Utilizing Biobased Chemistry to Enhance Economic and Environmental Performance

Welcome to OCAPP's on-line training outlining the outstanding environmental and economic benefits from utilizing renewable biobased chemistry. This training will emphasize the opportunities for both material substitution and possible new product designs/formulations for biobased feed stocks. Information in this presentation is for pollution prevention outreach purposes only and not an endorsement of any biobased product, process, formulation or organization.

"I believe the Great Creator has put ores and oil on this earth to give us a breathing spell ... As we exhaust them, we must be prepared to fall back on our farms, which are God's true storehouse and can never be exhausted. **For we can learn to synthesize materials for every human need from the things that grow."**

George Washington Carver (1864 - 1943)

The idea of utilizing biobased materials for commercial applications is not a new concept and extensive research exists for substituting renewable materials for limited natural resources.

As an agricultural chemist, Carver discovered three hundred uses for peanuts and hundreds more uses for soybeans, pecans and sweet potatoes.

Among the listed items that he suggested to southern farmers to help them economically were his recipes and improvements to/for:

adhesives, **axle grease**, **bleach**, buttermilk, chili sauce, fuel briquettes, **ink**, instant coffee, **linoleum**, mayonnaise, meat tenderizer, **metal polish**, **paper**, **plastic**, **pavement**, **shaving cream, shoe polish, synthetic rubber, talcum powder and wood stain.**

There are literally endless possibilities for commercial product formulations based on renewable feed stocks. In this particular case the feed stocks were utilized to increase soil fertility and increase the sustainability of the existing agricultural production systems.

Benefits of Biobased Products

- Renewable Raw Materials- properly managed (grown, harvested and processed) materials can be a sustainable source of products and energy.
- Lower Toxicity- biological materials generally are less toxic and are inherently biodegradable.
- Economically Advantageous- biobased products can be grown and processed close to their point of use. Non-renewable resources must be extracted and shipped from wherever they are found (many times this is hundreds or thousands of miles from their point of use)
- Job Creation- biobased products offer opportunities for both production and processing of locally produced materials.

The benefits of biobased products versus products based on non-renewable materials are numerous and increasingly well documented. The benefits above are but a few of the environmental and economic benefits of locally or regionally produced and manufactured biobased products. For Ohio the significance of stimulating economic growth and achieving environmental improvements to our air, land and water can not be overstated. Ohio has a unique opportunity due to a high number of logistical, agricultural and manufacturing assets to benefit greatly from embracing a biobased manufacturing strategy.

Biobased products have rapidly become an important market segment within a variety of manufacturing sectors. Specialization and sector awareness have become as a growing business opportunity. USDA has proposed the BioPreferred label to make purchasing biobased products more transparent. The BioPreferred℠ program aims to increase the purchase and use of renewable, environmentally friendly biobased products while providing "green" jobs and new markets for farmers, manufacturers, and vendors.

The BioPreferred program offers three major benefits: Climate Change Impact Reduction, Energy/Environmental Security, and Economic Development.

What is BioPreferred and what are biobased products?

The 2002 and 2008 Farm Bills established a biobased markets program to increase the purchase and use o biobased products. The program has two components:

- A preferred procurement program for Federal agencies and their contractors, and
- A voluntary labeling program for the broad-scale consumer marketing of biobased products.

USDA, the lead agency for this part of the Farm Bill, refers to the program as BioPreferred℠.

Biobased products are commercial or industrial products (other than food or feed) that are composed of biological or renewable agricultural materials or an intermediate ingredient or feedstock.

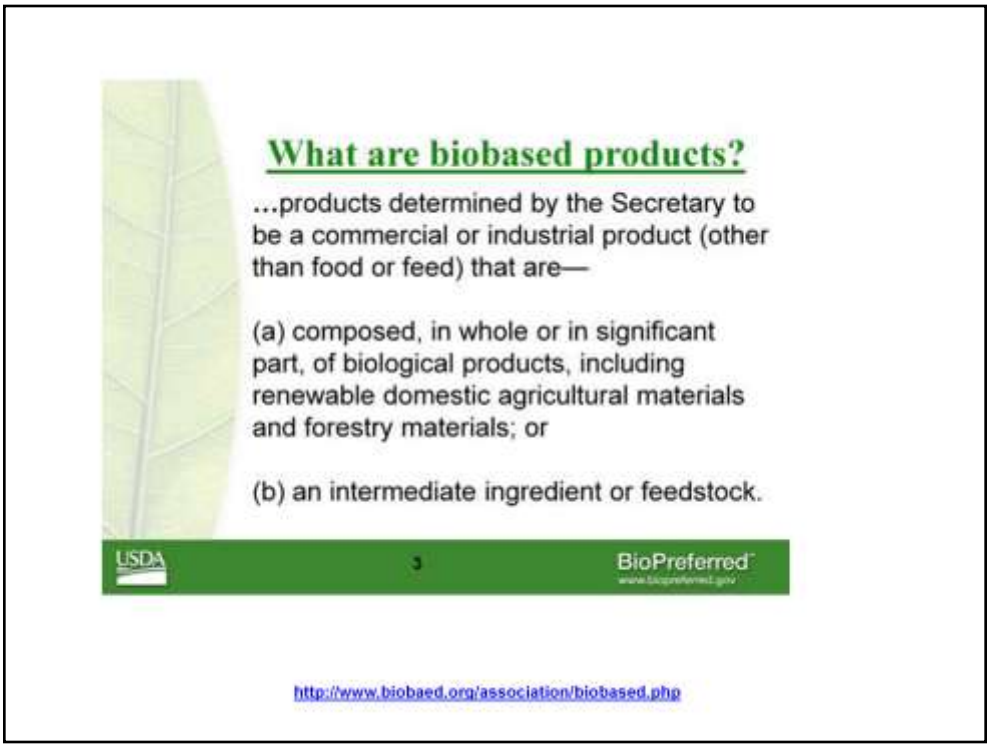
Why use biobased products?

