

# Measuring the biobased economy: A Canadian perspective

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**A** surge over recent years in scientific knowledge and technical competence has enabled the growth of a biobased economy that harnesses biological processes—especially products and processes inherent to industrial biotechnology—for practical applications in traditional industries.

The concept of the biobased economy goes beyond the traditional definition of biotechnology. The biobased economy focuses on biological tools and products from renewable resources to create wealth and sustainability in the production of medical treatments, diagnostics, more-nutritional foods, energy, chemicals, and materials, while improving the quality of the environment. The concept has been extensively written about internationally. In his book, *BioBusiness in Asia*,<sup>1</sup> Dr. Gurinder Shahi describes the bioeconomy as being responsible for one third of the world's economy. The OECD's *The Bioeconomy to 2030: Designing a Policy Agenda*<sup>2</sup> project will be released later in 2008 and has been in the works since 2006.

Understanding the biobased economy facilitates the right financial, policy, and regulatory frameworks that enable the integration of biotechnology into traditional economic sectors while also revitalizing these sectors.

As one of the key components of the biobased economy, industrial biotechnology contributes to national economies through wealth creation and sustainability. From biofuels to enzymes to bioplastics, the products and processes of industrial biotechnology are the building blocks of the new national economies. This article outlines the footprint of the Canadian biobased economy and situates it in an international context.

## Methodology

An econometric model of determination is used to calculate the GDP of the Canadian biobased economy. This model follows a specific

three-phase approach. In Phase One, the GDPs of the biobased North American Industry Classification System (NAICS) breakdowns (those reflected in the biobased economy definition) are calculated as a percentage of total-country GDP. This percentage is subsequently applied in Phases Two and Three to the total remaining country economy, with Phase Two incorporating direct spin-off industries such as professional services, wholesale, and retail trade, and with Step Three accounting for the remaining economy segments.

The final step consists of adding all the totals in each phase to yield the total industry (or bioeconomy) GDP, which can be compared to total-country GDP, other industries, and per capita rankings. A multiplier is calculated by comparing the percentage difference between the industry GDP at the end of Step One and that obtained at the end of Phase Three.

The main inputs to the model come from *Statistics Canada* data on gross domestic product at basic prices,<sup>3</sup> by NAICS, and from additional industry sources utilized to meet the biobased economy definition.<sup>4</sup> For purposes of comparability, US GDP by industry data was obtained through the US Department of Commerce's Bureau of Economic Analysis. Other country datasets were obtained through respective national statistical agencies and through the *Statistical Office of the European Communities*.

The value of a biobased economy was then determined using the value of industry subsectors that contributed to it and fit within the biobased economy definition. These sectoral contributors include: a percentage of health sector GDP, with the percentage based on pharmaceutical and medicine expenditures; a percentage of agricultural sector GDP, the percentage based on added-value crops (i.e., biotech crops); and the biobased manufacturing GDP, which includes the manufacturing of pharmaceuticals and medicines, organic chemicals, and engineered or fermented foods and beverages, thus encompassing key segments of industrial biotechnology.

Comparing Canada's biobased economy with those of other countries over the last four years, it is possible to outline Canadian

**Table 1: Biobased economies by GDP**

| BIOBASED ECONOMIES | BIOBASED ECONOMY GDP<br>(all figures, 2002<br>billion Canadian dollars) | BIOBASED GDP PER CAPITA<br>(Canadian dollars) | AS PERCENTAGE OF<br>TOTAL-COUNTRY GDP |
|--------------------|---|---|---------------------------------------|
| United States      | 1,250   | 4,160   | 8.45                                  |
| Canada             | 78.3  | 2,380   | 6.40                                  |
| Japan*             | 290   | 2,270   | 6.18                                  |
| France             | 131   | 1,990   | 5.88                                  |
| India*             | 84.7  | 50.7  | 5.60                                  |
| Germany*           | 144   | 1,850   | 4.33                                  |
| United Kingdom     | 120   | 1,980   | 3.75                                  |

\*See *Limitations* section, p. 366

competencies, establish trends, highlight areas of improvement, and recognize Canadian competitive advantages.

**Summary of findings: The Canadian bioeconomy**

Results of this analysis illustrate that the 2007 Canadian biobased economy, measured in gross domestic product, is valued at approximately \$78.3 billion dollars, equivalent to 6.40% of Canada’s total GDP. (All values are in Canadian dollars unless otherwise noted.) On a per capita basis, this represents \$2,380 (Table 1).

Applying the same methodology to other large world economies reveals clear differences in national biobased economies. On a GDP per capita basis, the United States’ biobased economy is over 60% more developed than that of Canada’s, at nearly \$3,850, giving it a value of upwards of \$1.25 trillion dollars, or 8.45 percent of total GDP.

