IB INSIGHTS: 10th Anniversary Special Report

Building a Sustainable Supply Chain for the Biobased Economy

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Introduction

For well over a decade, the industrial biotechnology industry has been working to develop technologies to make industrial processes and products more eco-efficient, to do more with less. The result has been enzymes that reduce industrial process steps, save energy, and eliminate end-of-pipe waste emissions; biochemicals that replace petrochemicals or deliver new functionality and performance; and bioplastics that replace the use of petroleum in things like automobile parts, fibers, films, food containers, and beverage bottling. In all of these applications, biotechnology enables the use of renewable raw materials to reduce the carbon intensity of products in everyday use.

These innovations have led policy makers around the world to endorse the development of the biobased economy. From President Obama to the European Union to the government of Malaysia, all have issued policies to promote the biobased economy as a way to combat climate change, strengthen agricultural economies, and spur innovation and investment. Policy-maker support is helpful of course, but the biobased economy is growing largely without incentives or policy support. Companies are collaborating based on mutual commercial interest. Technology developers and consumer packaged goods companies are teaming to de-risk technology and scale it up. With these new markets, other considerations–namely consumers' high expectations for sustainable products–have come to the forefront.

A successful biobased economy can help reduce dependence on oil. But if it is to depend on agricultural raw materials, then it needs to do so without impinging on nature, food security, or water availability. To realize its full potential, the industrial biotechnology sector needs to establish its sustainability credentials definitively and in a straightforward way. It is no longer possible to do so on an individual company basis. The whole industry has a responsibility to take an active role in providing a path to a sustainable biobased economy.

Building the Foundation of a Biobased Economy

REPLACING PETROLEUM WITH BIODERIVED PRODUCTS

Since the Organisation of Economic Cooperation and Development (OECD) published its landmark survey and case studies of applications of biotechnology to industrial sustainability in 2001, a number of life cycle assessments (LCA) have been performed. The following two examples demonstrate the great potential for reducing greenhouse gas (GHG) emissions. Novozymes (Bagsvaerd, Denmark) and others have developed advanced detergent biocatalysts (enzymes) that clean clothes at much lower wash water temperatures. Novozymes published an LCA showing that by reducing wash water temperatures 15 degrees from 100°F to 85°F, energy consumption for washing could be reduced 30%. Another example is DuPont's (Wilmington, DE) Bio-PDO™, a polymer that can be used in a wide array of products from cosmetics to anti-freeze to carpet and clothing fiber. Producing Bio-PDO™ from carbohydrates consumes 38% less energy and emits 42% fewer GHG gas emissions compared to petroleum-derived propanediol or propylene glycol.

Other chemicals currently made from petroleum can now be replaced with bioderived alternatives, including the following:

- Acrylic acid–in a range of products and applications including textile fiber, coatings, paints, cosmetic formulations, and super absorbent material used in baby diapers;
- Polymers–including polypropylene, polyethylene, polylactic acid, polyamide, and polyethylene terephthalate (PET) can be used in countless automotive, building, industrial, and consumer applications;
- Succinic acid and butanediol–both platform molecules that can be used in numerous products, such as spandex

NEW VALUE CHAINS, NEW CHALLENGES

New biobased products have brought new customers. In fact, an entire new value chain has emerged. When you replace fossil resources with renewable resources, you replace the oil well with a farm or a forest, and the petrochemical value chain with the biobased value chain. New value chains are disruptive by their very nature. They bring together players that are unaccustomed to working with each other. New value chains also collide with the regulatory, trade, and policy frameworks constructed for the incumbent (petroleum) technology. Leading companies in new value chains respond to these precompetitive challenges by building multiparty initiatives to tackle them. One of the principle challenges facing the biobased economy is the sustainability of the upstream feedstock supply.