When you use your purchase card to buy biobased products, you are helping your agency

- Increase our energy security and independence
- Spur economic development
- Improve our environment
- Comply with the law

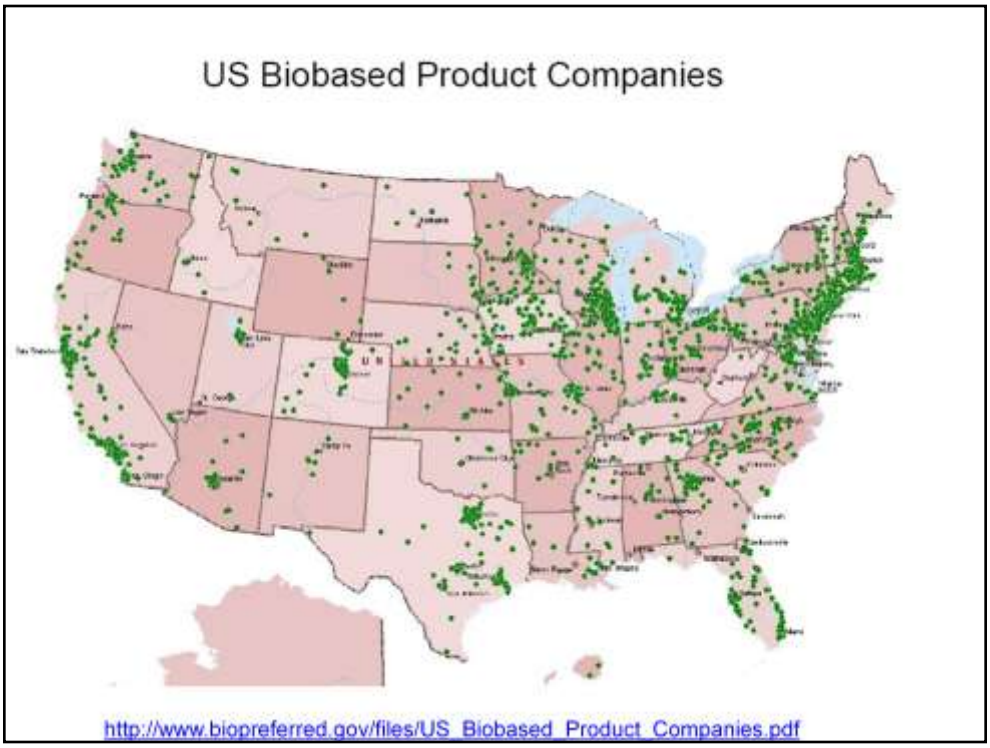
Purchasing biobased products promotes the use of renewable resources and helps manage the carbon cycle. Using biobased products as alternatives to petroleum-based products enhances our national energy security by reducing dependence on oil and natural gas. In addition, the increased demand for agricultural and forestry materials can help create new manufacturing activity and job formation. Many biobased products are environmentally friendly, and can help create safer, healthier workplaces.

Increasingly market segments are being defined that clearly prefer biobased materials over non-renewable materials. Past Executive Orders and, energy, national security and other Federal policies have opened opportunities for companies to create new products and modify existing designs/formulations to capture market share. For Ohio this may be an opportunity to capture market share for materials that were previously produced and processed far from our State.



Let us start off by generally defining what a bio-based product is. In general, a significantly high portion of the material composition should be of plant and or animal materials. The production, processing and transport of these materials in a sustainable manner should be a major component of maximizing the environmental and economic benefit of the product. Producing products that limit the future viability of natural systems would yield only nominal short term benefits.

Biobased products have continued to grow rapidly and have created opportunities for many start-up companies and new market segments for existing companies.



This map shows the locations of more than 2,200 companies in the United States that either manufacture or distribute biobased products. These vendors manufacture or sell products that (1) have already been designated for preferred Federal procurement via USDA's BioPreferred Program, and (2) are expected to be "BioPreferred designated" given future program implementation.

Source: Iowa State University, Center for Industrial Research and Service (CIRAS), October 2009.

ASTM test method D 6866-04

ASTM International Radioisotope Standard Method that USDA is requiring for determining and certifying biobased content, the term **"biobased content" is defined in this final rule as the amount of biobased carbon in the material or product as a percent of the weight(mass) of the total organic carbon in the product.** This calculation excludes all inorganic material in the product.

http://www.biopreferred.gov/files/03-31347.pdf

http://www.soybiobased.org/resources/meeting012904_ASTM_Briefing.doc

The percentage of biobased content in any organic portion of a product can be easily discerned.

Basis for the test method

Solar radiation causes some of the carbon in the atmospheric CO_2 gas to become a radioactive isotope known as C-14. Once captured, the C-14 carbon decays to the stable carbon isotope C-12. This is a slow process on human time scale; the C-14 content decreases by a factor of two for every 5000 years. However, when it reaches fossil age, which is measured in millions of years, there is no more C-14 isotope left in the carbon. Thus, we have a built-in time clock to differentiate, between biobased carbon (new carbon, and non-biobased (fossil) carbon and quantify the biobased content on a fraction mass (weight) or percent mass (weight) of the total organic material present. The test method measures the C-14/C-12 isotope ratio in the sample and compares it to the C-14/C-12 isotope ratio in a standard 100% biobased material to give percent biobased content of the sample.

Walmart

1-800-331-0085 www.walmartstores.com

Sustainable Product Index: Fact Sheet

On July 16, 2009, Walmart announced plans to develop a worldwide sustainable product index, which is expected to lead to higher quality, lower costs and measure the sustainability of products and help customers, live better in the 21st century. One of the biggest challenges we all face is measuring the sustainability of a product. Walmart believes a research-driven approach involving universities, retailers, suppliers and non-government organizations (NGOs) can accelerate and broaden this effort.

