcoat Inc	Vista Science and Technology		Redcoat Inc	Norgen Biotek Corp	Sherwin-Williams Canada Inc.
Vineland Research and Innovation Centre	Walker Industries Holdings Ltd.		Vinifera For Life	Pharmetics	Vista Science and Technology
Vista Science and Technology			Vista Science and Technology	Redcoat Inc	Walker Industries Holdings Limited
				Vista Science and Technology	

Table 5. Value chain positions of organizations in the Niagara bioeconomy inventory.

PROCESSING			FEEDSTOCKS			R&D	DISTRIBUTION & HANDLING
Chemical/ Physical	Thermal	Biological	Agriculture	Municipal Solid Waste	Forestry		
Casco Inc.	Walker Industries Holdings Ltd.	Abitibi-Consolidated Company of Canada	Casco Inc.	Walker Industries Holdings Ltd.	Abitibi-Consolidated Company of Canada	AAFC-Vineland Research Farm	PlanET Biogas Solutions
Joseph's Estate Wines Inc.		Bee Biomedicals	Clark Agri Services			Bee Biomedicals	
Pharmetics		Biolyse Pharma	Joseph's Estate Wines Inc.			Biolyse Pharma	
Sherwin-Williams Canada Inc.		Clark Agri Service	Vinifera For Life			Brock University	
Vinifera For Life		Envirofix Corp	Walker Industries Holdings Ltd.			Clark Agri Services	
		Jungbunzlauer Canada Inc.				Emery's Health Products	
		Norgen Biotek Corp				Joseph's Estate Wines Inc.	
		Walker Industries Holdings Ltd.				Kare & Hope Inc.	
						Niagara College	
						Norgen Biotek Corp	
						Pharmetics	
						Planet Biogas Solutions	
						Redcoat Consulting	
						Sherwin-Williams Canada Inc.	
						Vineland Research and Innovation Centre (VRIC)	
						Vinifera For Life	
						Vista Science and Technology Inc.	
						Walker Industries Holdings Ltd.	



Bioeconomy Critical Success Factors Benchmarking

The critical success factors (CSF) used to evaluate the Niagara Bioeconomy cluster do not have predictive utility (i.e. they can not be used to determine if a successful cluster will emerge). The CSF are a qualitative method to determine if the key factors are in place in the Region to support businesses and regional economic development in the bioeconomy. Used in conjunction with different benchmarks, the CSFs provide an effective means to highlight areas with the greatest potential and opportunities for improvement.

The CSFs were ranked on a scale 0-5 to evaluate how well the Niagara Region’s bioeconomy met each critical success factor (Table 6). The assessment of the CSFs (Table 7) was based on qualitative review and interpretation of literature cited in this report and relevant information provided to VISTA by the Steering Committee.

Table 6. Scale for ranking critical success factors to assess the Niagara Bioeconomy.

SCALE DEFINITION	
0	Non-Existent or is a source of serious disadvantage
1	Not Present
2	Weak presence
3	Present but not sufficient to provide advantage
4	Present, contributes positively to region
5	Strong, provides competitive advantage

The ranking of the CSF suggests the presence of a nascent, but growing bioeconomy cluster in the Niagara Region. With a location quotient of 0.71 compared to the province, the Niagara Region faces competition from other regions in the province and across Canada with economic growth strategies focused on building a bioeconomy. Several regions are actively pursuing bioeconomy related initiatives: The Municipality of Chatham-Kent has issued a request for proposal for an bio-auto opportunity study. The purpose of the initiative is to identify technologies in Europe that could be fast-tracked into production in manufacturing operations in Chatham-Kent, enhancing the existing bio-auto industry in the municipality. The Southern Ontario Bioproducts Innovation Network (SOBIN) recently announced the new Centre for Agricultural Renewable Energy and Sustainability (CARES) at the Ridgetown Campus, University of Guelph. The Centre will have an agricultural focus, with the objectives of strengthening the agriculture sector, improving sustainability and development, increasing alternative energy and energy conservation, and leveraging education, training and research. It will include a research and demonstration facility to test new technologies. The Saskatchewan Research Council has issued a request for proposal for “R&D Needs and Opportunities in Nutrition, Health and Wellness.” This initiative is a follow up to the study published in 2007: Building Saskatchewan’s Bioeconomy – A Life Sciences Strategy. The report identified two priority opportunities for the province: biofuels/bioproducts and nutrition, health and wellness.

All nine critical success factors are present in the Region and influencing the development of the Niagara Bioeconomy. Increases in several indicators suggest that the bioeconomy in Niagara is developing and growing.:

- # employed in Scientific Research and Development Services
- University and College education attainment rates
- LQ- Scientific Research and Development
- R&D funding support and activities levels in the public research institutes

Targeted regional policies and strategies to support and stimulate continued cluster development could have positive impacts on the economy of the Niagara Region.

• Strong Science Base

A strong science base provides the necessary base from which innovations, ideas and products for development will originate. Cases studies have demonstrated that most clusters grow and develop using science and technology generated from local institutions.¹¹ While number and quality of universities, colleges and other research-oriented institutions in the area are important criteria in assessing the strength of a science base, it is not the only consideration. The impact of the institution on the local economy is an important consideration. For instance, John Hopkins University, which by any measure is an outstanding and internationally leading institution and the single largest recipient of research funding from the National Institute of Health¹², seems to have had only a minor effect on local growth.¹³ The lack of local impact has been attributed to the institution’s organizational culture, which has emphasized purely academic research and discouraged its commercialization.¹⁴ Thus the historical and institutional context that influences the university’s organizational culture and approach is a factor to consider.

Table 7. Ranking of critical success factors for the Niagara Bioeconomy

CRITICAL SUCCESS FACTOR	INDICATORS	RANKING
Strong Science Base	<ul style="list-style-type: none"> • Leading research organizations; relevant and active university departments • Critical mass of researchers 	3
Research & Development Support	<ul style="list-style-type: none"> • Level of R&D funding from both public and private sources • National, provincial R&D ranking 	4
Entrepreneurial Culture	<ul style="list-style-type: none"> • Incentives offered to small businesses and inventors, Entrepreneurial activity in the region. • Business incubators • Number of new establishments • Commercial awareness and entrepreneurship in universities and research institutes 	4

¹¹ Ecotec Research & Consulting, “A Practical Guide to Cluster Development,” <http://clusters.wallonie.be/federateur/en/surveys-and-assessments/at-the-international-level/a-practical-guide-to-cluster-development.html>. (accessed October 28, 2008)

¹² B. Clayman and J. Holbrook, “The Survival of University Spin-offs and their Relevance to Regional Development,” <http://www.innovation.ca/publications/clayman1.pdf> (accessed October 28, 2008).

¹³ Pontus Braunerhjelm and Bo Carlsson, “Introduction: Regional Growth, Clusters and Institutions,” *Industry and Innovation* 10, no., 1-3, 2003: 1.

¹⁴ Ibid.

CRITICAL SUCCESS FACTOR	INDICATORS	RANKING
Availability of finance	<ul style="list-style-type: none"> • Seed capital • Venture Capital • Business Angels 	3
Business support services	<ul style="list-style-type: none"> • Number of businesses that support other businesses: legal, accounting, intellectual property, human resources 	3
Skilled workforce	<ul style="list-style-type: none"> • Availability of skilled workforce • Training provision at all levels 	3
Effective networking	<ul style="list-style-type: none"> • Shared aspirations to be a cluster • Regional trade associations • Shared equipment and infrastructure • Frequent collaborations 	2
Supportive policy environment	<ul style="list-style-type: none"> • National and provincial innovation support policies • Support from regional/local economic development offices 	2
Physical Infrastructure	<ul style="list-style-type: none"> • Telecommunication, transportation infrastructure • Access to consistent supply of inputs • Specialized premises such as incubators and laboratories 	3

One way to assess an institution's view of commercialization is to investigate spin-off formation and invention disclosures. University spin-offs have been linked to regional development.¹⁵ A study by researchers at Simon Fraser University found that overall (across all industries) 80% of university spin-offs operate in the same region as the university from which they originated and thus are significant drivers of regional economic activity.¹⁶ Another indicator of a strong science base is the presence faculty members with relevant expertise.

Another important consideration in assessing an institution's approach to commercialization is to examine the type of interaction between the institution and local firms. Licensing rights to a technology developed at an institution to local firms is a key activity that can support and grow local firms. Another way institutions can support local firms is through contract research and training and other types of joint projects. Such activity serves to strengthen the receptor capacity in a region over time, which provides the base for future growth and development of a regional economic base.

There are four public research institutions in the region with research programs broadly related to the bioeconomy:

Vineland Research and Innovation Centre has a research objective of developing a bio-active compound industry in the Niagara Region based on the extraction of individual molecular species from Niagara Peninsula crops, and processing co-products.¹⁷

¹⁵ Ibid.

¹⁶ Bruce Clayman and Adam Holbrook, "The Survival of University Spin-offs and their Relevance to Regional Development," <http://www.innovation.ca/publications/clayman1.pdf> (accessed October 28, 2008).

¹⁷ Vineland Research and Innovation, "Value-Added Traits: Identification and Development of Value from Bioactive Compounds" 5-year business plan Available [Online] http://www.vinelandontario.ca/v1/pdf/5_Year_Plan_June_3-08_Public.pdf Accessed October 10, 2008.

The Strategic Research Plan (SRP) 2006-2011 of Brock University outlines the development of a life science focus across three faculties: Mathematics and Science, Applied Health Sciences and Social Science. Specific areas of research include "...biotechnology, neurosciences, material sciences (biomaterials), health promotion, life span, crop development, plant-based and synthetic pharma- and nutraceuticals, and bioproducts."¹⁸ Several research institutes at Brock are relevant to the bioeconomy:¹⁹

- The Institute of Molecular Catalysis
The Institute brings together scientists from the Departments of Biology, Chemistry, and Physics whose interests are in chemical or biological catalysis. It is "...designed to be a unique regional centre supporting research in: the design, synthesis and characterization of new catalysts; application of these catalysts to chemical synthesis; biocatalysis (whole cell and isolated enzymes); and mechanistic studies aimed at understanding how catalysts work."²⁰
- Cool Climate Oenology and Viticulture Institute (CCOVI)
The goal of CCOVI is to meet the research and educational needs of the cool climate grape growing and wine producing regions of Canada.
- The Centre for the Environment
The Centre focuses on everyday environmental concerns. It has programs and the expertise in environmental chemistry, biology, geology, geography, sociology, politics and economics.²¹
- Centre for Biotechnology
The centre provides expertise and resources to the field of biotechnology. It is a joint venture of the Departments of Chemistry and Biological Sciences.²²

Niagara College is one of 10 Ontario colleges that form the Colleges Ontario Network for Industry Innovation (CONII), a new applied research and development network. The aim of CONII is to help "small and medium enterprises (SMEs) solve technical problems, adapt new technologies for the marketplace, and develop new or improved products and processes."²³ This \$3.5million program is part of the plans by the government of Ontario to speed up the R&D process and market products more quickly to improve the competitiveness of the province in the global market. The College is involved in a variety of applied research projects that include the development of new environmental products and advanced visualization for land use management.

The Agriculture and Agri-Food Canada (AAFC) Southern Crop Protection and Food Research Centre (AAFC, Vineland Research Farm) supports the development of improved methods of integrated pest management.²⁴ One of the goals of AAFC is to "develop new opportunities for agriculture from

¹⁸ Brock University Strategic Research Plan (SRP) 2006-2011 Available [Online] http://www.brocku.ca/avpr/pdf/brock_strategic_research_plan_2006_to_2011.pdf and <https://www.brocku.ca/researchservices/>. Accessed October 8, 2008

¹⁹ Brock University Research Institutes. Available [Online] <https://www.brocku.ca/avpr/researchers/institutes.php>. Accessed October 8, 2008

²⁰ "Brock can meet your business needs" Available [Online] <http://www.brocku.ca/extrel/community/business.html>. Accessed October 16, 2008

²¹ Ibid.

²² Ibid.

²³ Colleges Ontario Network for Industry Innovation, "About" Available [Online] <http://www.conii.ca/aboutconii.php>. Accessed October 21, 2008

²⁴ Southern Crop Protection and Food Research Centre. AAFC website <http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1180640801098&lang=e> (accessed October 30, 2008)

bioresources.”²⁵ Some of the roles the centre has identified include increasing scientific capacity and knowledge to support the “...agriculture and agri-food sector in using biomass to develop new products, new uses, and new markets.”²⁶ Additionally, “to develop strategies as well as tools, techniques, and processes that enhance total biomass utilization”²⁷. Furthermore, “...undertake scientific collaboration in the development of biomass, bioprocesses and biorefinery systems for the production of biofuels, industrial biomaterials and chemicals, and health products.”²⁸

The science base in the Region could be described as nascent. While the public research institutions represent significant potential for impacting regional growth in the bioeconomy through research and development, the collective activities and capabilities have yet to be coordinated and mobilized in a way that realizes that potential. Within the R&D position of the value chain there are 14 private sector organizations. Interaction between these firms and the public sector research organizations appears to be limited. Walkers is involved in several R&D projects with Brock University and Niagara College. However, Walkers tends to work more intensely with research institutions outside the Region.²⁹ Bee Biomedical appears to have an on-going collaboration with Brock University. Niagara College is actively engaged with local vineyards and other agriculture sectors in connection with their land use technology research program. Commercialization and spin-off activities within the Region have been limited.