SUSTAINABILITY CRITERIA, CERTIFICATION & CONTINUOUS IMPROVEMENT

Multiple sustainability criteria and sustainability schemes have been proposed for different feedstock sources, and each has

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its strengths and weaknesses. The International Energy Agency's (IEA) bioenergy strategic study group, an international body of independent experts, has prepared several reports on sustainability certification and a separate summary of the work.[1] Key findings and recommendations from the IEA report ''Monitoring Sustainability Certification of Bioenergy'' are of value[1]:

- Policies and regulations should take into account how markets operate and evolve. Development of an international framework could help bring coherence between various country and industry specific requirements
- Certification schemes can serve as alternative tools for ensuring the sustainability of biomass where clear regulatory frameworks do not exist
- Companies seek certification to meet regulatory requirements or to gain market access and select schemes based on company strategy, structure, and market position. Scheme credibility is a key selection criterion. Compliance with the International Social and Environmental Accreditation and Labeling Alliance (ISEAL) and similar organizations is a valuable guiding principle. Certification schemes should be developed in a multiparty stakeholder process with open dialogue and transparency
- Competition among schemes may lead to efficiency and effectiveness improvements but may also lead to confusion in the marketplace. Schemes should balance comprehensiveness with the economic and administrative burdens of implementation

Another important document comparing various certification schemes was published by the World Wildlife Federation (WWF) in November 2013: ''Searching for Sustainability. Comparative Analysis of Certification Schemes for Biomass Used for the Production of Biofuels.''[2] While the analysis focuses primarily on compliance with the Renewable Energy Directive (RED) in the European Union, it is informative and points to the challenges faced by companies in the biobased economy.

THE BIGGER PICTURE

The petroleum-based economy brings climate change, concentration of wealth and power in petroleum-rich nations, international conflict, military confrontations, corruption in many countries, and catastrophic industrial accidents, among other ills. Born in the mid-19th century, the petroleum-based economy grew alongside, and indeed nourished and fostered the modern age. The biobased economy, in contrast, was born of life science technology advances of the late 20th century when problems unknown to oil pioneers had become apparent. The petroleum industry historically has avoided dealing with its externalities. The biobased industry cannot.

Unlike the exploitation of fossil fuels with unavoidable negative impacts, it is possible to utilize renewable raw materials sustainably. But, success depends on functioning ''commons'' and system thinking. Agriculture is an ancient art with ever-advancing practices and improvements in crop varieties and yield. Creating a successful biobased economy will require a focus on ways to reduce the carbon footprint of production agriculture while making it more sustainable across several dimensions.

SUSTAINABLE AGRICULTURE

Fortunately, in the United States, a significant multi-stakeholder process is underway evaluating this very issue, the Field to Market Alliance for Sustainable Agriculture. The non-profit Keystone Center of Colorado launched Field to Market in 2009 to engage the complete supply chain for six commodity crops including corn and soy. Major stakeholders include many nongovernmental organizations (NGOs) and conservation groups. They gathered over a 3-year period and agreed to a list of key performance indicators of sustainable performance on the farm. They have published baseline performance indicators of sustainable practices. Field to Market has also developed a sophisticated online tool to help growers visualize the environmental impact of farm management practice decisions. The *FieldPrint Calculator* allows an individual grower or groups of them to enter input output data on a field-by-field basis. Performance is plotted in various ways to visualize the field's specific environmental footprint. Different management practices, like conservation tillage and nutrient management scenarios, can be modeled and compared. Field to Market aims to help production agriculture achieve long-term and continuous improvement in ecosystem efficiency by engaging the entire supply chain. The baseline performance indicators for corn are shown in *Figure 1*.

Applying best management practices to agricultural production can reap large benefits in ecosystem efficiency and GHG reduction. A recent study conducted by the University of Minnesota and Colorado State University confirmed that using best corn production practices can result in a crop with a very good carbon footprint.[4] The study analyzed 3 years of farm level data from over 40 family farms in the Southwest Minnesota corn draw area. The researchers modeled the effect of key management strategies on the net carbon footprint of corn grown on the farms. Thousands of scenarios were compared to determine the optimum set of practices. The study found that disciplined application of fertilizer at the optimum rate would reduce carbon emissions by 46% over current average practices. By the addition of conservation tilling these farms would sequester carbon in the soil at significant rates (*Fig. 2*).