The Need for an Index

- The world's population is increasing.
  - It is estimated that the global population will reach 9 billion by 2050.
- The world's natural resources are decreasing.
  - Natural resources for everything we grow, eat, drink, make, package, buy, transport and throw away is outpacing the earth's capacity to sustain it.
- Customers want more efficient, longer lasting, better performing products. They want to know:
  - the materials in the product are safe
  - that it is made well
  - the product was produced in a responsible way

http://walmartstores.com/download/3879.pdf

Walmart has provided **more than 100,000 global suppliers** with a brief survey to evaluate their own companies' sustainability. The questions focus on four areas: energy and climate; material efficiency; natural resources; and people and community. The survey is a key step toward enhancing transparency in their supply chain. They asked their top-tier suppliers in the U.S. to complete the survey by **October 1, 2009**, and are working with the remaining suppliers to determine an appropriate timeline for them to complete the survey.

Step 1: Supplier Assessment

We will provide our more than 100,000 global suppliers with a brief survey to evaluate their own companies' sustainability. The questions will focus on four areas: energy and climate; material efficiency; natural resources; and people and community. The survey is a key step toward enhancing transparency in our supply chain. We asked our top-tier suppliers in the U.S. to complete the survey by October 1, 2009, and are working with our other suppliers to determine an appropriate timeline for them to complete the survey.

Step 2: Lifecycle Analysis Database
Second, we're helping create a consortium of universities to collaborate with suppliers, retailers, non-governmental organizations and government officials. The consortium will help develop a global database of information on products' lifecycles – from raw materials to disposal. We provided initial funding for the Sustainability Index Consortium and invite other retailers and suppliers to contribute. Arizona State University and the University of Arkansas will jointly administer the consortium.

Step 3: A Simple Tool for Customers
The final step of the index is to provide customers with product information in a simple, convenient, easy to understand manner so they can make choices and consume in a more sustainable way. This will provide customers with greater transparency into the quality and history of products than they have today.

http://walmartstores.com/Sustainability/9292.aspx

The worldwide sustainability index initiative was created as part of Walmart's ongoing mission to be a more sustainable company. Increasingly, customers want products that are more efficient, last longer and perform better. They want to know the product's entire lifecycle. They want to know the materials in the product are safe, that it is made well and is produced in a responsible way.

With this initiative Walmart is creating a more transparent supply chain, driving product innovation and ultimately providing customers with information to assess products' sustainability.

Energy and Climate: Reducing Energy Costs and Greenhouse Gas Emissions

1. Have you measured your corporate greenhouse gas emissions?

2. Have you opted to report your greenhouse gas emissions to the Carbon Disclosure Project (CDP)?

3. What is your total annual greenhouse gas emissions reported in the most recent year measured?

4. Have you set publicly available greenhouse gas reduction targets? If yes, what are those targets?

Material Efficiency: Reducing Waste and Enhancing Quality

1. If measured, please report the total amount of solid waste generated from the facilities that produce your product(s) for Walmart for the most recent year measured.

2. Have you set publicly available solid waste reduction targets? If yes, what are those targets?

3. If measured, please report total water use from facilities that produce your product(s) for Walmart for the most recent year measured.

4. Have you set publicly available water use reduction targets? If yes, what are those targets?

Natural Resources: Producing High Quality, Responsibly Sourced Raw Materials

1. Have you established publicly available sustainability purchasing guidelines for your direct suppliers that address issues such as environmental compliance, employment practices and product/ingredient safety?

2. Have you obtained 3rd party certifications for any of the products that you sell to Walmart?

People and Community: Ensuring Responsible and Ethical Production

1. Do you know the location of 100 percent of the facilities that produce your product(s)?

2. Before beginning a business relationship with a manufacturing facility, do you evaluate the quality of, and capacity for, production?

3. Do you have a process for managing social compliance at the manufacturing level?

4. Do you work with your supply base to resolve issues found during social compliance evaluations and also document specific corrections and improvements?

5. Do you invest in community development activities in the markets you source from and/or operate within?

These are the 15 questions asked for all Walmart suppliers, with the objective to build a life-cycle analysis database and ultimately provide data to consumers. Biobased feed-stocks, products and processes will become increasingly important to assist manufacturers in meeting green supply chain objectives.

THE WHITE HOUSE
Office of the Press Secretary
For Immediate Release October 5, 2009
EXECUTIVE ORDER

FEDERAL LEADERSHIP IN ENVIRONMENTAL, ENERGY, AND ECONOMIC PERFORMANCE

"advance sustainable acquisition to ensure that **95 percent of new contract actions** including task and delivery orders, **for products and services** with the exception of acquisition of weapon systems, are energy-efficient (Energy Star or Federal Energy Management Program (FEMP) designated), water-efficient**, biobased**, environmentally preferable (e.g., Electronic Product Environmental Assessment Tool (EPEAT) certified), non-ozone depleting, contain recycled content, or are **non-toxic or less-toxic alternatives**, where such products and services meet agency performance requirements;

The tradition of mandating that federal government both utilize and support environmentally preferable products and services continues with the executive order issued in October of 2009.

Michigan Green Chemistry Program

EXECUTIVE DIRECTIVE No. 2006-6

PROMOTION OF GREEN CHEMISTRY FOR SUSTAINABLE ECONOMIC DEVELOPMENT AND PROTECTION OF PUBLIC HEALTH

WHEREAS, "green chemistry" is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances;

WHEREAS, "green chemistry" can be an effective approach to **pollution prevention** because it applies innovative scientific solutions to real-world environmental situations;

1. Provide encouragement for **green chemistry research, development, demonstration, education, and technology transfer.**

2. Examine methods by which state government can create incentives for consideration and use of green chemistry processes and products.

