Commentary

The Biobased Economy at a Crossroads: 15 Years of Progress and Next Steps

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In March 2015, I celebrated my 15th anniversary at the helm of the Biotechnology Industry Organization’s (BIO) Industrial and Environmental Section. Over the past 15 years, growth of BIO’s Industrial & Environmental Section has reflected the emergence of the biobased economy. From a small group of pioneering companies with a vision of biorefining, the industrial biotech sector has grown to encompass large chemical manufacturers, advanced biofuels producers, food ingredient and processing aid makers, and even consumer product companies. BIO has achieved some significant policy wins for the sector, boosting industry growth and supporting the emergence of new technologies. But what will the future bring? I believe future opportunities in the biobased economy will be driven by new technology breakthroughs, consumer trends, economies of scale for biorefining, the growing adoption of industrial biotechnology innovation by non-traditional players, and the need to find climate change solutions in the manufacturing space.

BIO’s Growth Reflects the Emergence of the Biobased Economy

For those who may not be familiar with the organization, BIO is the world’s largest biotechnology trade association. It represents more than 1,000 biotechnology companies, academic institutions, state biotech centers, and related organizations across the United States and in more than 30 other countries. BIO members research and develop innovative healthcare, agricultural, industrial, and environmental biotechnology products. The organization is divided into four sections to address the policy priorities of health, food and agriculture, industrial, and emerging biotech companies.

When BIO’s Industrial & Environmental Section started back in 1997, there were only a handful of members and several were focused on bioremediation not industrial biotech. Today, the membership of BIO’s Industrial & Environmental Section is approaching 100 companies (Fig. 1). This has been the fastest growing section of BIO’s membership over the past 10 years, reflecting growth in the biobased economy. Through the application of industrial biotechnology, BIO members are improving conventional biofuels, producing advanced and cellulosic biofuels, generating renewable chemicals, and speeding development of new purpose-grown energy crops. Their efforts build the bioeconomy—an economy that enables improved living standards around the world and at the same time replaces non-renewable, petroleum-based materials with cleaner, greener biobased materials.

BIO’s Industrial & Environmental Section brings together the entire value chain of renewable chemical and biofuel production (Fig. 2). Over the years it has grown to include dedicated energy crop developers, core technology providers, biofuel and renewable chemical producers, and consumer product manufacturers. The members are united by the shared vision of building the bioeconomy with its nexus in the integrated biorefinery.

As a service to our members, BIO also annually hosts the premier industrial biotechnology conference, the World Congress on Industrial Biotechnology. The event focuses on fostering investment and partnerships between companies across the value chain. Initially, that value chain extended from agriculture to chemistry. More and more, Congress attendees have sought to expand the view of the value chain to include consumer product manufacturers. The World Congress started small but has grown right along with the biobased economy and it now boasts over 1,150 attendees.

Another indication of the growth of the biobased economy is the number of press articles and publications in the space. Media coverage has grown steadily over the years, but it was clear early on that we needed a new publication that focused solely on industrial biotech. So, many years ago, I had lunch with the publisher of Genetic Engineering & Biotechnology News, Mary Ann Liebert, to discuss the creation of a new publication focused on industrial biotechnology. We both agreed the time had come to start such a publication, as industrial biotech was really taking off. To her credit, Mary Ann saw the opportunity and acted on it, launching Industrial Biotechnology journal. Now, after much success and more than 10 years later, we are pleased to announce that Industrial Biotechnology is now the official journal of the BIO World Congress.

Policy Drivers for the Bioeconomy

Industrial biotechnology underpins the development of advanced biofuels, renewable chemicals, and biobased products. It also facilitates more efficient industrial bioprocesses, which are recognized by the federal government for reducing pollution at the source, conserving energy, and reducing greenhouse gas emissions. New technologies, including synthetic biology, are being developed within the industrial biotechnology sector.

One of the earliest policy successes for the industrial biotech sector was the 2005 adoption of the federal Renewable Fuel...
Standard (RFS), requiring the production and use of biofuels in the US to replace petroleum gasoline. Only 2 years later, Congress expanded the program to meet 20% of the nation’s transportation fuel needs—as much as 36 billion gallons per year by 2022—with more emphasis on advanced and cellulosic biofuels.

The RFS opens the US transportation fuel market to advanced biofuels, guaranteeing that if producers can generate the fuels, then American consumers will be able to use them. The aim of the program is both to reduce US reliance on foreign oil and to reduce the carbon intensity of US transportation. The RFS is the only congressionally authorized climate program; it has helped avert 31 million tons of CO₂ emissions since its inception, and could potentially save up to 2.5 billion tons of CO₂ by 2030. Further, the RFS creates jobs and promotes economic growth, particularly in rural areas of the US. It fosters innovation and attracts investment in a broad range of technologies, such as the aviation biofuels industry.

The RFS is the bedrock policy for the advanced biofuel industry, driving investment into research and development as well as new biorefinery construction and retrofitting of older infrastructure. The industry worked at a record pace to pilot new technologies for biofuels; the activity resulted in biorefinery demonstrations that produced a variety of new products. Under this successful policy, the US became the world leader in biofuel production, having attracted investment from around the world, most notably in commercial-scale cellulosic biorefineries.

But the bioeconomy is not just about biofuels. Renewable chemical platforms are being rapidly commercialized following the intense R&D efforts spurred by the RFS. Renewable chemicals also reduce greenhouse gas emissions, along with other pollutant emissions associated with supply, processing, and use of petroleum and petrochemicals. New energy crops are being improved, including switchgrass, miscanthus, sweet sorghum, and fast-growing trees. Algae have been studied both as a feedstock, a protein source, and a production organism, with applications in fuels, cosmetics, and even food.