Between 2001 and 2006 the number of people employed in scientific research and development services in the Niagara Region increased by a compound annual growth rate (CAGR) of 12%, while the provincial CAGR was 4%. In 2001, there were 145 people employed in scientific research and development services in the Niagara Region. This number increased in 2006 to 255. The LQ for R&D in Niagara, based on 2006 census data was 0.52, an increase from 0.43 in 2001.³⁰

• Research and Development

R&D is the foundation of a strong science base and subsequent innovation. Most leading technology regions have acquired their status due to the presence of a strong and established research base in relevant fields and the availability of continuing investment from private and public sector firms to sustain the lengthy and costly process of product development.³¹ National, provincial, regional and private-sector funds are necessary to develop a strong science base and to support regional economic growth and development. Support for R&D can take many forms, including R&D tax credits, technology transfer schemes and specific funds for industry-academic collaborations. While much more difficult to assess, non-monetary support for R&D is also essential and includes effective policies that reward R&D efforts by firms. Trends in R&D activity and funding at Niagara-based public research institutes and a recent ranking of R&D by census management areas (CMA) was used to assess how well Niagara meets this critical success factor

²⁵ AAFC Science and Innovation Strategy Priorities.. <http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1183760559460&lang=e#6>. AAFC website (accessed October 30, 2008)

²⁶ *Ibid*

²⁷ *Ibid*

²⁸ *Ibid*

²⁹ Mike Watt, Walker Industries Holding Ltd. in an interview with M.A. Lemay. October 10, 2008.

³⁰ Employment for the scientific research and development services sector does not include researchers in universities, colleges or government research institutions.

³¹ David Wolfe, “Clusters from the Inside-Out: Lessons from the Canadian Study of Cluster Development,” DRUID Summer Conference, Copenhagen, June 12-14, 2003.

Recently the St. Catharines –Niagara census management area (CMA) was ranked 20th out of 27 CMAs across Canada and 8th in Ontario in R&D.³² Overall, St. Catharines –Niagara ranked 19th for corporate R&D and 25th for university research.^{33, 34}

While government funding for R&D is available, one of the issues faced by the public sector institutions in the Region in securing R&D funds is the competition with other public institutions in the country. The Niagara Region does not have an established research base with long-standing funding from the public and private sectors. Brock University is in the midst of a transition from an undergraduate teaching university to a comprehensive university. Historically, faculty at Brock have focused on teaching, rather than on research. While the University has been successful in increasing its R&D funding, a transition such as this is long term. Niagara College is nationally recognized as a pioneer in building College-based applied research capacity. R&D is a relatively new activity for Colleges and funding for specific college-based R&D activities, while improving is very limited. Niagara College has been very successful in competing for these limited funds. Over the past two years, the number of R&D projects has tripled, the number of students participating in applied research has increased by four times and the number of faculty involved in applied has tripled, while R&D revenues have doubled at Niagara College. Vineland Research and Innovation Centre is a new organization in the Region and has yet to define and implement a full R&D strategy and therefore has not realized its full potential for securing R&D funding. VRIC has received substantial support from the provincial and federal governments. AAFC-Vineland does not compete for public funding in the same way that the College, University or VRIC do. It receives internal funding from AAFC to support the on-going research activities of the researchers at the facility. However, there is the potential for collaborations that could be in part supported by AAFC.

The Government of Ontario has launched a \$1.15 billion Next Generation of Jobs Fund strategy. This fund is a 5-year "...strategy to support companies in business expansion /retention and attract foreign investment in green auto research, parts production and assembly; clean fuels research, development and commercialization; manufacturing, processing, environmental technologies; services (ICT & Financial), anchor investments to support cluster development; and opportunity based/ unique investments."³⁵ The Biopharmaceutical Investment Program (BIP)³⁶ is one of the components of this fund. The BIP is a "...\$150 million program to encourage brand name pharmaceutical firms and advanced-stage human health biotech firms (e.g. vaccine manufacturers) to establish and grow their research and development and/or

³² Research Infosource Inc. "Canada" Available [Online] <http://www.researchinfosource.com/media/2006CRYMethod.pdf> Accessed October 8th, 2008

³³ "The Corporate R&D score is out of a possible 64 points. Points are awarded based on a CMA's ranking on the following 7 corporate R&D related measures: number of companies performing R&D, number of R&D companies per capita, corporate R&D spending, corporate R&D spending per capita, number of scientists and engineers employed, number of scientists and engineers employed per capita and percent of labour force in Natural and Applied Sciences and related occupations. Each measure was allocated up to 9.1 points." "The University Research score is out of a possible 36 points. Points are awarded based on a CMA's ranking on the following 4 university research related measures: total university research income, faculty research intensity, number of scientific publications and publication intensity. Each measure was allocated up to 9.1 points."

³⁴ Research Infosource Inc. "Canada" Available [Online] <http://www.researchinfosource.com/media/2006CRYMethod.pdf> Accessed October 8th, 2008

³⁵ Ministry of Economic Development and Trade, Ontario. Available [Online] http://www.2ontario.com/sbeprograms/govtprograms_progdetails_en.asp?lang=en&pID=215 Accessed October 8, 2008.

³⁶ Ministry of Research and Innovation "Next Generation of Jobs Fund - Biopharmaceutical Investment Program" Available [Online] http://www.2ontario.com/sbeprograms/govtprograms_progdetails_en.asp?lang=en&pID=214 Accessed October 7th, 2008

their advanced manufacturing investments in Ontario.³⁷ Other examples government R&D funding in the bioeconomy is the \$500 million NextGen Biofuels Fund through the Sustainable Development Technology Canada³⁸, aimed at supporting the establishment of first-of-kind commercial scale demonstration facilities for the production of next-generation renewable fuels (i.e. cellulosic ethanol or next-generation biodiesel) and co-products. Through the Ontario Ministry of Revenue, the Ontario New Technology Tax Incentive (ONTTI) is available to encourage the development and transfer of new technology. It allows “taxpayers an immediate 100% write-off of the eligible cost of qualifying intellectual properties acquired in the course of an intellectual property (IP) transfer.”³⁹ The Ontario Ministry of Agriculture, Food and Rural Affairs provides funding for research in a diverse range of bioeconomy sectors.⁴⁰

The strength of R&D in the Niagara Region, while still nascent and disperse, was an unexpected outcome. Building an investment attraction strategy for the bioeconomy around this critical success factor is a compelling opportunity with long-term benefits and impacts and one that warrants serious consideration by all stakeholders in the Region. Regional policy facilitating capacity building in R&D in the Niagara Region should be priority for the Regional, as well as Municipal economic development agencies. Mobilizing the resources and expertise within the public sector research institutions to support and advance the R&D capacity within the private sector is crucial for the growth of this critical success factor. Strong linkages between the public sector research institutions and the private sector organizations will lead to significant opportunities for economy development and investment attraction. This collaboration should be facilitated by the GHBN and strongly supported by Niagara College, Brock University, Vineland Research and Innovation Centre and Agriculture and Agri-Food Canada. Together, these organizations should engage the private sector in meaningful dialogue around the needs of the private sector for supportive R&D.

• Entrepreneurial Culture

While there is little information on policies that can encourage the culture of entrepreneurship, most case studies have identified this as an important factor in the growth of a cluster.⁴¹ The most common method to support an entrepreneurial culture is through incentives offered to inventors and small businesses.⁴² A recent study by the Brookings Institute found that entrepreneurship is more important than a strong research base. Their reasoning is that commercialization of new technology will not happen unless there is an ability to turn these ideas into businesses.⁴³ To make this happen the report suggested that

³⁷ *Ibid.*

³⁸ Sustainable Development Technology Canada “NextGen Biofuels Fund” Available [Online] http://www.2ontario.com/sbep/programs/govtprograms_progdetails_en.asp?lang=en&plD=202 Accessed October 8, 2008

³⁹ Ontario Ministry of Revenue, the Ontario New Technology Tax Incentive (ONTTI) Available [Online] http://www.2ontario.com/sbep/programs/govtprograms_progdetails_en.asp?lang=en&plD=63 Accessed October 8, 2008

⁴⁰ Research, Education, Risk Management and Laboratories. Ontario Ministry of Agriculture, Food and Rural Affairs website. <http://www.omafra.gov.on.ca/english/research/> (accessed October 28, 2008)

⁴¹ Ecotec Research & Consulting, “A Practical Guide to Cluster Development,” <http://clusters.wallonie.be/federateur/en/surveys-and-assessments/at-the-international-level/a-practical-guide-to-cluster-development.html> (accessed October 28, 2008)

⁴² *Ibid.*

⁴³ Joseph Cortright, “Signs of Life: The Growth of Biotechnology Centers in the U.S.,” http://www.brookings.edu/es/urban/biotech_cortright.ppt (accessed October 28, 2008).

entrepreneurial researchers and industry-relevant talent at the technical and managerial level are required.⁴⁴

The level of entrepreneurship, which seems to be a measure of the health of a cluster, can be assessed through the growth in companies, number of start-ups and spin-outs. In many regions where economic development policy is trying to foster technology-based clusters, there will be a very high percentage of new start-ups and small firms.⁴⁵ The rate of new business start-ups over the last 5 years in relevant industries was analysed to assess the degree of entrepreneurship in the Niagara Region.

Between 1999 and 2007, there was a net gain of 6,171 owner operated businesses in Niagara.⁴⁶ Approximately 1000 businesses start up annually in the Niagara region with majority in the service sector.⁴⁷ Between 1999-2007 there were more jobs created in the Region than lost.⁴⁸ "This is proof of adaptation within the Region and that "entrepreneurs and enterprises within Niagara are creating opportunities for growth".⁴⁹ Data on business start-ups in the bioeconomy were not readily available, however; most the organizations included in the Niagara Bioeconomy Inventory are either relatively new organizations or their activities in the bioeconomy are new.

The bioeconomy by its very nature is entrepreneurial and therefore this critical success factor shows some strength. The entrepreneurial culture in the Region is nascent, but growing. Strategic efforts to support and nurture the entrepreneurial culture are warranted. The City of Guelph has had some success in building an awareness for entrepreneurship through the Guelph Partnership for Innovation (GPI):

"Guelph Partnership for Innovation is a consortium of life science stakeholders with the vision of making Guelph one of the top life science centres in North America. Our mandate is to grow the size and capacity of the Guelph agritech cluster by connecting people, money and ideas and by advocating for improved research and commercialization infrastructure. Our mission is to foster the development of Guelph as a leading centre for life science and agri-food research, development and commercialization through advocacy, education and communication."⁵⁰

An organization with a mandate to support the Niagara bioeconomy based on the GPI is an initiative worthy of further consideration by the Steering Committee. The Golden Horseshoe Biosciences Network could take a lead role and incubate such an organization until such time that it could be "spun-out" as a self-sustaining enterprise.

⁴⁴ *Ibid.*

⁴⁵ David Wolfe, "Clusters from the Inside-Out: Lessons from the Canadian Study of Cluster Development," DRUID Summer Conference, Copenhagen, June 12-14, 2003.

⁴⁶ Paul Knafelc (2008), Niagara Economic Briefing, "Community Benchmarks" April 4th, 2008. Page 16. Niagara Economic Development Corp. website [http://www.niagaracanada.com/uploads/Niagara_Economic_Briefing_2008\(1\).pdf](http://www.niagaracanada.com/uploads/Niagara_Economic_Briefing_2008(1).pdf) (accessed October 28, 2008)

⁴⁷ Niagara Science and Innovation Park Feasibility Study⁴⁷, May 9, 2003. A Project for the Niagara Science and Innovation Park Steering Committee, by Jim Hughes Advisory Services

⁴⁸ *Ibid.*, Page 15

⁴⁹ *Ibid.*

⁵⁰ Guelph Partnership for Innovation website <http://www.guelphinnovation.com/Home/About/tabid/54/Default.aspx> (accessed December 7, 2008)

• Availability of Financing

The subject of business finance is always an important one in economic development. Availability of finance contributes to successful clusters by ensuring that capital is available to companies to support growth and development activities. Some regions have targeted VC, seed, and angel money to companies in a specific cluster as a means to retain and grow the cluster.