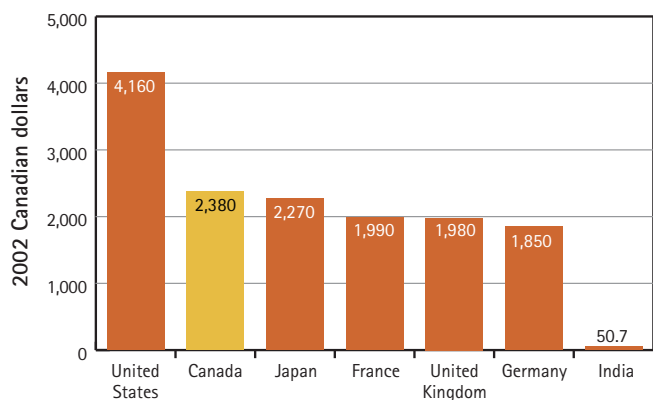


Figure 1. Biobased economies

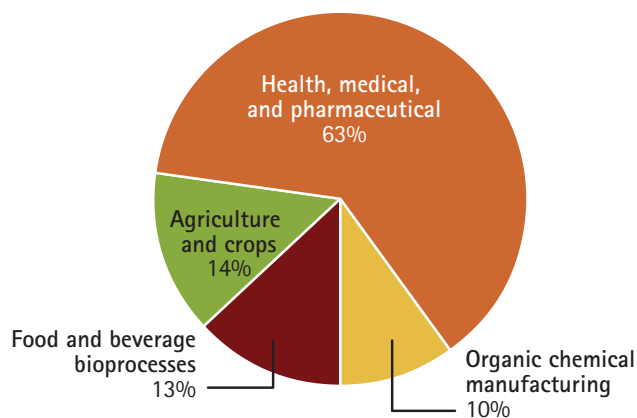
European countries tend to have slightly less-developed biobased economies on a GDP per capita basis, ranging from France’s \$1,990 to Germany’s \$1,850 (Figure 1). Japan’s biobased GDP per capita of \$2,270 closely resembles Canada’s, with a difference of less than \$100 per inhabitant.

**Discussion**

Recognizing industrial biotechnology’s role within the larger biobased economy in diverse fields such as biofuels, enzymes, organic chemical manufacturing, and bioprocesses enables us to better understand the large difference in size between national biobased economies.

Looking at Canada’s biobased economy and its main components (Figure 2), one sees a mix of all four biobased economy main sub-sectors. Led by the health, medicine, and pharmaceutical segment, it is followed by agriculture and crop production. Meanwhile, in comparison, this latter sector’s non-existence in European Union member countries (which have yet to adopt biotechnology crops, with the exception of small pockets and a minor introduction of biotech maize in Spain<sup>5</sup>) is a potential disadvantage for the development of a strong industrial biotechnology industry, and biobased economy, in Europe. Canada’s crop-production sector GDP is nearly \$14.7 billion, with 17.3 million acres of genetically modified crops out of 74.6 million total acres of principal cropland.<sup>6</sup>

Having adopted more than 352 million acres of biotech crops, the United States surpasses all countries examined, with more than \$148 of per capita GDP contribution, followed by Canada at \$107 and India at \$17. European biobased economies see no contributions from crop production. However, the small margins of difference within the value-added agricultural segment do not adequately explain the overall differences in the two North American per capita biobased economies.



**Figure 2.** Canada's biobased economy: main components

The different values in the Canadian and the American GDP per capita can most readily be explained by comparing the value of manufacturing sectors that fall under the biobased economy definition, with particular attention on the pharmaceutical and medicine aggregate. On a gross output basis, the United States' pharma aggregate represents \$154 billion to Canada's \$8.14 billion.<sup>7</sup> Accounting on a per capita basis, the United States' sector is 18.9 times larger than its Canadian counterpart.

India presents an interesting comparison in relation to Canada. Though India's biobased GDP closely resembles that of Canada's in a total dollar figure (\$84.7 billion to Canada's \$78.3 billion) and as a percentage of the total economy (5.60% to Canada's 6.40%), it lags significantly on a GDP per capita basis, with \$50.7 per capita GDP, versus \$2,380 in Canada. Canadian farmers, producers, and consumers are on average thus in a better position to reap the returns associated with the adoption of next generation industrial biotech processes, including biofuels and biorefining processes.

India has also been the subject of previous study related to the biobased economy. In his aforementioned book, Dr. Shahi describes India's bioeconomy as comprising half of the country's total economy, though his definition includes more basic agrarian processes, as opposed to the value-added requirement of the model of determination used here.