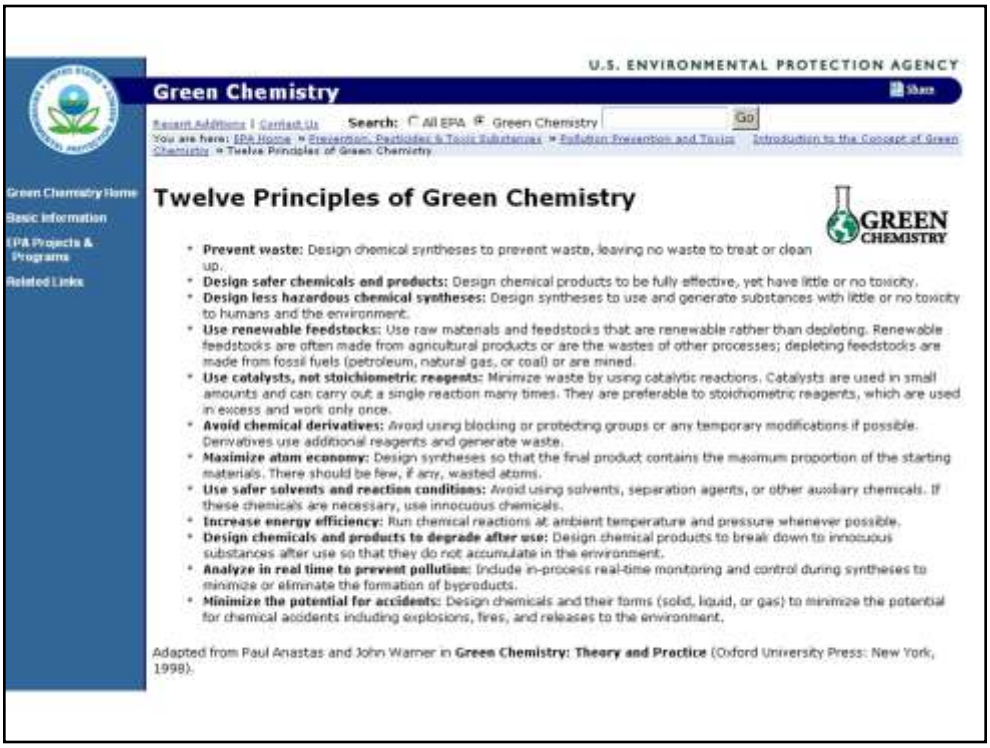
3. Facilitate the **adoption of green chemistry innovations in Michigan**.

4. Expand **education and training of undergraduate and graduate students, and professional chemists and chemical engineers in Michigan, including through partnerships with industry, in green chemistry science and engineering.**

http://www.michigan.gov/deq/0,1607,7-135-3585_49005-223016--,00.html

Our neighbors to the North have recognized the significance of Green Chemistry as an engine of economic progress that can help to stimulate new business opportunities.

The 1st Annual Michigan Green Chemistry Conference was held September 25, 2009 and brought together leading experts in the field of technology, chemistry, engineering, and business process improvement to inspire and inform Michigan business leaders to develop an infrastructure for advancing and sustaining green products and processes in the State of Michigan. The conference proceedings can be found at the link above and here: http://www.michigan.gov/deq/0,1607,7-135-3585_49005-223016--,00.html



U.S. ENVIRONMENTAL PROTECTION AGENCY

Green Chemistry

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You are here: EPA Home » Prevention, Pesticides & Toxic Substances » Pollution Prevention and Toxics Introduction to the Concept of Green Chemistry » Twelve Principles of Green Chemistry

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Twelve Principles of Green Chemistry

GREEN CHEMISTRY

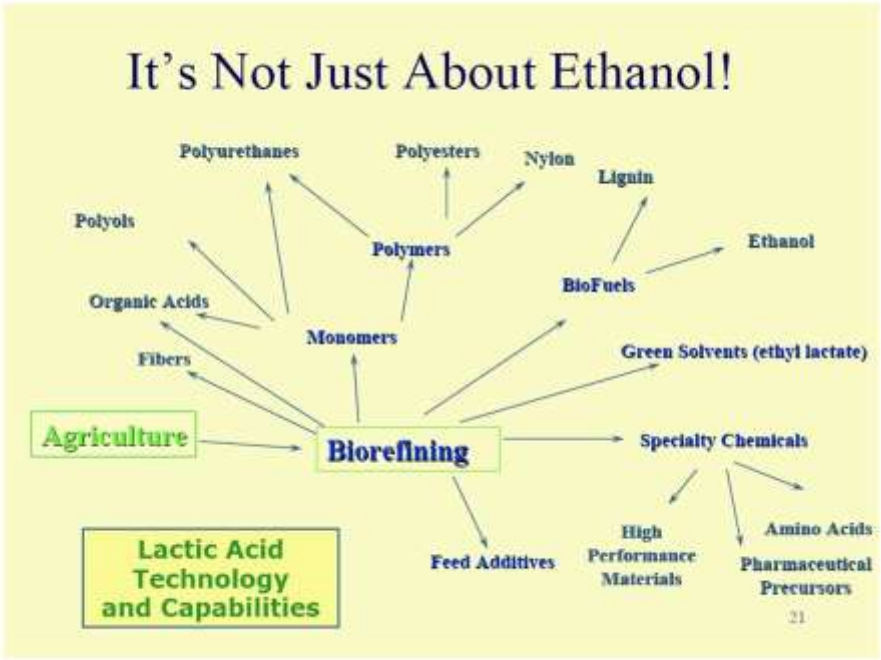
- **Prevent waste:** Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.
- **Design safer chemicals and products:** Design chemical products to be fully effective, yet have little or no toxicity.
- **Design less hazardous chemical syntheses:** Design syntheses to use and generate substances with little or no toxicity to humans and the environment.
- **Use renewable feedstocks:** Use raw materials and feedstocks that are renewable rather than depleting. Renewable feedstocks are often made from agricultural products or are the wastes of other processes; depleting feedstocks are made from fossil fuels (petroleum, natural gas, or coal) or are mined.
- **Use catalysts, not stoichiometric reagents:** Minimize waste by using catalytic reactions. Catalysts are used in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and work only once.
- **Avoid chemical derivatives:** Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.
- **Maximize atom economy:** Design syntheses so that the final product contains the maximum proportion of the starting materials. There should be few, if any, wasted atoms.
- **Use safer solvents and reaction conditions:** Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.
- **Increase energy efficiency:** Run chemical reactions at ambient temperature and pressure whenever possible.
- **Design chemicals and products to degrade after use:** Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.
- **Analyze in real time to prevent pollution:** Include in-process real-time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.
- **Minimize the potential for accidents:** Design chemicals and their forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

Adapted from Paul Anastas and John Warner in **Green Chemistry: Theory and Practice** (Oxford University Press: New York, 1998).