COMPETITION FOR LAND AND FOOD

As we look to an expanding biobased economy, one issue to keep in focus is the use of land and the need to produce sufficient food for growing populations. Since 2008 there has been sustained criticism on the impact of biofuel expansion on deforestation and the conversion of virgin landscapes. A seminal analysis used general equilibrium models to predict that as more acres were used for biofuel crops an equivalent or larger number of virgin acres somewhere else in the world would be brought into food production to replace them.[5] This international indirect land use change (ILUC) factor became enshrined in government policies generally ascribing a negative (penalty) to biofuels' positive GHG balance compared to petroleum. Since 2008, expert debate has improved understanding of ILUC impact considerably, although regulation has been slow in adjusting the ILUC penalties in many biofuel policy regimes.

A summary article by Biomass Research of Wageningen, The Netherlands, looked at the land use change and crop production data in 34 countries between 2000 and 2010.[6] These countries

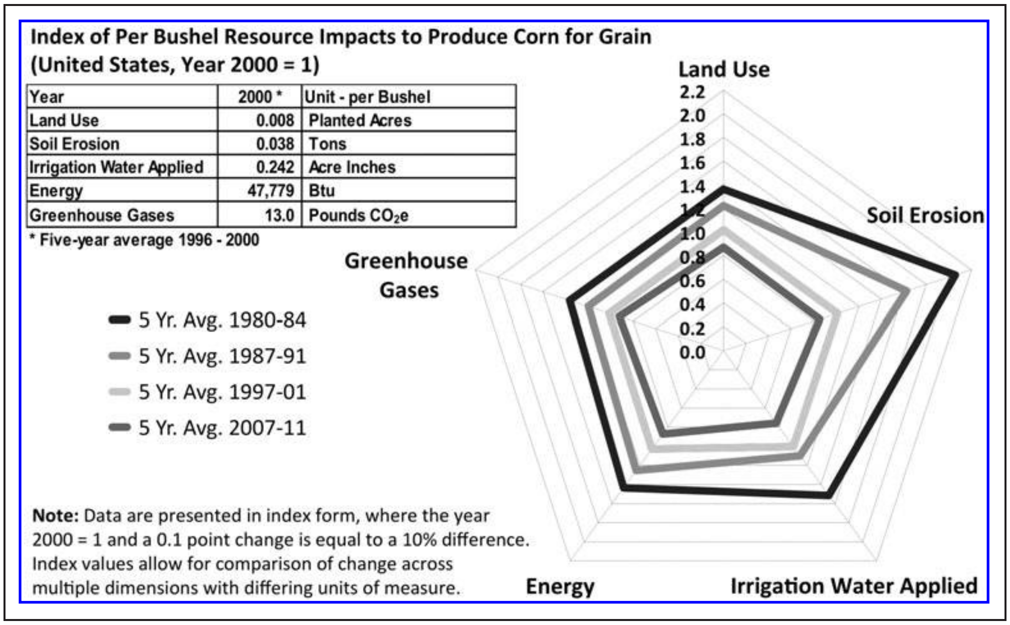

Fig. 1. The footprint of corn production has been steadily improving.[3]

represented nearly 90% of global biofuel production. In contrast to the projections based on the equilibrium model, the study found that urbanization, infrastructure development, and other factors were stronger drivers of land use change than biofuels. The study also found that yield intensification and double cropping more than compensated for the land devoted to biofuel production.

A study in late 2012 published in the journal *Population and Development Review*, reported on the impact of agricultural innovation, affluence, diet, and population on arable land and nature.[7] The authors looked at World Bank and Food and Agriculture Organization of the United Nations (FAO) reports and found considerable cause for optimism. The authors found that over the last 50 years, the amount of land devoted to food production had remained stable in spite of population growth and increased global wealth. Indeed, the authors predicted that the amount of arable land devoted to food production has already peaked, including the production of biofuels from the same land.