For current purposes, there are two critical questions. The first is whether firms fund their activities primarily from retained earnings (inside funding) or seek funding outside the firm. A firm that relies solely on retained funds will be relatively secure, but its growth potential is limited. A firm that seeks outside funding takes a greater risk but is more likely to grow and have a larger impact on the regional economy.⁵¹ Among firms that do seek outside funding, another key question concerns the form of that funding. For many of the firms engaged in R&D, an important early source of funds is grants, whether from provincial programs or from federal agencies. Over time, such grants may remain a part of the financing picture but should be diversified in source and supplemented with other financing.⁵²

A number of cluster studies have pointed to the importance of “learning, linkage, and investment” within the region, particularly when venture capital is used.⁵³ In the financing of highly speculative and risky new technologies, the financier’s personal familiarity with firms receiving funds is considered not only an advantage, but almost a necessity.⁵⁴ The Niagara Region’s venture capital market is still immature at this stage, and the geographic location of the funding source is less important than the type and volume of funding. Other sources of funding are also relevant and should be considered. For instance, start-ups would likely require private investment, VC and private equity growth funds, while companies at the growth stage will also need access to VC and private equity growth funds as well as asset-based working capital, long-term debt (cash flow) and public equity. However, in general it is capital at the early-stages that is most critical and most difficult to obtain. To assess how the Niagara Region meets this CSF, the number of organizations in the Region that offer financing were considered.

In addition to the banks, credit unions and BDC, there are three local organizations provide financing support to Niagara’s businesses: Venture Niagara, South Niagara Community Futures Development Corporation and Niagara Enterprise Agency (NEA). NEA also provides promotional and administrative support to the Niagara Growth Fund, a community-sponsored venture capital fund with Regional Municipality of Niagara as the community sponsor.⁵⁵

Provincial and federal sources of financing are available to bioeconomy companies in the Region: The Agricultural Adaptation Council (AAC), a non-profit coalition of 64 Ontario agricultural, agri-food and rural organizations that seeks to distribute federal government funding to help new, innovative projects that

⁵¹ E Hill, and J. Brennan, “A methodology for identifying the drivers of industrial clusters: The foundation of regional competitive advantage,” *Economic Development Quarterly* 14, 2002: 65.

⁵² *Ibid.*

⁵³ L. Mytelka and F. Farinelli, “Local clusters, innovation systems, and sustained competitiveness,” Maastricht, The Netherlands: United Nations University 2001.

⁵⁴ R. Oliver, “The coming biotech age,” New York: McGraw Hill 2000.

⁵⁵ *Ibid.*

will benefit the sector.⁵⁶ The NRC Industrial Research Assistance Program (NRC-IRAP)⁵⁷ provides both technical and business advisory services with some financial support to help grow small and medium-sized enterprises.

• Business Support Services

Legal, financial, consulting and human resources services are a few of the services that companies require. These services should be readily available in the region to support the growth and development of the cluster. To assess how the Niagara Region meet this CSF, the percentage of individuals employed with firms that provide business and technical support to other firms in the region was analyzed. Trends in location quotient for the business support services sector were also considered.

Professional services in the Niagara Region with specific expertise in the bioeconomy are limited. Specialized legal representation was found mainly in Toronto, Ottawa, Hamilton, Mississauga, Waterloo and London. Kelly Scientific Resource is one of the few Niagara-based agencies that recruit scientists for science-oriented organizations. The Golden Horseshoe Biosciences Network (GHBN), Bioenterprise, MaRS Landing and Ontario Agrifood Technologies offer support services to organizations active in the bioeconomy. While not based in Niagara, these organizations offer specialized services for the bioeconomy.

Between 2001 and 2006 the location quotient for business support services increased from 0.55 to 0.82. In 2006 there were approximately 4600 people employed in the business support services sector in the Niagara Region. Small business development support is available in the following organizations: Niagara Economic Development Corporation (NEDC)⁵⁸, Ontario Office Works Inc., the Small Business Club Niagara– and Club 2000 Niagara Inc.

• Skilled Workforce

This factor has been investigated thoroughly in the literature.⁵⁹ The main argument for effective networking is that networks generate formal and informal flows of knowledge and information throughout the cluster.⁶⁰ This information/knowledge sharing within the cluster is important to the success of the cluster because it supports “collective learning, competitive performance and stronger relationships.”⁶¹ For this CSF, the number of organizations that facilitated networking opportunities in the Region were considered. The ranking is qualitative and reflects our interpretation of the “networking infrastructure” that is in place in the Niagara Region.

⁵⁶ Agricultural Adaptation Council (AAC). Available [Online] <http://www.adaptcouncil.org/aboutus/aboutus.asp>. Accessed October 14, 2008

⁵⁷ NRC Industrial Research Assistance Program (NRC-IRAP). Available [Online] http://www.nrc-cnrc.gc.ca/main_e.html. Accessed October 14, 2008

⁵⁸ Local Business Support Organizations, Available [Online] <http://www.niagaracanada.com/content/?page=521>. Accessed October 8, 2008

⁵⁹ Ibid.

⁶⁰ Ibid.

⁶¹ Michael Dahl, “Knowledge flows through informal contacts in industrial clusters: myth or reality?” *Research Policy* 33, no., 10, 2004: 1673.

There is a consensus throughout the research literature that successful clusters are those that are able to access a skilled workforce.⁶² This is a key factor in attracting and retaining companies in a cluster. A range of appropriate skills should be present in the local population – from a suitably qualified labour force to management skills. Trends in education attainment levels were used as a proxy for assessing this CSF.

Lower education attainment at the university level in the Region compared to the province limit the skilled workforce available to take on positions in R&D. However, growth in university education attainment in Niagara from 2001 to 2006 was 31%, compared to the provincial growth rate of 15%. Higher attainment rates at the college level suggest that the pool of technical workers will be an advantage for those organizations needing skilled labour and skilled technicians.⁶³ The major investment in the Welland Campus by Niagara College will drive increased levels of skilled labour in the Region over the medium to long term. Labour shortages in all types of positions were cited by bioeconomy stakeholders as a serious barrier to growth within the Niagara Region.

• Effective Networking

There are few business associations related to the bioeconomy located in the region. There was little evidence of substantial networking among the organizations identified in the Niagara Bioeconomy Inventory. Brock University hosts a science and technology networking event every month. The Golden Horseshoe Biosciences Network (GHBN) has developed several innovative networking initiatives that are held in the Region on a regular basis. The lack of strategic and operational partnerships among the local government, public research institutions, the private sector and not for profit organizations negatively impacts this critical success factor.

Some of the associations and networks related to the bioeconomy outside the region include the Canadian Renewable Fuels Association (CRFA) (Ottawa), and BioProducts Canada Inc. (Ottawa). Additionally there is OntarioBioproducts.com which is a "...consortium of Regional Innovation Networks (RIN) with a focus on using biomass to create fuels, energy, chemicals, composites and a host of other products... and ...provide additional information for the entire Province of Ontario"⁶⁴. BIOTECanada is another national industry-funded association involving companies in the health, agricultural, and industrial sectors developing commercial biotechnology in Canada.⁶⁵ BioEnterprise Corporation acts as a commercialization agent, promotes the creation, growth and expansion of businesses in the Agri-Food and Agri-Life Sciences and Bio-Product Industries.⁶⁶ MaRS Landing provides a link between agriculture and food, veterinary and rural-related discoveries with medical, scientific and health advances in Ontario.⁶⁷ Soy 20/20 project works to bring together academic and industry partners as well as government to stimulate

⁶² Ecotec Research & Consulting, "A Practical Guide to Cluster Development", <http://clusters.wallonie.be/federateur/en/surveys-and-assessments/at-the-international-level/a-practical-guide-to-cluster-development.html>. (accessed October 28, 2008)

⁶³ Knafel, Paul. Niagara Economic Briefing. April 2008. NEDC website. [http://www.niagaracanada.com/uploads/Niagara_Economic_Briefing_2008\(1\).pdf](http://www.niagaracanada.com/uploads/Niagara_Economic_Briefing_2008(1).pdf) (accessed October 27, 2008)

⁶⁴ Ontario BioProducts.com Available [Online] <http://www.ontariobioproducts.com/chemicals.aspx#eastern> Accessed October 14, 2008

⁶⁵ BIOTECanada Available [Online] <http://www.biotech.ca/content.php?sec=2> Accessed October 16, 2008

⁶⁶ BioEnterprise Corporation Available [Online] <http://www.bioenterprise.ca/> Accessed October 16, 2008

⁶⁷ MaRS Landing, Available [Online] <http://www.marslanding.ca/> Accessed October 16, 2008

and seize new global bioscience opportunities for Canadian soybeans.⁶⁸ Ontario Agri-Food Technologies (OAFT) ensures that Ontario producers have access to the latest technologies for the development of new market opportunities and be able to compete globally.⁶⁹

Building enhanced networking opportunities throughout the bioeconomy sectors is critical to growing the nascent cluster. An organization based on the GPI model could have significant impact on improving this CSF. Networking and collaboration among the public sector research institutions and the private sector enterprises are critical to continued growth and development of the Niagara bioeconomy.

• Supportive Policy Environment

A key aspect of successful clusters has been the partnerships that form between stakeholders.⁷⁰ Within successful clusters, academia, industry and governmental organizations work together to create an environment that supports the growth and development of the cluster. This can include favourable finance policies; technology transfer assistance and business advice and consulting. Many aspects of this CSF have already been touched upon by the previous CSFs listed above. A qualitative assessment of how well the Niagara Region meets this CSF was provided based on the review of various documents.

Both the federal and provincial government have targeted policies and programs to develop and stimulate growth in the bioeconomy. The Niagara Region has no clear innovation support policies for the bioeconomy; however, the NEDC and its partners have undertaken initial projects to investigate the potential of economic growth in the area of the bioeconomy. The Region is committed to supporting the development of new high growth industries such as bio-manufacturing.⁷¹ This was identified in the Economic Growth Strategy of the Niagara Region.⁷² The regional government "...has the desire to attract high value, knowledge based industries and diversity the economic and social base of the region".⁷³ The Port Colborne Economic and Tourism Development Corporation (PCETC) has been instrumental in the setting up Carbohydrate Valley—a key cluster for bio-technology processing firms in Port Colborne—formed between two bio processing firms Jungbunzlauer and CASCO Inc.⁷⁴ There are efforts to attract more bio-based organizations to the Valley by the PCETC.

Development of policy to support the growth and development of the Niagara bioeconomy is a priority that should not be delayed. Within the context of this report, policy is broadly defined to include all endeavours (implicit or explicit) that demonstrate a commitment to facilitating the growth of the

⁶⁸Soy 20/20 project Available [Online] <http://www.soy2020.ca/>. Accessed October 20, 2008

⁶⁹ Ontario Agri-Food Technologies (OAFT) Available [Online] <http://www.oaft.org/about/default.aspx>. Accessed October 20, 2008

⁷⁰ Angle Technology, "Medical Technologies, Cluster Mapping & Analysis," Final Report, Prepared by ANGLE Technology, 22 March 2002.

⁷¹ Niagara Economic Development Corporation NEDC "\$1.9Million for Niagara, April 2008" Available [Online] <http://www.niagaracanada.com/content/index.asp?page=674>. Accessed October 16, 2008

⁷² Niagara Economic Development Corporation (NEDC). "Navigating Our Future: Niagara's Economic Growth Strategy 2005-2010." Available [Online] http://www.niagaracanada.com/uploads/EGS_Full_Document_Can_Be_Printed_as_Requested.pdf. Accessed October 14, 2008. Page 20

⁷³ Brock University Strategic Research Plan (SRP) 2006-2011 Available [Online] http://www.brocku.ca/avpr/pdf/brock_strategic_research_plan_2006_to_2011.pdf. Accessed October 8, 2008

⁷⁴ "Carbohydrate Valley" Available [Online] <http://www.pcetdc.ca/carbvalley.php>. Accessed October 16, 2008

bioeconomy in Niagara. Given the unique characteristics of the bioeconomy, it is unlikely that traditional policy options will provide meaningful outcome. It will be necessary to explore novel approaches to policy development (e.g. R&D free trade zones). Investigating policy research or best practices in other jurisdictions may offer critical insights for policy options. The NEDC should take a lead role and engage the 12 municipalities of the Niagara Region to collaborate on the development of policy that clearly demonstrates the commitment of the regional and municipal stakeholders to grow and develop the bioeconomy in Niagara. Consultation with the other stakeholders (as identified in the Niagara Bioeconomy Inventory) is an essential element of the policy development process.