For biobased products to be considered effective replacements/substitutes or novel products they must conform to the principles of green chemistry as rigorously as any other derivative, extracted or synthesized material.

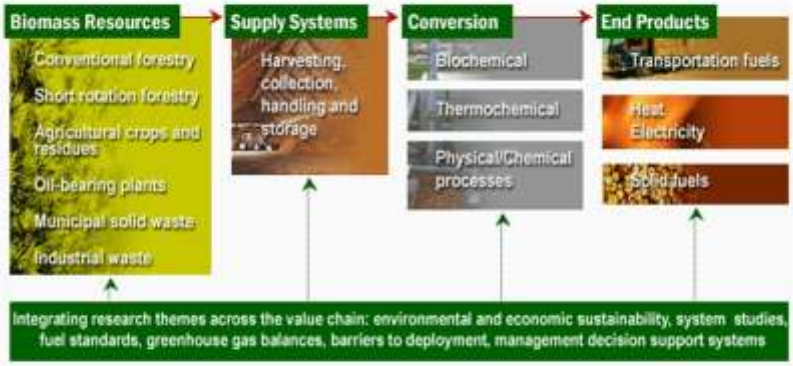
As fictional future Senator John “Bluto” Blutarsky may have so eloquently characterized----

Next Slide



It's Not Just About Ethanol !

The ongoing economic and public policy debates over the merits of ethanol production have largely overshadowed the actual significance of a systematic natural and manufacturing approach to effectively utilizing renewable resources. The advancement of agricultural, intermediate and final manufacturing technologies play integral roles in providing sustainable biobased alternatives to existing production and manufacturing systems. The above diagram is a small sampling of possible products and co-products of agricultural and biorefining processes.



http://www.ieabioenergy.com/OurWork.aspx

http://www.ieabioenergy.com/IEABioenergy.aspx

Current processes and on-going **global cooperative** research & development continually yield new business opportunities for economically and environmentally beneficial uses for materials that were previously considered "wastes". For many businesses these opportunities may change cost centers (waste costs) into profit centers (revenue producing products). IEA Bioenergy is an organisation set up in 1978 by the International Energy Agency (IEA) with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment.

The International Energy Agency was founded in 1974 as an autonomous body within the OECD to implement an international energy programme in response to the oil shocks. Membership consists of 25 of the 29 OECD member countries. Activities are directed towards the IEA member countries' collective energy policy objectives of energy security, economic and social development, and environmental protection. One important activity undertaken in pursuit of these goals is a programme to facilitate co-operation to develop new and improved energy technologies.

Activities are set up under Implementing Agreements. These are independent bodies operating in a framework provided by the IEA. There are 40 currently active Implementing Agreements, one of which is IEA Bioenergy.

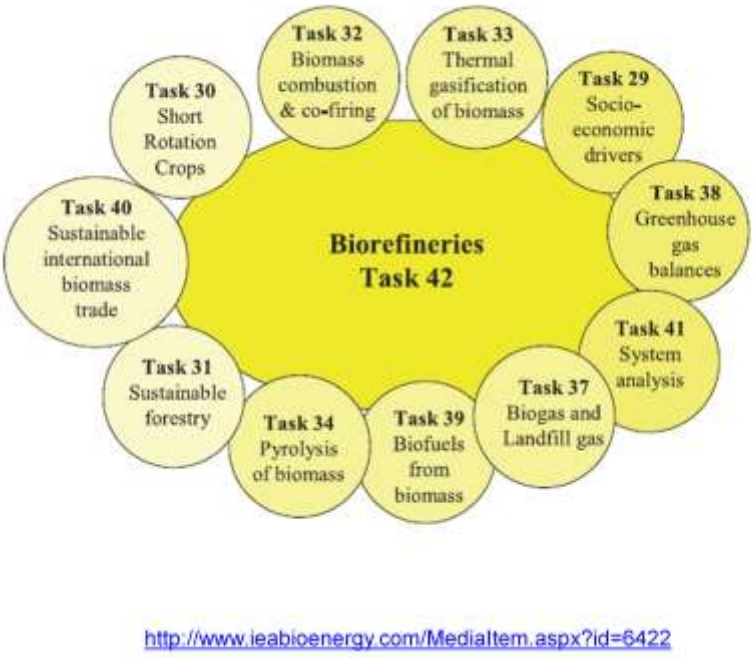
Bioenergy resources such as forestry and agriculture crops, biomass residues and wastes already provide about 14% of the world's primary energy supplies.

Bioenergy offers cost-effective and sustainable opportunities with the potential to meet 50% of world energy demands during the next century and at the same time meet the requirement of reducing carbon emissions from fossil fuels.

The ongoing Tasks and the recently discontinued Task are as follows:

Task 29 : Socio-Economic Drivers in Implementing Bioenergy Projects
Task 30 : Short Rotation Crops for Bioenergy Systems
Task 31 : Biomass Production for Energy from Sustainable Forestry
Task 32 : Biomass Combustion and Co-firing
Task 33 : Thermal Gasification of Biomass
Task 34 : Pyrolysis of Biomass
Task 36 : Integrating Energy Recovery into Solid Waste Management
Task 37 : Energy from Biogas and Landfill Gas
Task 38 : Greenhouse Gas Balances of Biomass and Bioenergy Systems
Task 39 : Commercialising 1st and 2nd Generation Liquid Biofuels from Biomass
Task 40 : Sustainable International Bioenergy Trade - Securing Supply and Demand
Task 41 : Bioenergy Systems Analysis
Task 42 : Biorefineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass

Implementing Agreement on Bioenergy, which forms part of a programme of international energy technology collaboration undertaken under the auspices of the International Energy Agency.
http://www.ieabioenergy.com/DirExco.aspx