Another policy success for BIO has been the Energy Title of the Farm Bill, first adopted in 2002, expanded in 2008, and reauthorized in 2014. The Energy Title programs support the development of biorefineries by improving new technologies’ access to financing from institutional lenders, by supporting farmers who grow new energy crops, and by leading the emergence of new markets for biobased products and renewable chemicals.

The Biorefinery, Renewable Chemical, and Biobased Product Assistance Program was first established in the 2002 Farm Bill, providing grants for the construction of biorefineries that primarily produce biofuels. In the 2008 Farm Bill, the program transformed into a loan guarantee program similar to other US Department of Agriculture (USDA) programs that work with lending institutions to make equity available in rural communities. This continues to be an important tool for securing investment in new biotechnologies that utilize agricultural...
feedstocks. The 2014 Farm Bill extended the program to support biorefineries that primarily or solely produce renewable chemicals. BIO is currently working with the USDA on rules to implement this expansion of the program.

The Biomass Crop Assistance Program came into being with the 2008 Farm Bill. It aimed to solve the problem for farmers who wanted to grow new energy crops to supply biorefineries that were planned or under construction, but could not make multiyear commitments and investments without some guarantee of a stable future market. Under this program, USDA helps match payments for delivery or establishment of new energy crops.

The Biobased Markets Program, now known as the BioPreferred program, was first established in the 2002 Farm Bill. It directed federal agencies and their contractors to purchase biobased products preferentially when they are available and cost competitive with petroleum products, providing federal leadership in opening the market place to new biobased products and renewable chemicals. When the program was expanded in 2008, USDA launched a voluntary testing and labeling program for biobased products, certifying and advertising their renewable content. The 2014 re-authorization of the program strengthened federal reporting for compliance with the preferential purchasing requirement.

### Expanding Economic Opportunities

The goal of the federal programs has always been to assist industrial biotech R&D efforts and to provide market space for biorefining to establish a foothold in the US economy. The benefits for the US are increased economic opportunities, particularly for rural communities, and improved environmental health. Recently, the USDA Office of the Chief Economist commissioned a study, which was prepared by Nexant, to estimate the potential market size for US biobased chemicals and materials and their competitiveness in the world market; assess the competitiveness of biobased products versus traditional petroleum products; and evaluate the sector as an engine for growth and job creation.

Nexant’s report, “Renewable Chemicals and Materials Opportunity Assessment,” projects a market potential of 3.2 million metric tons within the US by 2022, with the bulk coming from specialty oils and C2 chemicals. Those C2 chemicals could be displaced by natural gas, which has become plentiful in the US in recent years, or they could come from the infrastructure already in place for ethanol. Aromatics also offer significant growth potential, particularly if automakers or the US Environmental Protection Agency (EPA) demand cleaner, healthier alternatives for these fuel ingredients.

By 2017, the Nexant report foresees the potential of $775 million of value added per year for renewable chemicals within the US market. Achieving this level of production would require a capital investment of $2.4 billion, a tall order for a US economy that is still struggling to sustain growth. But the economic incentive exists, since the timeline till payback of the capital investment is only slightly more than 3 years. Similarly, Nexant predicts that by 2022 the value-added potential will grow to $3 billion per year, with a required capital cost of $6 billion. The timeline for paying back the original capital investment accelerates to 2 years.

Biorefining appears to have a firm foothold in the global economy, with multiple new technologies for producing renewable chemicals reaching commercial status. In the global market, Lux Research estimates that past rapid growth of biorefining will enable an expansion of global production capacity of renewable chemicals in the next few years. In 2013, global production capacity reached 6.9 million metric tons. With relatively small growth in the number of facilities, capacity will nearly double to 13.2 million metric tons by 2017. By 2021, the global market for biobased chemicals alone is expected to increase to $12.2 billion, accounting for 10.9 million metric tons of biorefining production.

Consumer demand for renewable goods and the economic competitiveness of biorefining compared to petroleum refining are beginning to pull the market for new biotechnology applications. Global brand owners, such as US-based Coca-Cola and France-based Danone, and leading retailers, including UK-based Marks & Spencer and France-based Carrefour, have become large end-users in the renewable chemicals value chain. Some view replacement of petroleum products with renewable materials as part and parcel of their sustainability initiatives, launched in response to consumer demand.

In response, partnerships have already formed between large, well-established chemical companies and small biotech startups. Some of the largest chemical companies have made major commitments to the field, including DuPont and DSM. BASF, Ajinomoto, and Mitsui are all currently pursuing biobased production. Others, such as Cargill and Dow, have a long history in industrial biotech partnerships.

The driving forces for continued expansion of the biotechnology industry have grown from government policy and environmental necessity to include economic competitiveness and consumer demand. The mission for BIO’s Industrial & Environmental Section over the next 15 years will be to harness those driving forces to continue commercialization of new technologies.

### Conclusions

Just as the growth of BIO’s Industrial & Environmental Section has mirrored the emergence of the biobased economy, I expect that the next 15 years will see the full development of both our membership and the sector, drawing in more companies along the biobased economy value chain. Our vision is one in which large-scale biorefineries are constructed to produce multiple products, not just fuels. But beyond that we see synthetic biology driving a new wave of innovation and industrial biotech steadily increasing the number of applications in a myriad of manufacturing sectors. Future economic opportunities will be driven by consumer trends and the economies of scale for biorefining, but BIO will continue to fight for the policy support necessary to fund R&D and to ensure access to markets. Progress will not come without some challenges. But if the scientists, companies, and associations stay involved and constructively engaged with the public and policy makers, the future looks very bright.

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