- Physical Infrastructure (Telecommunications, Transportation, Specialized Premises and Feedstock supply)

This factor is important since it will determine the ease with which business activities can be undertaken. Previous case studies have demonstrated that communication links, transportation routes and access to a stable supply of energy are key factors in the development of successful clusters.⁷⁵ Essentially the key factors characterizing the physical infrastructure of a region is a good network of roads and broadband access. Canada is the most connected country in terms of broadband access and one of the most energy abundant. Also included in the ranking of this CSF is an analysis of the availability of specialized infrastructure that would be required by a bioeconomy-based company (i.e. incubators, manufacturing facilities, laboratory facilities) and the quantity and quality of biomass feedstock generated in the Region. The assessment of this CSF is based on a qualitative review of relevant information provided to VISTA by the Steering Committee and web searching.

The transportation network currently in place in the Niagara Region has challenges. According to Niagara's Economic Growth Strategy 2005-2010 report, the "... transportation system is a priority concern among businesses, government agencies and residents throughout the region. Transportation inadequacies are limiting local economic growth"⁷⁶. Niagara has an extensive network of rail corridors and access to the Welland Canal.

There are no incubators or other specialized facilities for the organizations active in the bioeconomy. The public research institutes (AAFC, Vineland Research, Brock University and Niagara College) have laboratories for research, innovation and product development that could service the bioeconomy sector. The proposed incubator program at Vineland Research and Innovation Centre could positively impact the Region and promote commercial activities in the bioeconomy.⁷⁷ nGen, Niagara Interactive Media is a model that could be considered for supporting the Niagara bioeconomy.⁷⁸

⁷⁵ Ecotec Research & Consulting, "A Practical Guide to Cluster Development," <http://clusters.wallonie.be/federateur/en/surveys-and-assessments/at-the-international-level/a-practical-guide-to-cluster-development.html>. (accessed October 28, 2008).

⁷⁶ Niagara Economic Development Corporation (NEDC). "Navigating Our Future: Niagara's Economic Growth Strategy 2005-2010." Available [Online] http://www.niagaracanada.com/uploads/EGS_Full_Document_Can_Be_Printed_as_Requested.pdf. Accessed October 14, 2008.

⁷⁷ The Vineland Renaissance Panel (December 2006). A Business Case: The Vineland Renaissance Project, Establishment of the Vineland Research and Innovation Centre. OMAFRA website <http://www.omafra.gov.on.ca/english/about/vinelandreport.pdf>. Accessed October 22, 2008.

⁷⁸nGen, Niagara Interactive Media. About Us" Available [Online] <http://www.ngen-niagara.com/about.htm>. Accessed October 22, 2008.

Consistent, accessible supplies of biomass feedstocks are critical to the bioeconomy. Biomass may be classified into two general categories: virgin biomass, which is the primary outcome of intentional biomass cultivation; and waste biomass, which comprises the residual fraction from primary harvest, as well as livestock wastes and organic municipal solid waste. Sources of biomass are relatively plentiful in the Niagara Region. Poultry farms, of which there are approximately 340 in Niagara,⁷⁹ produce approximately 600-1,000 tons of manure each year.⁸⁰ The Niagara Region has the highest concentrations of poultry in the province.⁸¹ Other agriculture commodity production generates substantial volumes of crop and livestock residues: greenhouses, wineries, horse farms and dairy operations. A brief review of regional manufacturers indicated that a variety of other sources of biomass were available in the Region: 33 wood product manufacturers, seven paper manufacturers and 43 furniture and related product manufacturers.⁸² The annual, available biomass (organic municipal solid waste, agricultural biomass—crops and crop residues, poultry manure and livestock manure) in the Region was estimated at about 1.0 million tonnes. This volume of biomass represents a level that could support commercial production of various types of bioenergy. Not included in this calculation is the algae that is produced in Lake Erie. While the weight or volume of this biomass has not been measured, it is substantial and represents potentially unique opportunities for waste to energy initiatives and natural health products.

The level and availability of biomass in the Niagara Region represents a competitive advantage. Further research is needed to determine the quality and quantity the biomass feedstocks available in the Region. Opportunities for collaboration among biomass producers should be explored. Already there is evidence that greenhouses and grape producers are recognizing the value of biomass for value-added opportunities. These organizations are listed in the Bioeconomy Inventory. The agriculture sector in Niagara represents substantial receptor capacity for a variety of bioeconomy opportunities based on the utilization of waste biomass. Waste to energy initiatives appear to be the most immediate and accessible opportunities at this time and should be pursued aggressively.



Opportunities for Niagara Bioeconomy

“Successful pursuit of opportunities in the bioeconomy require that new concepts make their way into research, development, commercialization and public policy associated with the bioeconomy.”⁸³

- Building Research and Development Capacity in the Bioeconomy

⁷⁹ The Regional Municipality of Niagara, “Chapter 5 Agriculture and the Niagara Economy,” *Regional Agricultural Economic Impact Study*, Fig. 4.38, <http://www.regional.niagara.on.ca/living/ap/pdf/Figure%204.38%20-%20Profile%20of%20the%20Niagara%20Poultry%20Industry.pdf> (accessed October 24, 2008).

⁸⁰ VISTA Science & Technology Inc., “Energy and Chemicals from Bio-Liquid,” February 2006.

⁸¹ Niagara Region, “Regional Agricultural Economic Impact Study Fact Sheet” June 2003.

⁸² VISTA Science & Technology Inc., Discussion Paper: A Niagara Region Bioproducts Initiative. March 2007.

⁸³ OMAFRA Strategic Research Themes: Priorities for 2008-2012 OMAFRA – University of Guelph Partnership. OMAFRA website <http://www.omafra.gov.on.ca/english/research/coordination/omafugresearchpri.pdf> (accessed October 28, 2008)

R&D represents an opportunity for investment attraction and economic development in two ways: specific to the bioeconomy and as a corporate function across all economic sectors. With an increase in the location quotient for Niagara for scientific research and development services from 0.43 in 2001 to 0.52 in 2006, there is a basis for developing economic growth strategies focused on promoting the Niagara Region as a place for research and development. The majority of private sector organizations placed in the R&D position of the value chain are involved in R&D related to natural health products, which represents a niche opportunity based on bioactive compounds extracted from local, native plants that would have application both in human and animal markets. From 1998- 2005, private sector investment in R&D in the Niagara Region increased 106%.⁸⁴

Given the Region's R&D ranking in 2004, further exploration of R&D capacity and activity in other key sectors of the Region is warranted. Positioning the Region as a centre for R&D is a compelling strategy for long-term economic growth and transitioning employment in the Region to a knowledge-based economy. Better linkages and alignment among the public research institutions and private sector would be necessary to realize the full potential of a long-term economic growth strategy based on R&D. A better understanding of R&D needs, activities and capabilities of both the public and private sector is critical. Building better relationships based on common needs and capabilities will be necessary to promote the Region as a place for R&D, to build synergies and share best practices.

Collaboration should be facilitated by the GHBN and strongly supported by Niagara College, Brock University, Vineland Research and Innovation Centre and Agriculture and Agri-Food Canada. Together, these organizations should engage the private sector in meaningful dialogue around the needs of private sector for supportive R&D.

• Building the Capacity of Bioeconomy Receptors – Waste to Energy Opportunities

Natural gas heating is a major input cost representing 20-35% of the total cost of production for greenhouse operations depending on the crop being grown⁸⁵. Another 10% is spent on electricity. There are approximately 340 poultry farms in the region with an estimated \$30-50,000/year in energy costs. Other agriculture commodities in Niagara have equally burdensome energy requirements. The volume of biomass waste from Niagara-based agriculture production was estimated at 700,000 tonnes. The amount of biomass in the form of algae in Lake Erie is unknown but substantial. As such, the agriculture production and processing sectors in the Region represent a strong receptor base for waste to energy technologies such as anaerobic digestion and pyrolysis. Already, several farms in the Region have recognized the potential of generating energy from agricultural waste biomass: Vandermeer Greenhouses in Niagara on the Lake, Bayview Flowers in Jordan and Inniskillin in Niagara on the Lake have installed anaerobic digestion systems that process agricultural residues into electricity and heat. While the agriculture sector has well-defined needs for more cost-effective fuel sources, there are also many other industrial businesses in the Region that could also be potential receptors of waste to energy technologies.

⁸⁴ Knafelc, P. Niagara Economic Briefing. 2007 http://www.niagaracanada.com/uploads/Econ_Brief_For_07.pdf (accessed October 30, 2008)

⁸⁵ The Regional Municipality of Niagara, "Chapter 5 Agriculture and the Niagara Economy," *Regional Agricultural Economic Impact Study*, Fig. 4.38, <http://www.regional.niagara.on.ca/living/ap/pdf/Figure%204.38%20-%20Profile%20of%20the%20Niagara%20Poultry%20Industry.pdf> (accessed October 28, 2008)

Bioenergy produced from plant and animal feedstocks is growing by an estimated 10% a year.⁸⁶ In its 2006 budget, the provincial government announced plans for net metering to allow electricity from water, wind, solar power and farm biomass to be sent to the grid, giving farmers who generate their own power an opportunity to earn credits towards their energy costs.⁸⁷

Waste to energy technologies are operationally proven and have demonstrated solid return on investment. The waste to energy receptor base in the Niagara Region offers a compelling basis to attract waste to energy technology providers to the Region. Planet Biogas Solutions is an example of the type of company that would find a solid market in the receptor base in the Niagara. Funding and technical support for regional renewable energy projects is available through the Community Power Fund.⁸⁸ The Ontario Sustainable Energy Association works with community-based groups to develop and initiate community-based power projects.⁸⁹

• Bioeconomy Niche Expertise in Fermentation

The wineries, while outside the scope and definition of the bioeconomy used for this study, represent an opportunity for building on existing expertise to develop a bioeconomy niche. Fermentation is a biological process used to manufacture a diverse range of industrial chemicals, in addition to wine. There is considerable technical and operational fermentation expertise resident in the wineries, the public research institutes, especially CCOVI and Jungbunzlauer in Port Colborne's "Carbohydrate Alley".

Biochemicals derived from biomass are generally obtained through industrial fermentation processes that make efficient use of a broad range of microorganisms to produce high-value fine chemicals, bulk chemicals, enzymes for use in pharmaceuticals through biocatalysis, and a broad range of industrial chemicals e.g. pesticides, solvents, plastics, vitamins and food additives. Worldwide demand for industrial enzymes is expected to reach \$2.7 billion by 2007 with a compound annual growth rate of 12%.

In recent years, advances in fermentation technology have shown much promise in the development of several bioprocesses and products. The products developed from industrial fermentation processes include ethanol, biogas, animal feed, enzymes, organic acids, solvents, amino acids, vitamins and other bioactive molecules including antibiotics and alkaloids. The rising cost of petroleum, the decreasing cost of biomass, and advances in both process technologies and biotechnologies are just a few of the many forces that are driving the trend towards bio-based industrial products. Growth in the biochemicals sector also stimulates economic development, particularly in rural communities, by creating new employment opportunities around the processing of raw materials from agricultural sources.

⁸⁶ Michael Vaughan, "Biofuel revolution 'beginning to happen now,'" *Globe & Mail*, December 1, 2005, <http://www.theglobeandmail.com/servlet/story/LAC.20051201.WHVAUGHAN01/GAStory/specialGlobeAuto/home/?query=> (accessed October 27, 2008).

⁸⁷ Cleaner, greener energy. Ontario Ministry of Energy and Infrastructure website. <http://www.energy.gov.on.ca/index.cfm?fuseaction=renewable.netmetering>. (accessed October 27, 2008).

⁸⁸ Community Power Fund. <http://www.cpfund.ca/>. (accessed October 29, 2008)

⁸⁹ Ontario Sustainable Energy Association. http://www.ontario-sea.org/Page.asp?PageID=751&SiteNodeID=205&BL_ExpandID=50 (accessed October 29, 2008)

Niagara's chemical industry anchored by three multinational chemical companies: PolyOne, Oxyvinyl and Cytech, in collaboration with the wineries, Jungbunzlauer and Brock University could form the basis for an investment attraction strategy to expand the nascent biochemical subsector in Niagara.

•Proposed Action Agenda

An action agenda targeting both the waste to energy and fermentation opportunities was outlined in a discussion paper prepared by VISTA in March 2007: A NIAGARA REGION BIOPRODUCTS INITIATIVE. This current report validates the findings and conclusions and builds on the recommendations of the discussion paper. The Steering Committee is strongly encouraged to use both reports as a basis for decisions on next steps and strategies for building the Niagara bioeconomy. The actions recommended in the Discussion Paper are included here for the convenience of the Steering Committee.

"Bioenergy Sector - Use proven technology to construct various biomass processing units to generate methane gas for the greenhouse industry and biodiesel for the poultry sector. These industrial sectors would be the lead stakeholders responsible, in large part, for developing the business case, financing most of the capital acquisition and either operating or contracting for the energy production systems.