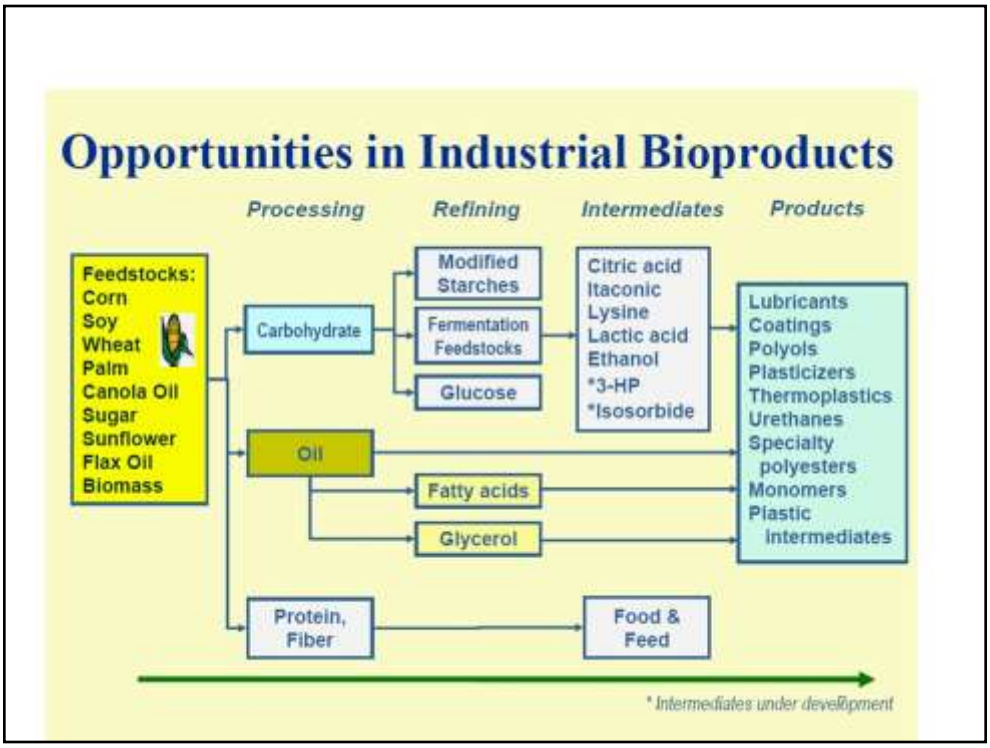


http://www.ieabioenergy.com/MediaItem.aspx?id=6422

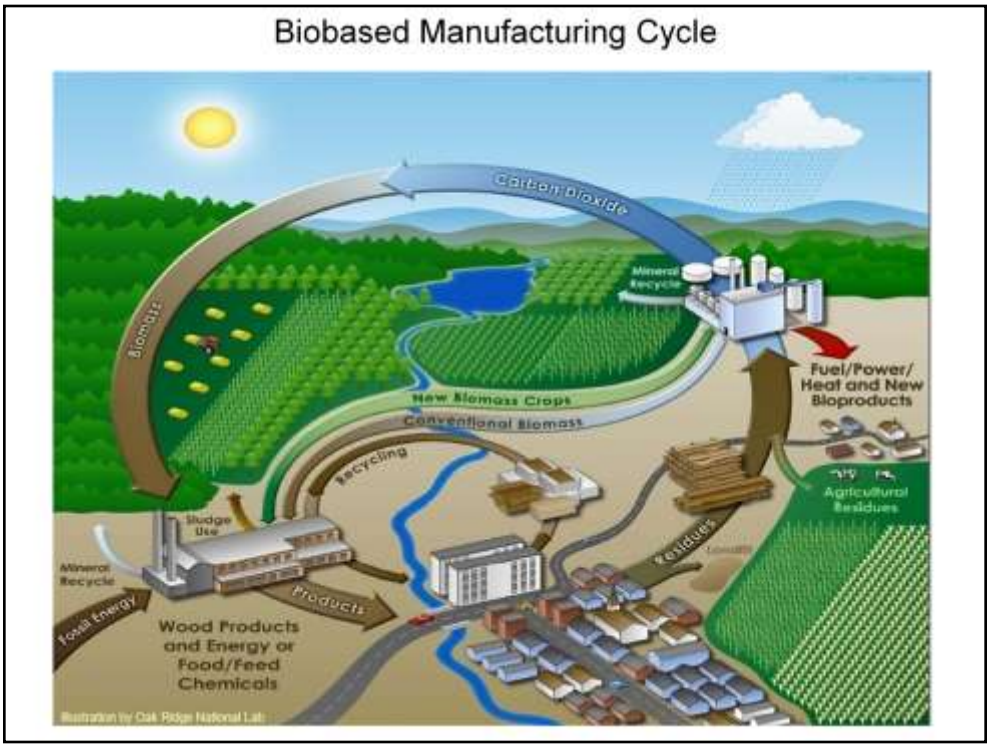
Schematic representation of the relationship of Task 42 to other IEA Bioenergy Tasks.

There is also strong co-operation between Task 42 and **national, international stakeholders and RD&D programmes, and the EU Technology Platforms.** The participants in Task 42 act as National Team Leaders for biorefinery technology knowledge transfer and reporting. The Task addresses issues such as:

• Biorefinery definition and biorefinery classification system.
• Country reports describing and mapping current processing potential of existing biorefineries in the participating countries, and assessment of biorefinery-related RD&D programmes to assist national governments in defining their national biorefinery policy goals and related programmes.
• Bringing together key stakeholders (industry, policy, NGOs, research) normally operating in different market sectors (e.g., transportation fuels, chemicals, energy, etc.) in multi-disciplinary partnerships to discuss common biorefinery-related topics, to foster necessary RD&D trajectories, and to accelerate the deployment of developed technologies.



Current production and processing technologies have identified numerous opportunities to utilize renewable, scalable, regionally local materials for non-renewable and increasingly scarce and costly materials. The list of potential future products based on renewable materials continues to grow at a rapid pace. This affords businesses a unique opportunity to take advantage of these materials ahead of competitors and seize economic and environmental benefits.



This representation of a production and manufacturing cycle based on renewable raw materials captures the concept of closing the loop on product inputs and outputs. A key component of this concept is the efficient utilization of materials and efficient processes to return nutrients back to the natural system. Energy and water components are also critical management issues in reaching a state of sustainable productivity.