Two recent developments are making the discussion about land use change and deforestation much more concrete–much less reliant on models and more on direct observation and action. Early in 2014, a partnership convened by the World Resources Institute including Google, United Nations Environment Programme (UNEP), the University of Maryland (College Park, MD), the Jane Goodall Institute (Arlington, VA) and other academic, NGO and intergovernmental (IGO) participants launched the Global Forest Watch (GFW.) GFW uses satellite imaging, government, NGO and other data sources to prepare global maps to show actual, real-time changes in forest cover around the world. Stakeholders around the world can now see for themselves how the forest cover around the world is changing. Hopefully, this will lead to greater action to preserve the world's forests.

In June 2014, the Union of Concerned Scientists published a report sharing success stories of real progress around the world.[8] Finding the pace of deforestation has declined 19% this decade, the report looks at successful efforts to halt deforestation in countries in Central and South America, Africa, and Asia. In several countries, forest restoration has begun. The report shows how global concern combined with local action can make a huge difference.

BIO's View

The Biotechnology Industry Organization (BIO, Washington, DC) believes abundance is possible if our natural resources are managed thoughtfully and systematically, innovation is allowed to flourish, and stakeholders are engaged and competing interests balanced for the greater good (see Appendix: Draft BIO Policy on Sustainable Feedstock Supply). BIO established a task

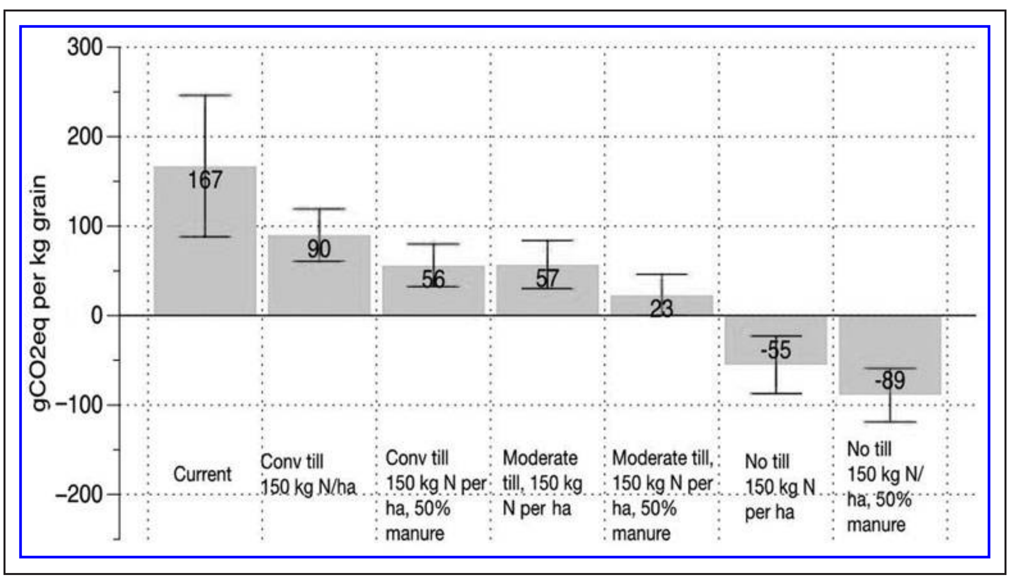

Fig. 2. Average net carbon footprints of surveyed farms as a function of tillage, nitrogen usage rate and animal manure utilization. Error bars represent one standard deviation from the mean value.[4]

force of its Climate, Sustainability, and Feedstock Working Group to help its members address these big challenges. The BIO Industrial and Environmental Sector (IES) Sustainable Supply Chain Task Force was formed to consider how member companies could satisfy demands for sourcing feedstock that would meet high expectations for sustainability. The Task Force work plan called for a high-level assessment of the current situation and the development of recommendations for delivery to the Governing Board intended for priority action as part of the 2014 strategic plan.