Biochemical Sector – Coordinate the R&D stakeholders in building a research capacity in industrial fermentation, and begin pilot projects in the region. The principal stakeholders would be Brock University, Niagara College and the National Research Council Institutes involved in sustainable bioproduct research. Strong efforts should also be made to include corporate participation since downstream the private sector will be operators of the new production capacity to be developed.

Action Plan Outline

The Niagara Economic Development Corporation (NEDC), as an agent of the Regional Municipality of Niagara, should play an important role in initiating, coordinating and facilitating the two bioproducts initiatives. However, the two lead stakeholder groups should build, direct and implement the Action Plan, since these two groups will be responsible for the evolution of the plans.

As a start point, it is recommended that NEDC distribute this discussion paper and convene meetings of the two stakeholder groups to determine the feasibility and critical factors necessary for success of the two plans. Thereafter, the stakeholders would need to devise an action agenda and construct the business case for each initiative as the core for an implementation plan. The importance of having the plans developed and implemented by end-users is critical to success, since the end-users will exert "pull-through" based on their specific business needs.

The implementation plans will be crucial in obtaining political and financial support from provincial and federal departments. Political support from Ministers at the Federal and Provincial level should be the first critical action outside the region. Implementation plans should be aligned with current public policy and presented in a manner that political support would be provided easily. Thereafter, the stakeholder groups responsible for the two plans should be prepared for numerous visits to lobby federal and provincial departments for funding.

Plans should demonstrate the commitment of substantial financial investment on the part of stakeholders as an important factor in convincing the federal and provincial departments of the seriousness with which the region is pursuing the bioproducts initiative. Competition for government funding is always strong. Therefore, the Niagara Region plans should demonstrate a commitment to shoulder the larger share of funding.

For substantial strategic funding, for example with Sustainable Development Technology Canada, NEDC could take a leading role in coordinating a submission that is supported by both the R&D community as well as regional industrial stakeholders. A review of recent funding awards demonstrates that this approach produces good results.

Finally, for the bioproducts initiative to be successful, all stakeholders should be prepared for an extended action/implementation period, in the order of ten years at a minimum, since this timeline has been the general experience of other regions embarking on similar initiatives. ⁹⁰

⁹⁰ VISTA Science & Technology Inc. 2007. Discussion Paper: A Niagara Region Bioproducts Initiative.



Appendix 1 – Cluster Theory

One of the major challenges of cluster analysis is that of cluster definition and related boundary issues. In general, one of the key barriers to cluster identification and analysis has been the lack of agreed upon definitions and criteria for cluster characterization.⁹¹ It is clear that the concept of clusters and the analyses of clusters would benefit from better understanding and an agreement of basic terms and concepts involved. More focused cluster promotion policies could be achieved if clusters were classified according to their state of development.⁹² State of Development is defined as the degree to which clusters may be self-aware and self-reinforcing.⁹³ Under this model, there are four main types of clusters: working clusters, latent clusters, potential clusters and wishful thinking clusters. Unfortunately, a set of analytical tools specific to the state of cluster development was not provided with this framework.

Much of the recent work on the topic has focused on finding ways to identify the kinds of regional activities that can be classified as clusters.⁹⁴ Perhaps the most extensive work being done in this area is that of the Institute for Strategy and Competitiveness at the Harvard Business School, which is an outgrowth of Porter's continuing work on the roles of clusters.⁹⁵ The Institute for Strategy and Competitiveness approach combines statistical analysis with assessment of clusters using Porter's "diamond" model. The statistical analysis focuses on employment, establishment, and wage data from county business patterns using patent data to test for the presence of sufficient statistically significant patterns of co-location and economic growth (Institute for Strategy and Competitiveness, 2002). The Porter approach has advantages in assessing clusters that already exist, identifying their strengths and weaknesses, and separating regional industries that are more likely to be clusters from those that are not.⁹⁶ But Porter's work as well as other analyses using publicly available data sets such as employment and income have two limitations: These analyses are better suited for assessing clusters that have already formed and are already reflected in economic data than for clusters that are in the process of forming, and existing standard economic data are ill-suited for capturing the complexity and subtlety of relationships among people and organizations that lie at the heart of "regional collective learning."⁹⁷

Researchers at the Centre for International Studies at the University of Toronto, specifically the Innovation Systems Research Network (ISRN) conducted a national study of cluster development. The ISRN's research methodology consisted of in-depth interviews with key cluster participants.⁹⁸ The cluster analysis was designed to define a common set of factors including the size and composition of the cluster, the history of the cluster's evolution, the relationship between firms, the relationship between cluster firms and the

⁹¹ R. Martin. and P. Sunley, "Deconstructing Clusters: Chaotic Concept or Policy Panacea?" *Journal of Economic* 3, no., 1, 2002: 5.

⁹² E. Peters and N. Hood, "Implementing the Cluster Approach," *Studies of Management and Organization* 30, no., 2. 2000: 68.

⁹³ Ibid.

⁹⁴ C. Colgan, "Assessing the evolution of Maine's technology clusters," *Maine Science and Technology Foundation* 2002.

⁹⁵ M. Porter, "The Competitive Advantage of Nations," New York: Free Press, 1998.

⁹⁶ E Hill, and J. Brennan, "A methodology for identifying the drivers of industrial clusters: The foundation of regional competitive advantage," *Economic Development Quarterly* 14, 2002: 65.

⁹⁷ Ibid.

⁹⁸ David Wolfe, "Clusters from the Inside-Out: Lessons from the Canadian Study of Cluster Development," DRUID Summer Conference, Copenhagen, June 12-14, 2003

research infrastructure, the geographical structure of these relationships, the role of finance capital, role of entrepreneurs and other factors contributing to growth.⁹⁹

Location quotient, which is the ratio of employment shares: the regional industry's share of total regional employment over the provincial industry's share of total national employment, can also be used to identify clusters.¹⁰⁰ A quotient of higher than one indicates a higher degree of specialization in the activities that comprise the cluster. Another method of assessing cluster strength is growth share matrix diagrams, which are more sophisticated methods of using location quotients. The growth share matrix diagram indicates the number of employees in a cluster within the region, the average annual job growth rate for the cluster and the location quotient for the cluster in the region. The representation of the growth-share matrix in graphical form provides a useful visual medium for depicting the relative strengths of a regional economy.

⁹⁹ Ibid.

¹⁰⁰ David Wolfe, "Clusters from the Inside-Out: Lessons from the Canadian Study of Cluster Development," DRUID Summer Conference, Copenhagen, June 12-14, 2003.



Appendix 2 – R&D Interview Guide

On behalf of the Niagara Economic Development Corporation (NEDC), Vista Science and Technology (Consultant) is undertaking research into the Bioeconomy Development Opportunities for the Niagara Region. Bioeconomy in the context of this research includes *the sectors of bioproducts (biomaterials, biochemicals and bioenergy), functional foods/nutraceuticals, biopharmaceuticals/biotherapeutics and environmental products*. Within this context, the Niagara Bioeconomy Industry Steering Committee seeks to examine the phenomenon of critical mass in the bioeconomy sector in the Niagara Region.

Please fill in the spaces below. Please feel free to use an additional page if necessary.

Section 1- Size and general/main operations of the company

1. a- What is the core function of the company's operations in the Niagara Region?
- b- How would you rate the company's operations (small, medium or large scale)?
- c- What is the company's total number of employees in the region?

Section 2- Nature of the company's bioeconomy related activity/activities

2. a- Please define the company's R&D as it relates to the bioeconomy. Are you involved in discrete projects or strategic projects for growth?
 - b- Is the R&D for new product development or for internal efficiencies?
 - c- What is the estimated budget (\$) for R&D operations directly related to the bioeconomy definition?
3. a- Who ultimately controls the R&D function? What input do they have in guiding R&D?
 - b- How much control does the local operation have on R&D?
 - c- Is the company's R&D a permanent function?
4. a- What are the company's future plans for R&D?
 - b- Do you anticipate expanding the R&D?
5. How many employees are in R&D? (Pool of qualified people)

Section 3- Expected inputs/policies/infrastructure from Niagara Economic Development Corporation to stimulate growth

6. What inputs/resources/policies would be required to attract more R&D to the Niagara Region?
7. Are there any other suggestions or comments?



Appendix 3 – Niagara Bioeconomy Directory

“Bioeconomy” implies that food/feed and non-food/feed biomass could be the basis for value-added activity in one or more markets, and could be part of competitive growth and prosperity strategies in a given region. The bioeconomy is an integral part of the larger economy and as such in the near term and perhaps for the foreseeable future, products of the bioeconomy are likely to be produced from blends of biomass and conventional materials. An expanded scope of the bioeconomy was adopted by the Steering Committee after careful consideration of the objectives and expectations of Committee members, and to remain consistent with current provincial and federal definitions. It was agreed that bioeconomy would include: bioproducts, further defined as biomaterials, bioenergy and biochemicals; functional foods/nutraceuticals; biopharmaceuticals / biotherapeutics and environmental products.

Bioproducts are defined as industrial/commercial products other than food, beverages, feed, and pharmaceuticals. Bioproducts are further classified as bioenergy, biochemicals and biomaterials (Table 1). Functional foods and nutraceuticals are classified as natural health products. Nutraceuticals are foods or active components of food that provide a medicinal or health benefit. Functional foods are foods that provide a health benefit beyond the nutrients it normally contains. Foods fortified with vitamins, bioactive compounds, herbs or nutraceuticals are considered to be functional foods. Omega-3 eggs are an example of an extraordinarily successful functional food; while omega-3 is an example of a nutraceutical. Biopharmaceuticals/biotherapeutics are drugs (Health Canada approved) that are manufactured through a bioreactor such as a plant that has been genetically modified to produce a vaccine or through fermentation. Another example of biopharmaceutical is the paclitaxel extracted from yew trees by Biolyse Pharma in St. Catharines. Environmental products are defined by a biomass waste or by-product feedstock, which is converted to a product that contributes to sustainable processes and production and reduces environmental footprint. Compost is a good example; however for the purposes of this analysis, the compost would have to be produced at a commercial/industrial scale.

Using the expanded scope and definitions approved by the Steering Committee, a variety of secondary sources (Table 2) were reviewed to identify those organizations based in the Niagara Region that met the selection criteria for inclusion in the Niagara Bioeconomy Inventory. Organizations were identified on the basis of activities related to any of the bioeconomy sectors: bioproducts, functional foods/nutraceuticals, biopharmaceuticals/biotherapeutics and environmental products. Under these criteria, wineries and greenhouse operations and other agricultural production were excluded from the inventory. In order to be included in the inventory, bioeconomy activity had to take place within the Niagara Region. Therefore, even though ADM Milling and Polyone are actively involved in the bioeconomy at a corporate level, the operations in the Niagara Region are not. Therefore, these organizations were not included in the inventory. A separate list of organizations that did not meet the strict selection criteria for the Bioeconomy Inventory, but possess characteristics of potential to contribute to the development of the bioeconomy has been provided to the Steering Committee in a separate document.

Table 1. Types of Bioproducts

BIOENERGY	BIOCHEMICALS	BIOMATERIALS
Any form of energy produced from biomass/renewable feedstocks : steam, electricity, thermal	Specialty chemicals manufactured through a biological process such as fermentation and/or using a biomass feedstock	Commercial/industrial compound produced from biomass or composites that incorporate biomass/renewable components
Ethanol Bio-diesel Methane Syngas Hydrogen Bio-oil Bioenergy – energy feedstocks (e.g. ethanol, methanol, butanol, biodiesel, bio-oil, biogas, pellets, hog fuel) as well as the end products (e.g. electricity, thermal energy).	Industrial chemicals (e.g. cleaners, lubricants, sealants, solvents,), Intermediate biochemicals (e.g. ethylene) Chemical inputs/feedstocks for production of other products (e.g. oils, phenols, resins) Biotechnology products where at least part of the product is a biological organism or component (e.g. enzymes, molecular probes, microbes, yeast, bacteria)	Bioplastics, biobased blends, natural fibre composites, biobased nanocomposites, biofoams, biorubber, biobased paints and coatings, bioadhesives, and bioinks, and natural fibres, as well as the resulting end products (e.g. textiles, carpets, mats), rigid components (e.g. tiles, panels, beams and posts, tubes/pipes, casings, or other formed products), or granulated products (e.g. chips, pellets, dust).