Economic Development and Infrastructure –Inexorably linked

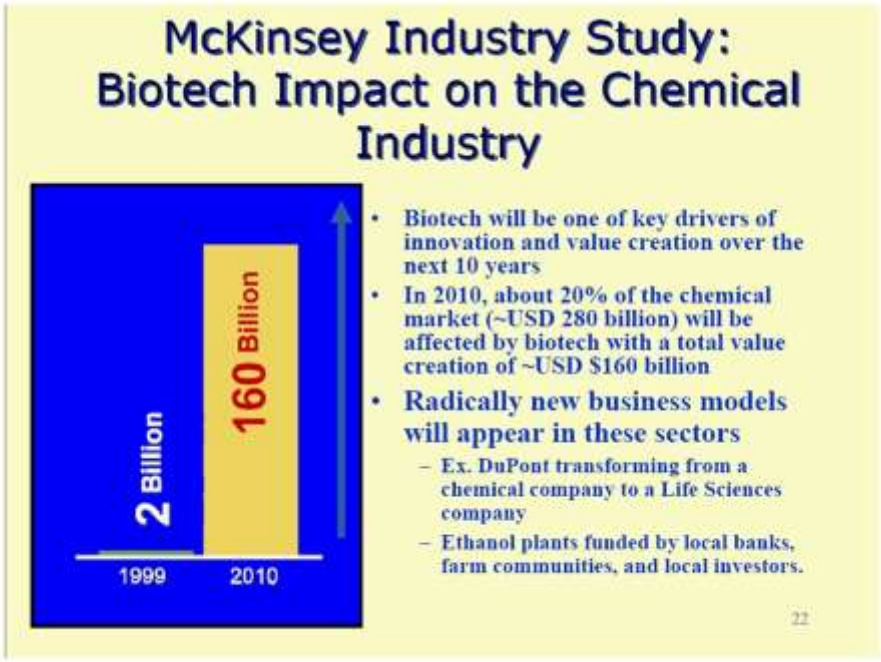
The Midwest has:

- The feedstocks
- The technology
- The best infrastructure – roads, rail, waterways, etc.
- The chemical industry infrastructure/distribution
- Agriprocessors and integrated biorefineries
- Grass roots locally supported ethanol dry mills

The Midwest needs:

- An engaged Financial industry (including Chicago)
- A supportive Political establishment throughout the Midwest
- An Analysis (e.g. impacts of cheap sugar markets vs advantages of scalable and efficient high tech manufacturing facilities near markets, incentives required, economic and technical requirements)
- A Plan (Perhaps at the Regional/Midwest level?)

Ohio is well situated to achieve multiple economic benefits from production, manufacturing, transportation, marketing and usage of biobased feed stocks and products. Ohio has unique opportunities in agricultural production, transportation infrastructure and manufacturing capabilities.



The impact of biobased materials on the market place is now at a critical strategy stage for the chemical industry. Advances in biotechnology are reshaping the landscape of alternative feed stocks. As process efficiencies increase and costs for these alternatives declines, changes to existing formulations and new products will rapidly develop. This provides unique opportunities for companies that strategically adapt and gain market share from companies that lag behind. Significant environmental cost savings are already being gained by companies that have taken this path.

Home > Healthcare > Biotechnology > General Biotech

U.S. Plant Biotech Impact: 2012 Business Analysis

Published Date: September 2003
Published By: Kline & Company, Inc.
Order Code: R379-0139

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Kline & Company, Inc., in collaboration with Doane Marketing Research, Inc., is pleased to announce the publication of the third edition of its syndicated service projecting the impact of plant biotechnology on the crop protection market. **BIOTECH 2012 BUSINESS ANALYSIS** is designed to forecast changes in market size, product market share, and major company market share in the U.S. agricultural chemicals sector, brought on by advances in agricultural biotechnology products.

Analysts at global accounting firm Ernst & Young estimate global biotech industry revenues for publicly-held companies at **$89.7 billion for 2008, a 12% increase from the previous year.** The firm also estimates that revenues of publicly-held biotech companies in the **U.S. rose 8% to $66.1 billion.**

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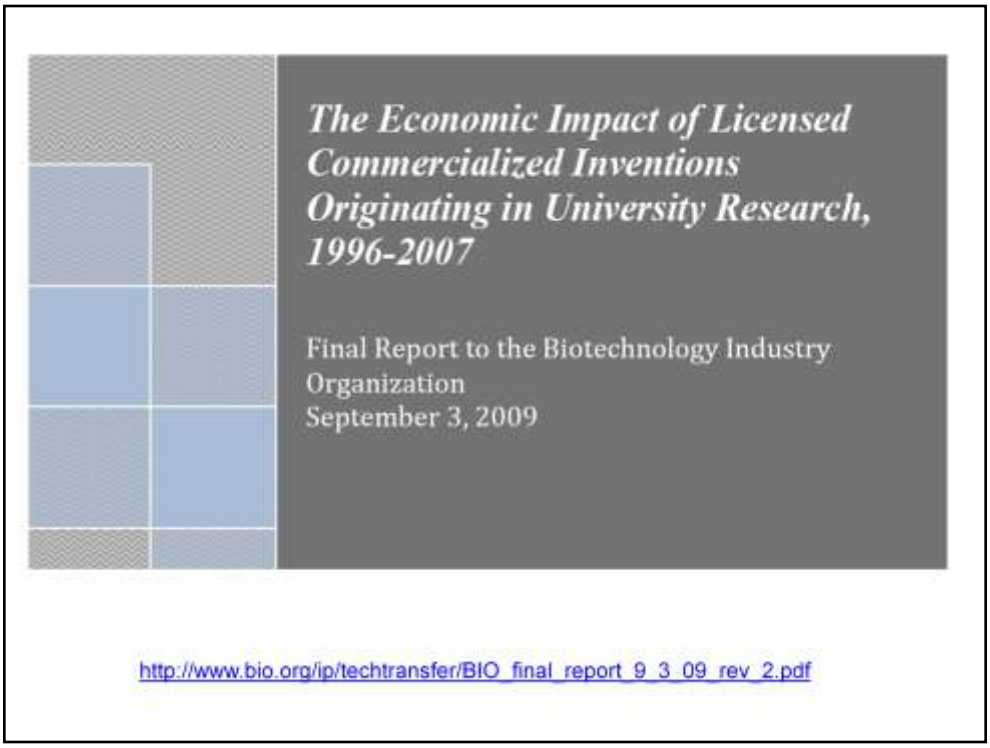
http://www.plunkettresearch.com/Industries/BiotechnologyDrugsGenetics/BiotechnologyDrugsGeneticsTrends/tabid/299/Default.aspx