### Growing the biobased economy

As Brazil, China, India, and other emerging economies grow, Canada, like most other established economies, faces the challenge of intensi-

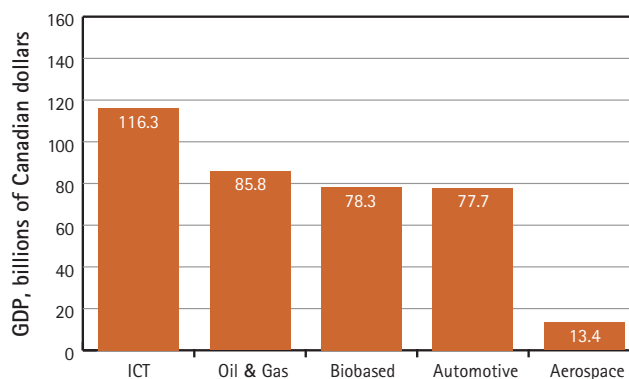
fying its biobased economy. Though traditionally agricultural and less developed, all three of these other countries have in recent years become users of genetically modified crops (GMOs), with this usage increasing.<sup>8</sup> The use of GMOs is opening the door to industrial biotechnology growth in these developing economies, through, for example, opportunities to produce biofuel feedstocks and to engage in biorefining, as well as production of higher-yield and higher-value crops.

On a GDP per capita basis, Brazil, China, and India will continue to lag behind other industrialized countries for a time, in part due to their large population bases—particularly when assessed under a model that accounts for health sector and pharmaceutical expenditures as well as value-added agriculture in quantifying the biobased economy.

Other industrialized nations, including members of the G8, are also actively competing to build leading bioeconomies. Mid-sized countries such as Ireland and Singapore have recently announced significant commitments to attract biotechnology to their shores, with investments of €20 billion over five years, and US\$8 billion, respectively.<sup>9</sup>

### Comparison to other industries

Applying this modeling approach to certain Canadian industries establishes that the biobased economy is one of Canada's leading economic drivers. As of 2007, the biobased economy for the first time surpassed the size of Canada's automotive industry, which the model values at \$77.7 billion, or 6.35 percent of the country's GDP (*Figure 3*). The bioeconomy dwarfed the aerospace sector, valued at 1.09 percent of the economy, and is gaining ground on Canada's oil and gas sector. If present average growth rates hold, the biobased economy will surpass the oil and gas sector (currently an \$85.8 billion industry) in 2011.



**Figure 3.** Industry comparison by GDP and percentage of the economy

### Conclusions

Though cross-sectoral and affecting a variety of different Canadian industries (and often out of the spotlight), Canada's biobased economy is already the backbone of the country's national economy. For Canadian decision makers, closing an existing economic gap with the United States can become a clear economic imperative and lead to a path of job creation and prosperity in an increasingly biobased generation. In addition to generating value on its own, the biobased economy is helping to grow and sustain competitiveness in ailing and traditional sectors of the economy, such as automotive manufacturing, through the application of new and innovative products and processes.

The challenge therefore becomes building a world-leading biobased economy and establishing the foundations for a safer, cleaner, healthier, and more sustainable future.

### Limitations

#### INPUT-OUTPUT TABLES

Another specific modeling approach could have proceeded by specific use of Input-Output (IO) tables. Though ideal in nature (as it may precisely define the secondary and tertiary spin-off effects of each NAICS subcategory), this approach would nonetheless pose certain practical and feasibility considerations. Data timeliness is a major obstacle. The most recent IO table (as of October 2008) is a 2004 release. Though it would be possible to project dollar values forward based on GDP figures, the economic model relies instead on GDP figures themselves, in combination with the retained assumption that the economic spin-offs are proportional to the weight of the value of the NAICS code vis-à-vis the total national economy. In order to properly validate the method employed, 2004 model results were matched to the 2004 Input-Output tables, and more specifically to the Outputs to Total Industries of the 42 L-level NAICS aggregations defined as being related to the biobased economy. For Canada, this provided a net output (or gross domestic product) of \$68.2 billion, compared to the model's result of \$69.4 billion, a difference of less than 2%.

#### DATA LIMITATIONS

Though many data sources provide comparative bases for international analysis, data is often available at different aggregate levels, by different industry sector breakdowns or simply in divergent forms, for example in chained, as opposed to unchained, dollars. Direct comparisons should take this into account. German, Japanese, and Indian data was obtained at different aggregate levels that were supplemented using additional sources, both within the OECD and national departments and agencies.

#### SPECIFIC NOTE ON THE BIOBASED ECONOMY DEFINITION

The biobased economy definition presented below expands the foci of the biobased economy beyond traditional boundaries and encompasses portions of many Canadian industries. In relation to the economic model of determination of the biobased economy, portions of the following NAICS subcategories are factored in, as being "directly" biobased:

- Health (NAICS 62 minus NAICS 624, multiplied by the percentage of Health expenditures related to pharmaceuticals)
- Crop production (a percentage of NAICS 111)
- Bioprocesses used in copper mining (a percentage of NAICS 212233)
- Pharmaceutical and Medicine Manufacturing (NAICS 3254)
- Other Basic Organic Chemical Manufacturing (NAICS 32519)
- Organic Acids and Derivatives, and Alcohol Peroxides and Ethers (a percentage of Basic Chemical Manufacturing, NAICS 3251, minus aforementioned NAICS 32519)
- Breweries, Wineries, and Distilleries (NAICS 3121 minus 31211) and a percentage of Dairy Products (NAICS 31151)

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