Table 2: Secondary sources reviewed for inventory

Ontario Functional Foods and Natural Health Products Directory, http://www.marslanding.ca/useredits/File/Final%20Directory.pdf
Ministry of Research and Innovation Bioproducts directory, http://mba.ebdata.com/mrio/search.jsp
Niagara Economic Development Corporation Business Directory
Golden Horseshoe BioSciences Network Business Directory
Vista Science & Technology Database

Organizations identified on the basis of being active in one or more bioeconomy sectors were further classified by their position in the value chain (Figure 1). The input position of the value chain is comprised of two distinct elements: feedstocks and equipment. The feedstock position was defined as the production of biomass feedstock or diversion of a waste biomass byproduct specifically for processing or

producing a product that belongs to one or more of the bioeconomy sectors: bioproducts, nutraceuticals/functional foods; biopharmaceuticals/biotherapeutics; and environmental products. Simply producing biomass such as growing grapes or livestock production was not a basis for inclusion in the feedstock position of the value chain. Consistent supplies of biomass feedstock is certainly an advantage to a region interested in building a bioeconomy and therefore volume of biomass produced in the Niagara Region is considered in the Critical Success Factors benchmarking. Feedstocks are defined as: biomass intended for use in and subjected to some form of processing to prepare the biomass for use in manufacturing or energy generation processes. Residuals from conventional agricultural crops (including food crops) are often referred to as 'waste' and are considered a potential source of biomass for bioproducts. Other feedstocks could be bioenergy co-product streams such as low or negative value byproducts from lignocellulosic biofuel industries or paper and pulp industries, crude glycerol from emerging biodiesel industries, Distillers' Dried Grains with solubles (DDGS) from corn ethanol industries, soy meal and canola meal (from soy/canola oil industries), CO₂, food processing waste streams, and energy crops like hemp or miscanthus. The equipment supply position of the value chain includes organizations that supply technology, equipment and/or components for processing and manufacturing. These organizations can be distributors or re-sellers of equipment or full service firms who design, build and operate bioprocessing/manufacturing systems.

The processing position of the value chain includes organizations that process a biomass feedstock and/or use a biologically-based processing method. An organization that processes chicken manure by pyrolysis to produce bio-oil and/or specialty chemicals would be included in the processing position of the value chain. Alternatively, a company manufacturing an industrial enzyme through a fermentation process would be included in the processing position of the value chain. Even though wineries use fermentation to process a biomass feedstock, the end product does not fit into the bioeconomy sectors that define the scope of the project and therefore the wineries were not included in the Niagara Bioeconomy Inventory. In order to be placed in the processing position or identified as producing a product belonging to any of the bioeconomy sectors, the organization had to operate on a commercial scale. The processing and/or the end product had to be destined for a commercial market, rather than internal use. A greenhouse using anaerobic digestion to produce energy to support its own operation would not be included in the inventory. A consortium of greenhouses that invest in an anaerobic digestion system to process greenhouse residues and/or other biomass feedstock as a separate operation with the intention of generating revenues would be included in the inventory.

The R&D position of the bioeconomy value chain includes organizations involved in scientific research, technology, product and process development, as well as technology transfer and commercialization related to any position within the bioeconomy value chain or any of the bioeconomy sectors.

Organization Name Abitibi-Consolidated Company of Canada
Position in Value Chain Processing, Feedstock
Type of Processing Technologies biological
Type of Feedstocks Forestry
Bioeconomy Market Sectors Environmental Products
Location Thorold
Phone 905 227-5000
Website <http://www.abicon.com>
Size large
Description Since 2002, Abitibi has been using biogas generated by Walker Industries to power 10% of manufacturing operations. In December 2003, the project was expanded to provide landfill gas for 25% of its steam requirements.

Organization Name Agriculture and Agri-Food Southern Crop Protection and Food Research Centre (Vineland Research Farm)
Position in Value Chain R&D
Bioeconomy Market Sectors Functional Foods/Nutraceuticals, Bioproducts - bioenergy, biochemicals, biomaterials
Location Vineland
Phone 905 562-4113
Website <http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1180640801098&lang=e>
Description Research activity at Vineland supports development of improved methods of integrated pest management. It is the main site of fruit tree research.

Organization Name Bee Biomedicals
Position in Value Chain Processing, R&D
Type of Processing Technologies biological
Bioeconomy Market Sectors Biopharmaceuticals/Biotherapeutics, Bioproducts - biochemicals
Location St. Catharines
Phone 905 685-6812
Size small
Description A small biopharmaceutical company involved in R&D of anti-viral, anti-inflammatory topical skin therapies based on the bioactive compounds of honey and

propolis. Bee Biomedical works with industrial partners represented by the Canadian Honey Council and other government agencies to develop new value added products for biomedical/biotherapeutics

Organization Name Biolyse Pharma
Position in Value Chain Processing, R&D
Type of Processing biological
Technologies
Bioeconomy Market Sectors Biopharmaceuticals/Biotherapeutics
Location St Catharines
Phone 905 687-4923
Website <http://www.biolyse.ca/>
Size small
Description Biolyse conducts R&D in the production of natural-based medical products and chemical extracts. Also involved in harvesting and manufacturing of paclitaxel, a cancer fighting drug using technology that concentrates and purifies natural bioactive compounds.

Organization Name Brock University
Position in Value Chain R&D
Bioeconomy Market Sectors Biopharmaceuticals/Biotherapeutics
Location St Catharines
Phone 905 688-5550 ext. 3826
Website <http://www.brocku.ca/biotechnology/>
Description The Institute of Molecular Catalysis conducts research in design, synthesis, and characterization of new catalysts; application of these catalysts to chemical synthesis; biocatalysis and mechanistic studies. The Centre for Biotechnology is a joint venture between departments of biological sciences and chemistry. The Cool Climate Oenology & Viticulture Institute contributes to the regional research into wine making products.

Organization Name Casco Inc.
Position in Value Chain Processing, Feedstock
Type of Processing chemical/physical
Technologies
Type of Feedstocks Agriculture

Bioeconomy Market Sectors Bioproducts - Biochemicals
Location Port Colborne
Phone 905 835-8220
Website <http://www.casco.ca>
Size large
Description Casco produces corn-derived products — starches, fermentable sugars, sweeteners, feed and oil used by more than 60 different industries.

Organization Name Clark Agri Services
Position in Value Chain Processing, Feedstock, R&D
Type of Processing biological
Technologies
Type of Feedstocks Agriculture
Bioeconomy Market Sectors Environmental Products
Location West Lincoln
Phone 905 957-3362
Website <http://www.theclarkcompanies.com>
Size large
Description Clark Agri Services is an agriculture retail company. It conducts R&D for new product development and field trials of high yielding corn for ethanol production with major seed companies and also focuses on converting manure to novel products bioproducts.

Organization Name Emery's Health Products
Position in Value Chain R&D
Bioeconomy Market Sectors Biopharmaceuticals/Biotherapeutics
Location St Catharines
Phone 905 687-3687
Website <http://www.fungusfree.ca/>
Size small
Description Emery's Health Products manufactures and sells an all natural herbal compound for the treatment of onychomycosis (finger and toenail fungus).

Organization Name Envirofix Corp
Position in Value Chain Processing
Type of Processing biological
Technologies
Bioeconomy Market Sectors Environmental products

Location Niagara Falls
Phone 905 562 4000 ext. 222
Website <http://www.envirofix.ca/>
Size small
Description Envirofix is a multi-disciplinary remediation company providing services in site cleanup, restoration and remediation. The company offer a variety of remediation systems including dual phase extractions, activated carbon systems, bio-venting, vapor phase extraction, insitu-exsitu bioremediation systems, hydrocarbon degrading, bacteria implementation system, bio-augmentation and bacterial culture enhancement systems, sediment, sludge, groundwater and industrial sewage.

Organization Name Joseph's Estate Wines Inc.
Position in Value Chain Processing, Feedstock, R&D
Type of Processing Technologies chemical/physical
Type of Feedstocks Agriculture
Bioeconomy Market Sectors Functional Foods/Nutraceuticals
Location Niagara-on-the-Lake
Phone 905 468-1259
Website <http://www.josephsestatewines.com>
Size small
Description Joseph Estate Winery produces a line of grape seed oil extracted from the grape pomace. The grape seed oil is rich in nutrients such as antioxidants and fatty acids such as linoleic acid. Through the second line of business: Vintage Flour Niagara Inc., a unique, nutritional and gluten free flour is manufactured from the grape skins. The flour can be used in any recipe where wheat flour is used.

Organization Name Jungbunzlauer Canada Inc.
Position in Value Chain Processing
Type of Processing Technologies biological
Bioeconomy Market Sectors Bioproducts - Biochemicals
Location Port Colborne
Phone 905 835-5444
Website <http://www.jungbunzlauer.ca>

Size large
Description Manufactures natural, biodegradable ingredients for the food, cosmetics and pharmaceutical industry. Some of the products include citric acid, gluconates and sweeteners. Citric acid is a natural occurring fruit acid produced commercially by microbial fermentation

Organization Name Kare & Hope Inc.
Position in Value Chain R&D
Bioeconomy Market Sectors Functional Foods/Nutraceuticals
Location St. Catharines
Phone 905 688-9460
Website <http://slimwizely.kareandhope.com/index.html>
Size small
Description Kare and Hope Inc. is involved in research and marketing innovative health products based on black seed oil, garlic, and other aromatic herbs.

Organization Name Niagara College
Position in Value Chain R&D
Bioeconomy Market Sectors Bioproducts - Bioenergy
Location Welland
Phone 905 641-2252, ext. 4150
Website <http://www.niagaracollege.ca/research/>
Description Niagara College is a member of the Colleges Ontario Network for Industrial Innovation (CONII), whose mandate is to help small companies solve technical problems, adapt new technologies, and develop or improve new products and processes. The College is involved in several on-going applied research projects directly related to the bioeconomy.

Organization Name Norgen Biotek Corp
Position in Value Chain Processing, R&D
Type of Processing biological
Technologies
Bioeconomy Market Sectors Biopharmaceuticals/Biotherapeutics
Location Thorold
Phone 905 227-8848
Website <http://www.norgenbiotek.com/>
Size small

Description Norgen Biotek Corp., an innovative Canadian biotechnology company focusing primarily on advancing powerful tools for nucleic acid and protein purification and concentration. Expertise in biology, virology, and immunology.

Organization Name Pharmetics
Position in Value Chain Processing, R&D
Type of Processing Technologies chemical/physical
Bioeconomy Market Sectors Biopharmaceuticals/Biotherapeutics, Functional Foods/Nutraceuticals
Location Fort Erie
Phone 905 871-1870
Website <http://www.pharmetics.com>
Size large
Description Pharmetics is a full service private label and contract manufacturer of pharmaceutical products and efficient development of nutraceuticals, biopharmaceuticals such as proteins, peptides and monoclonal antibodies (MAb).

Organization Name Planet Biogas Solutions
Position in Value Chain Processing, R&D, Distribution & Handling
Bioeconomy Market Sectors Bioproducts - Bioenergy
Location St. Catharines
Phone 905 9351969
Website <http://www.planet-biogas.ca>
Size medium
Description PlanET Biogas Solutions designs, builds and installs anaerobic digester systems for use in greenhouses, poultry barns or factories that produce organic by-products. They are currently constructing their second digester at Vandermeer Greenhouses at Niagara-on-the-Lake. Their main focus is the Ontario market, however, they serve biogas customers throughout Canada and selected projects in the USA.

Organization Name Redcoat Consulting
Position in Value Chain R&D
Bioeconomy Market Sectors Functional Foods/Nutraceuticals, Environmental Products, Biopharmaceuticals/Biotherapeutics,

Bioproducts
 Location Ridgeway
 Phone 905 228-1877
 Website <http://www.rc2.ca>
 Size small
 Description Redcoat Consulting undertakes early stage IP development & technology transfer consultancy as the foundation for a privately operated business incubator working in collaboration with academic institutions and commercial partners

Organization Name Sherwin-Williams Canada Inc.
 Position in Value Chain Processing, R&D
 Type of Processing chemical/physical
 Technologies
 Bioeconomy Market Sectors Environmental products
 Location Fort Erie
 Phone 905 871-2724
 Website <http://www.sherwin-williams.com>
 Size large
 Description Sherwin-Williams conducts R&D and through its GreenSure Initiatives uses sustainable raw materials such as soy and sunflower oil in their paints.

Organization Name Vineland Research and Innovation Centre (VRIC)
 Position in Value Chain R&D
 Bioeconomy Market Sectors Bioproducts - Biochemicals
 Location Lincoln
 Phone 905 562-0320
 Website http://www.vinelandontario.ca/v1/ps_research.php
 Description VRIC has an objective of developing a bio-active compound industry in the Niagara Region based on the extraction of individual molecular species from Niagara Peninsula crops, and/or processing co-products.

Organization Name Vinifera For Life
 Position in Value Chain Processing, Feedstock, R&D
 Type of Processing chemical/physical
 Technologies
 Type of Feedstocks Agriculture

Bioeconomy Market Sectors Functional Foods/Nutraceuticals
Location Jordan
Phone 905 562-4339
Website <http://www.viniferaforlife.com/>
Size small
Description Vinifera For Life manufactures premium grape powders from grape skins and seeds. The grape powders, which contain high levels of fibre and polyphenols such as antioxidants and resveratrol are premium ingredients in gourmet breads, pasta and other other products.