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Appendix

Over the past 15 years, progress in life science technology and in agricultural production systems has made it possible to envision a future where renewable raw material feedstocks will replace fossil feedstocks in the production of chemicals and materials needed by society. This new industrial production system has been labeled the ''bioeconomy.'' Renewable raw materials and green chemistry form the basis of a biobased economy that will bring economic growth to rural areas and improved life cycle performance to industrial production.

The challenges facing the biobased economy from the sustainability of the upstream feedstock supply was the main issue to be addressed by the BIO Task Force. It began its work by listing agricultural raw materials, principally carbohydrates and oils. The list included eight feedstock sources: corn, sugar cane, sorghum, dedicated energy corps, soy, sugar beets, cassava, and forest products. The Task Force reviewed the sustainability profiles of each feedstock source and a set of agreed upon certification schemes. Its assessment included a review of key performance indicators, tools used to quantify performance, level of stakeholder involvement, and membership in the International Social and Environmental Accreditation and Labeling (ISEAL) Alliance.

BIO reviewed the strengths and weaknesses of the Roundtable for Sustainable Biomaterials (RSB), International Sustainability and Carbon Certification (ISCC), Working Landscapes Certificate, Bonsucro, Council on Sustainable Biomass Production (CSBP), Forest Stewardship Council (FSC), Sustainable Forest Initiative (SFI), ISEAL Alliance, and Field to Market. The Task Force also investigated the multiplicity of issues surrounding certification schemes, including the rigor of stakeholder engagement, governance structure, system design, performance indicators, third party audits, cost of compliance, and so forth. Of particular value in the process was reference material prepared by the IEA Bioenergy strategic study group.

Validating the sustainability of renewable raw materials has intrinsic value and is also important to a growing number of end-user customers who increasingly are demanding accountability along their supply chain, reflecting the consumer concern for lower GHG emissions and better environmental performance. BIO members seek to take an active role in determining how to assess feedstock sustainability in response to this downstream need. To further this goal, the Industrial & Environmental Section of BIO supports the following policy recommendations:

- BIO IES will be a catalyst for knowledge sharing and capacity building among its member companies and their external stakeholders and will maintain open dialogue with all parties, so as to understand many points of view
- BIO IES will support the dissemination and dispersion of information, technology, and best practices so that the benefits of innovation can be widely shared
- BIO IES member companies will be active supporters of efforts to bring continuous improvement to production agricultural feedstock suppliers that demonstrate the same commitment to sustainably produced feedstocks and, to the extent appropriate, feedstock suppliers should be evaluated on these parameters:
    - Performance indicators developed and endorsed by a wide spectrum of stakeholders

    - Robust sustainability schemes or industry best practices developed for continuous improvement in ecosystem performance
- BIO IES sees the value of certification in certain circumstances and recommends that its members engage their customers in search of schemes that meet the highest expectations for rigor, broad stakeholder buy-in, and credible governance systems. These attributes are usually possessed by certification schemes that are members of the ISEAL Alliance
- BIO IES member companies should use agricultural raw materials and feedstocks that are produced in a socially responsible and sustainable manner

BIO IES member companies are developing products that replace petroleum and bring new performance to consumer and industrial goods. The organization recognizes that it has a responsibility to engage the many stakeholders and initiatives now working to make agricultural production of biobased feedstocks more sustainable. In furtherance of that responsibility, the BIO IES Governing Board has discussed the draft policy regarding the sourcing of renewable raw materials. BIO member companies are encouraged to develop and implement voluntary practices and policies consistent with the statements and guidance set forth in this policy.

(Under BIO's bylaws and applicable antitrust law, BIO's individual member companies are not bound by Association policy. The application of specific policy provisions or recommendations to concrete situations is to be determined by each member company in its discretion and judgment, consistent with applicable law.)