Organization Name Vista Science and Technology Inc.
Position in Value Chain R&D
Bioeconomy Market Sectors Functional Foods/Nutraceuticals, Environmental Products, Biopharmaceuticals/Biotherapeutics, Bioproducts
Location Welland
Phone 905 734-3000
Website <http://www.vistast.com>
Size small
Description VISTA Science & Technology Inc. works with organizations across the innovation value chain to maximize the outcomes of their investments in R&D. The bioeconomy is an area of special expertise.

Organization Name Walker Industries Holdings Limited
Position in Value Chain Processing, Feedstock, R&D
Type of Processing Technologies biological, thermal
Type of Feedstocks Municipal Solid Waste, Agriculture
Bioeconomy Market Sectors Environmental Products, Bioproducts - bioenergy
Location Niagara Falls
Phone 905 227-4142
Website <http://www.walkerind.com/>
Size medium
Description Walkers Industries' is involved in several markets of the bioeconomy including bioproducts and environmental products. The company is active in several positions of the bioeconomy value chain: inputs- feedstocks, processing and R&D.



Appendix 4 - Global Bioproducts Sector Analysis

The search for sustainable economies has gradually led governments around the world to investigate and pursue programs and policies to develop and manage biocompatible products and processes, and alternative sources of energy to curtail growing societal and environmental concerns. Biomass, according to the Government of Canada, defined as “renewable or sustainable feed stock/materials of agriculture, animal, forestry, marine, or aquaculture origins or from municipal and industrial waste”¹⁰¹, has become the bedrock for most of the ongoing scientific research and development programs and projects in the quest to find environmentally—friendly replacement products. The gradual, global shift towards a bioeconomy has become a reality in several countries such as the United States, Canada, Brazil, Japan, China, India, Indonesia, South Africa, Mozambique, Malawi and some member countries of the European Union.¹⁰² As a result of these initiatives, bioproducts have evolved as an emerging sector in the global economy. For instance, in Canada some large companies focus on bioproducts development as a secondary activity while small firms focus on industrial biotechnology and bioproducts development.¹⁰³ Statistics Canada defines bioproducts as “biologically-based industrial products and processes other than food, feed and medicines made out of biomass or using biotechnological techniques”.¹⁰⁴

- Trends, Drivers, Size and Growth Rate

- Trends

Generally, the trend for pursuing bioproducts in a bioeconomy has been to find alternative sources of energy, to reduce industrial and domestic waste and develop more environmentally friendly products. Research and development into bioproducts is on the rise globally to find solutions to global crisis such as the growing concerns of climate change and environmental degradation (use of biomaterials and biochemicals), use of renewable resources and the depletion of non-renewable fossil fuels contributing to greenhouse emissions and global warming (use of bioenergy). According to the Organization for Economic Cooperation and Development (OECD) Task Force on Biotechnology Sustainable Industrial Development, improvement in industrial eco-efficiency and lower operation costs can be achieved if industries embark on the use of biotechnology, bio-based feedstock and bioprocesses in their production. One of the viewpoints of the OECD is that in a bio-based economy, a greater and more efficient use of bio-based products and processes based on more renewable resources, and reducing the impact of industrial

¹⁰¹ Johanne Boivin, SIEID, Statistics Canada. Bioproduct development in Canada: the state of an emerging and promising sector. Innovation Analysis Bulletin, Vol.1, February 2006. Available [Online]

<http://www.statcan.ca/bsolc/english/bsolc?catno=88-003-X20060019103>. Accessed September 9th, 2008

¹⁰² BIODIESEL 2020: Global Market Survey, Feedstock Trends and Market Forecasts 2nd Edition (2008).

Available [Online] <http://www.biofuels-news.com/biodiesel2020/>. Accessed September 11, 2008.

¹⁰³ Sparling, David, John Cranfield, Spencer Henson, Pamela Laughland. Bioproducts Development Survey: Analysis of the Summary Results September 2006, page xxv-xxvi. Prepared for Agriculture and Agri-Food Canada. Available [Online]

http://www4.agr.gc.ca/resources/prod/doc/pol/pub/bioprod/pdf/bioproducts_e.pdf. Accessed September 9th, 2008

¹⁰⁴ Statistics Canada, Bioproducts Development Survey, The Daily, Monday, May 16, 2005. Available [Online]

<http://www.statcan.ca/Daily/English/050516/d050516c.htm>. accessed September 9th, 2008

activities, could open up new products, new markets and new industries.¹⁰⁵ A typical example is the industrial based applications of biotechnology that are replacing the traditional pharmaceutical, energy and manufacturing production.¹⁰⁶ Another emerging development is the large scale growing of alternative lower-cost feedstock such as jatropha, castor, algae and vegetable oil for the production of renewable diesel.¹⁰⁷

•• Market Drivers

In general, the drivers for bioproducts could be grouped into three main categories such as socio-economic benefits, environmental benefits and energy security.

- The implementation of government driven incentives, legislative instruments in the respective countries and international agreements such as the Kyoto Protocol are significant drivers influencing the adoption of bioproducts across of the world. For example, the European Commission Directive-EC 2003/30/EC specifically promotes the increased use of biofuels. This is because biodiesel has lower prices and has lower sulphur emissions and better lubrication compared to mineral diesel.¹⁰⁸
- The achievement of greater energy self-sufficiency is another driver. With the depletion of the non-renewable fossil fuels, price uncertainty and energy security have become major issues. The United States, Europe, and other emerging economies such as Brazil, have plans and programs to reduce their foreign oil dependence.¹⁰⁹
- Higher oil prices create price uncertainty in both developed and developing countries and this is making the transition to renewable alternatives. Some of the alternatives include the use of ethanol, solar, wind, and hydrogen.¹¹⁰
- The quest to lower environmental pollutants and toxicity has also contributed to the development of bioproducts. Additionally, waste disposal regulations have also promoted the use of non-hazardous substances.¹¹¹
- Another driver is the emergence of using biodegradable materials or biomaterials to reduce post-operative adhesions, the development of absorbable and erodible orthopaedics and wound closure biomaterials in the healthcare system. Increase in sports injuries and treatment encourage absorbable and erodible biomaterials.¹¹²

¹⁰⁵ Organization for Economic Cooperation and Development (OECD) OECD Task Force on Biotechnology for Sustainable Industrial Development, *The Application of Biotechnology to Industrial Sustainability (2001)* Available [Online] http://www.oecd.org/documentprint/0,3455,en_2649_34537_34723948_1_1_1_1,00.html accessed September 10, 2008

¹⁰⁶ Canadian Corporate News, (November 2006). BioProducts Canada 2006/BIOTECHCanada: Strengthening Canadian Global Opportunity. Available [Online] <http://www.highbeam.com/> (subscription required). Accessed September 10, 2008

¹⁰⁷ Ibid.

¹⁰⁸ Frost & Sullivan (2005). Bioplastics technology and market assessment (North America; Europe; Asia), and Frost & Sullivan, (2005). European Biofuels-Market and Opportunity Analysis, August 16, 2005. Available [Online] www.frost.com (subscription required). Accessed September 9, 2008.

¹⁰⁹ Ibid.

¹¹⁰ Frost & Sullivan (2007). European Biolubricants Markets, August 1, 2007. Available [Online] www.frost.com (subscription required). Accessed September 9, 2008.

¹¹¹ Ibid.

¹¹² Frost & Sullivan (2005). European Biofuels-Market and Opportunity Analysis, August 16, 2005. And Frost & Sullivan (2003). European Biomaterial Markets. Available [Online] www.frost.com (subscription required). Accessed September 9, 2008,

- Investments into research and development with government and non-government support is on the increase, therefore stimulating the research communities around the globe to develop more efficient, affordable methodologies and processes for industrial productions.¹¹³
- The broad availability, diverse nature of low cost feedstock allowing for production in all climates ensures continuous supply.¹¹⁴ has also encouraged countries with large scale agriculture and forestry sectors to embark on developing the more bioproducts.
- The discovery, the potential use, and the global demand for enzymes in biotechnology are creating opportunities to developed bioprocessing in industrial productions. Some of the end-users are agricultural, food processing, detergents and pharmaceutical industries.¹¹⁵
- Agricultural biotechnology (use of transgenic seeds/ genetically modified (GM) seeds) dealing with population growth, food shortages and enhancing rural developments are all giving rise to the new emerging sector of bioproducts in a bioeconomy.¹¹⁶
- Existence of the protection of intellectual property rights which encourages researchers to conduct their work¹¹⁷.

•• Size and Growth Rate

Some countries have made greater strides in the bioeconomy than others. There is a large market for bioproducts globally. For example, there has been a surge in production of biodiesel from alternative sources such as non-food feedstocks.¹¹⁸ Europe currently consumes 80% of the global biodiesel consumption and production. The biodiesel production in the United States has grown from 25 million gallons yearly (in 2004) to more than 450 million gallons by 2007.¹¹⁹ Brazil, China, India and Europe have all set targets to replace 5% to 20% of total diesel with biodiesel.¹²⁰ The demand for biodiesel and the overcapacity in Asia, Europe and the U.S. are driving the global investment and trade into non-food feedstocks. Having identified the vast potential of non-food feedstock such as jatropha and castor, China and Brazil have set aside a combined area 76 million hectares of non-arable to for the production of non-food feedstock based biodiesel.¹²¹ Some African countries have also dedicated resources to programs to embark on large-scale production of non-food feedstocks for biodiesel. As an emerging sector across the globe, the size of bioproducts markets is still undefined. Concerning biofuels, in the quest to attain energy security both developed and developing countries have embarked on the search for alternative sources to non-renewable fossil fuels that are fast depleting. This reality came to light especially after the 1970s

¹¹³ Frost & Sullivan (2007). European Biolubricants Markets, August 1, 2007. Available [Online] www.frost.com. (subscription required). Accessed September 9, 2008.

¹¹⁴ Frost & Sullivan (2007). European Bioethanol and Feedstock Markets Analysis, August 9, 2007. Available [Online] www.frost.com. (subscription required). Accessed September 9, 2008

¹¹⁵ Frost & Sullivan (2004). Biotechnology industry impact service (technical insights). Available [Online] www.frost.com. (subscription required). Accessed September 9, 2008

¹¹⁶ Frost & Sullivan. (1999). World agriculture genomics and biotechnology markets, Available [Online] www.frost.com. (subscription required). Accessed August 28, 2008.

¹¹⁷ Frost & Sullivan. (2003). Asia Pacific Biotechnology Markets: Business Terrain Map; Future Outlook and Relative competitive Position. April 7, 2003, Available [Online] www.frost.com. (subscription required). Accessed August 28, 2008

¹¹⁸ BIODIESEL 2020: Global Market Survey, Feedstock Trends and Market Forecasts 2nd Edition (2008). Available [Online] <http://www.biofuels-news.com/biodiesel2020/>. Accessed September 11, 2008

¹¹⁹ Ibid.

¹²⁰ BIODIESEL 2020: Global Market Survey, Feedstock Trends and Market Forecasts 2nd Edition (2008). Available [Online] <http://www.biofuels-news.com/biodiesel2020/>. Accessed September 11, 2008

¹²¹ Ibid.

energy crisis. According to the International Energy Agency (IEA, 2004) the production of ethanol as a biofuel increased from 20 billion litres in 2000 to 40 billion litres in 2005, providing about 2.8% motor gasoline use in the world. Further, the International Energy Agency forecasts consumption will reach 65 billion by 2010 (IEA, 2004).¹²²

Brazil, which is the world's largest producer and consumer of ethanol from sugarcane (3 million vehicles/day running on pure ethanol), produces an annual combined capacity of 14 billion litres from 300 ethanol plants.¹²³ The United States is the second largest producer with the number of plants increasing from 50 in 1999 to 95 in 2005 with an additional 31 being constructed. The third largest producer is China, which is also the largest in Asia with an annual capacity of more than 3 billion litres. India is the fourth with a production capacity of 2.7 billion litres. Since the beginning of this decade several European Union members such as Germany, Spain, France United Kingdom and Sweden have increased their production of biofuels.¹²⁴

The Asia Pacific regional biotechnology market is expected to grow to \$114.62 billion by 2010 from \$19.84 billion in 2001. The region includes countries such as Japan, South Asia, China, Australia, India, Singapore and Malaysia. With this huge increase, it is expected that the potential for bioproducts will form part of this growth.¹²⁵ For example, Japan has a huge bio-industry that is expected to use biocatalysts. China and India have embarked on producing ethanol from non-food feedstocks. This also creates an opportunity to use GM seeds in the production of more biomass—non-food feedstocks—to meet the local demand. South East Asia is poised to make strides into the huge bioproducts potential despite their financial constraints.

¹²⁶

• Major Markets

•• The United States (U.S.)

Governments in North and South America, Europe and Asia are pursuing developmental policies and programs to tap into the potential of bioproducts.¹²⁷ The U.S. Department of Energy (U.S.DOE) and U.S. Department of Agriculture (USDA) have developed policies towards bioproducts. Their programs support the development of biomass feedstock production and conversion technologies to meet the domestic demand for electric power, chemicals and materials. The policies and programs are further intended to

¹²² Walburger, Allan M., Danny Le Roy, Krishan K. Kaushik, and Kurt, Klein, March 2006. Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and the United States. A BIOCAP, Research Integration Program Synthesis Paper, page 41. Available [Online] http://www.biocap.ca/rif/report/Walburger_A.pdf accessed Wednesday, September 10, 2008

¹²³ *Ibid.* Page 3.

¹²⁴ Walburger, Allan M., Danny Le Roy, Krishan K. Kaushik, and Kurt, Klein, March 2006. Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and the United States. A BIOCAP, Research Integration Program Synthesis Paper, page 41. Available [Online] http://www.biocap.ca/rif/report/Walburger_A.pdf accessed Wednesday, September 10, 2008. Page 2.

¹²⁵ Frost & Sullivan. (2003). Asia Pacific Biotechnology Markets: Business Terrain Map; Future Outlook and Relative competitive Position. April 7, 2003, Available [Online] www.frost.com. (subscription required). Accessed August 28, 2008.

¹²⁶ Mazlyn Mena (2001). Southeast Asia: Gearing Up for the Bio-Economy Wave, Frost & Sullivan Market Insight 2001. Available [Online] www.frost.com. (subscription required). Accessed September 11, 2008.

¹²⁷ Walburger, Allan M., Danny Le Roy, Krishan K. Kaushik, and Kurt, Klein, March 2006. Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and the United States. A BIOCAP, Research Integration Program Synthesis Paper, page 41. Available [Online] http://www.biocap.ca/rif/report/Walburger_A.pdf accessed Wednesday, September 10, 2008

improve the environment through new sources of energy, reducing foreign oil dependence and increasing the use of agricultural crops¹²⁸ and forest resources as feedstock for bioenergy and bioproducts and enhancing rural development.¹²⁹

By developing the biotechnology industry, the U.S. plans to move toward a bio-based economy with the objective of attaining energy security.¹³⁰ There has been a focus on bio-based chemicals manufacturing and the development of a domestic bio-industry. Some specific targets stated in the Biomass Research and Development Act of 2000 stress the need to develop and increase the production of bio-products from biomass from 5% in 2001 to 25% by 2030.¹³¹ Additionally, it is expected that the share of bio-fuel production from biomass will increase from 0.5% in 2001 to 20% by 2030.¹³² The U.S. has demonstrated a high commitment to achieving these objectives. There is a high level of political will and an extensive research and development support as well as the setting of standards and financial incentives being provided. The passage of the Biomass Research and Development Act of 2000 has a focus on energy and value added products from a variety of agricultural and forest residues. To demonstrate that commitment, in 2003, the U.S. DOE spent \$125 million on biomass production research and the USDA spent an additional \$259 million.¹³³ Furthermore, the DOE spent an additional \$100 million in support of bio-refinery trial projects. The returns on these investments are being realized. For instance, the demand for corn-derived chemical products is forecasted to grow at 13% annually and the total bioproduct production is expected to grow to approximately 30 million tonnes yearly by 2020.¹³⁴ Moreover, in an effort to provide markets for the bioproducts, the government through the Farm Bill of 2002, has mandated federal procurement when bio-based products become available and are equivalent to alternatives from a fossil fuel base.¹³⁵ This has served as an incentive to local farmers to produce more crops for industrial use.

•• Canada

The first national bioproducts survey was undertaken in 2003 by Statistics Canada to understand the depth and extent of the emerging bioproduct sector in Canada. The target population of the survey was all the Canadian firms that use biomass and other renewable or sustainable feedstock/materials to develop or produce bioproducts. The results indicated that 232 companies were involved in bioproducts production and processes.¹³⁶ Agricultural biomass was the primary source of feedstocks for bioproduct firms. The motivation for developing bioproducts was increased sales and market share, and developing new

¹²⁸ The two most important crops grown in the U.S. are soybeans and corn.

¹²⁹ U. S. Department of Energy and U.S. Department of Agriculture 2005. Biomass as a feedstock for Bioenergy and Bioproducts Industry: The Technical Feasibility of A Billion-Ton Annual Supply, April 2005, page 1. Available [Online] http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf. Accessed October 28th, 2008

¹³⁰ The European Bio-Based Economy (2008), "Around the World" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.

¹³¹ *Ibid*

¹³² *Ibid*.

¹³³ *Ibid*.

¹³⁴ The European Bio-Based Economy (2008), "Around the World" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.

¹³⁵ *Ibid*.

¹³⁶ Johanne Boivin, SIEID, Statistics Canada. Bioproduct development in Canada: the state of an emerging and promising sector. Innovation Analysis Bulletin, Vol.1, February 2006. Available [Online] <http://www.statcan.ca/bsolc/english/bsolc?catno=88-003-X20060019103> Accessed September 9th, 2008

products and new market¹³⁷. According to the recent Bioproducts Development and production survey 2006, the number of companies involved in bioproducts increased from 232 to 239.¹³⁸ According to the Ontario Ministry of Natural Resources (MNR), 6% of the total energy consumed in Canada is produced from biomass sources. Most of the production is in the pulp and paper industries, which use residues from their production to produce the electricity and steam. The Ministry has, thus, identified in Ontario forest biofibre to produce biomaterials, biopharmaceuticals, bioenergy and other bioproducts. Forest biofibre has the potential for solving some of the energy issues for the pulp and paper industries currently incurring high energy operating cost.¹³⁹ Since the availability of biomass is diverse, it presents Canada, the second largest industrial biotechnology community in the world, with a huge advantage. The renewable biomass resources and bioproducts are expected to account for \$100 billion of GDP by 2020.¹⁴⁰ Since Canada is a large net exporter of energy, the country does not need the infrastructure of a biofuels industry; rather, it needs policies focused on reducing greenhouse gases, some selected air pollutants, increasing agricultural incomes and pursuing rural development.¹⁴¹

•• Europe

The EU has a focus of becoming a world leader in developing and applying environmental technologies. In 2004, the Environmental Technologies Plan (ETAP) was implemented¹⁴². The plan included actions such as creating an easier transition from research to markets, improving market conditions concerning procurement of environmental technologies, creating incentives and removing barriers; acting globally by promoting environmental technologies in developing countries and promoting responsible foreign direct investment. The ETAP is one of the platforms that have resulted in developing bioproducts. Furthermore, the European Commission launched the European Technology Platform on Sustainable Chemistry (SusChem TP) for establishing a stronger public-private partnership to boost investment on research and innovation and to increase European competitiveness in the different sectors of the economy. The goals of the platform were to create broader open dialogue among the stakeholders, create more innovations in biochemical technologies and implement an action plan to align the important EU policies and initiatives and provide recommendations on European framework conditions.¹⁴³ The biomass action plan in Europe has a legislative directive in place to double inland consumption of renewable energy sources from 5.4% in 1997 to 12.0% by 2010. Directive 2003/30 EC is currently in place to replace diesel and petrol up to 5.75% by 2010 with a detaxation of biofuels policy supported by the directive 2003/96/EC.¹⁴⁴ In Europe, Germany

¹³⁷ Next Generation of Agriculture and Agri-Food Policy. Economic Background: Opportunities for Canadian Farmers: Innovation and the Bioeconomy. Available [Online] <http://dsp-psd.pwgsc.gc.ca/Collection/A22-410-2006E.pdf>. Page 3. Accessed September 30, 2008

¹³⁸ Science, Innovation and Electronic Information Division. Bioproducts development and production survey 2006. Statistics Canada. Information request received on September 9th, 2008.

¹³⁹ Larmour, Adelle (2007). Opportunities in biofibre (NEWS). Northern Ontario Business. COPYRIGHT 2007 Laurentian Business Publishing, Inc. Available [Online] www.highbeam.com. (subscription required). Accessed September 10, 2008.

¹⁴⁰ Canadian Corporate News, (November 20, 2006). BioProducts Canada/BIOTEC Canada: Strengthening Canadian Global Opportunity. 2006 CCN Matthews. Available [Online] www.highbeam.com. (subscription required). Accessed September 11, 2008.

¹⁴¹ Walburger, Allan M., Danny Le Roy, Krishan K. Kaushik, and Kurt Klein, March 2006. Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and the United States. A BIOCAP, Research Integration Program Synthesis Paper, page 41. Available [Online] http://www.biocap.ca/rif/report/Walburger_A.pdf. accessed Wednesday, September 10, 2008

¹⁴² The European Bio-Based Economy (2008), "In Europe" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.

¹⁴³ The European Bio-Based Economy (2008), "Around the World" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.

¹⁴⁴ Ibid

is the largest single market for absorbable and erodible biomaterials, followed by France, Italy, UK, Spain and some of the Scandinavian countries. The market was estimated at \$470 million in 1999 and by 2002 it had increased to 539.3 million.¹⁴⁵

•• Japan

Japan was one of the first countries to use bio-catalyst—an enzyme technology—to produce acrylamide. In 2003, the Japanese bio-industry was estimated to have a return of \$15 billion with the chemicals sector accounting for 26%.¹⁴⁶ Although Japan has a strong biotechnology industry, its agricultural base does not have the capacity to provide the ready supply of the biomass locally needed by the bio-refineries to stay competitive in the emerging bio-processing sector. In Japan, there is more emphasis on developing a higher-value bio-processing sector than bio-fuels and bulk chemicals. This was stressed in the action plan released in 2002 by the Biotechnology Strategy Council, which stated three strategies as achieving health and longevity, food safety and functionality, and a sustainable society.¹⁴⁷ Contrary to Europe and the U.S., Japan invests more in biotechnology for health oriented foods, power generation and the environment than investment into the healthcare biotechnology.

•• Developing Countries

Unlike Japan, China has significant agricultural potential and a fast growing economy. Therefore, it will be able to meet the demand for biomass needed by the local industrial plants. Also like Japan, China has a long history in food fermentation using biotechnology. Thus, it has invested in a large-scale fermentation capacity for bulk chemicals such as ascorbic and citric acid to boost export markets. Other investments include construction of additional bio-ethanol plants such as the largest plant in the world, anticipated to produce 600,000 tonnes annually to meet the demand of the growing car population in China. This has also created jobs for local communities where the plant has been built. Regarding the economic development of the bioproducts sector, according to the IEA (2004), rural development has been enhanced in Brazil after the creation of about 700,000 jobs as a result of the booming sugarcane and ethanol industry.¹⁴⁸

Most developing countries (in Africa and Asia) do not have the resources to develop industrial biotechnology on their own. However, most of them have the large agricultural sectors, which have the potential of supplying the feedstock needed by some of the developed nations thus opening up growth opportunities for those developing nations.¹⁴⁹ Due to the cost of transportation, some countries have adopted the production and processing of non-food feedstocks for easier transportation, for example, the

¹⁴⁵ And Frost & Sullivan (2003). *European Biomaterial Markets*. Available [Online] www.frost.com. (subscription required). Accessed September 9, 2008.

¹⁴⁶ *ibid.*

¹⁴⁷ The European Bio-Based Economy (2008), "Around the World" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.

¹⁴⁸ Walburger, Allan M., Danny Le Roy, Krishan K. Kaushik, and Kurt Klein, March 2006. *Policies to Stimulate Biofuel Production in Canada: Lessons from Europe and the United States*. A BIOCAP, Research Integration Program Synthesis Paper, page 41. Available [Online] http://www.biocap.ca/rif/report/Walburger_A.pdf accessed Wednesday, September 10, 2008

¹⁴⁹ The European Bio-Based Economy (2008), "Around the World" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.

production of *Jatropha carcus*.¹⁵⁰ When large production scale is achieved with the supporting legislative instruments, developing countries can boost their economies by adopting a bio-based economy as the world demand for feedstock (biomass) peaks. Additionally, developed countries also have the opportunity to share technologies with developing nations to positively affect the socio-economic development of the latter.¹⁵¹

¹⁵⁰ BIODIESEL 2020: Global Market Survey, Feedstock Trends and Market Forecasts 2nd Edition (2008). Available [Online] <http://www.biofuels-news.com/biodiesel2020/>. Accessed September 11, 2008

¹⁵¹ The European Bio-Based Economy (2008), "Around the World" Available [Online] <http://www.bio-economy.net/>. Accessed September 11, 2008.