Summing over the entire 12 years for which we have data, we estimate that the total contribution of university licensing to gross industry output at least $108.5 billion and as much as $457.1 billion (again without accounting for product substitution effects). A moderately conservative estimate based on 5% royalty rates yields an estimated impact of university licensing on total industry output over 1996-2007 of $195.6 billion.

OECD Biotechnology Statistics 2009

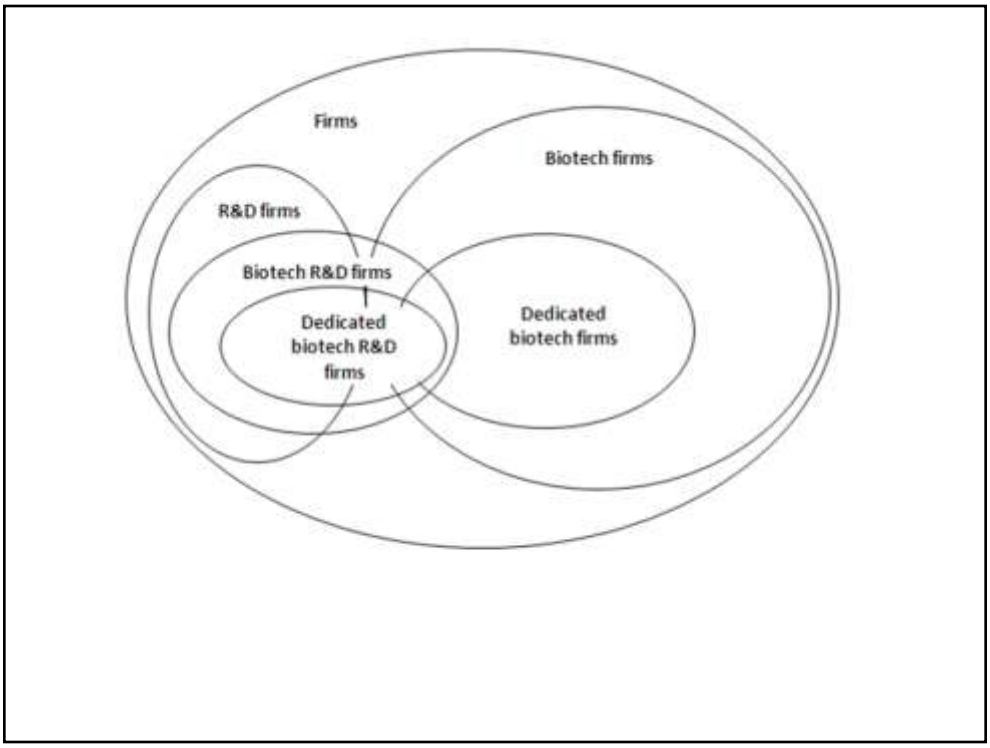
By Brigitte van Beuzekom and Anthony Arundel

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 30 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities takes part in the work of the OECD.

http://www.oecd.org/dataoecd/4/23/42833898.pdf



There are some significant difficulties in estimating the value of "biobased" economic value. There are many terms such as biotech, bio-science, and biobased as lables for various manufacturing, R&D and production/processing industries. Many businesses may have a biobased or renewable product, process or feed stock, but not be primarily a "biotech" company. For example DuPont has a goal to be 25% biobased in the near future, but they are not considered a "biotech" company.

Table 5.6. Sales by biotechnology R&D firms in million constant 2000 PPP$

		Biotech R&D active firms	Total sales	Of which Biotech sales	Biotech R&D per biotech firm	Biotech sales per biotech firm	% total R&D in total sales	% biotech R&D in biotech sales
			Million constant 2000 PPP$		Million constant 2000 PPP$			
Austria	2006	77	2 568.6	..	..	..	23%	..
Belgium	2006	136	7 595.9	3 761.9	3.750	27.661	13%	14%
Belgium (Flanders)	2007	50	2 822.4	660.5	10.813	13.211	55%	82%
Czech Republic	2007	82	..	..	0.872	..	..	..
Finland	2007	141	..	..	0.726	..	..	..
France	2003	755	..	..	1.611	..	..	..
	2004	796	..	..	1.653	..	..	..
	2005	720	..	..	2.539	..	..	..
	2006	824	..	..	2.453	..	..	..
Ireland	2005	100	..	..	2.529	..	..	..
Italy	2002	161	..	..	1.374	..	..	..
	2003	175	..	..	1.091	..	..	..
	2004	155	..	..	1.533	..	..	..
	2005	124	..	..	2.355	..	..	..
	2006	146	..	..	1.546	..	..	..
Korea	2002	510	..	2 374.6	0.732	4.656	..	16%
	2003	528	..	2 505.4	0.791	4.745	..	17%
	2004	596	..	2 857.9	0.798	4.796	..	17%
	2005	638	..	3 279.7	0.886	5.141	..	17%
	2006	627	..	3 745.9	1.032	5.974	..	17%
Norway	2005	173	..	..	0.669	..	..	..
Portugal	2005	52	4 745.1	..	0.219	..	1%	..
Slovak Republic	2005	27	..	..	0.967	..	..	..
	2006	27	..	..	0.405	..	..	..
Spain	2004	278	..	..	0.634	..	..	..
	2005	375	..	..	0.594	..	..	..
	2006	467	..	..	0.672	..	..	..
Sweden	2007	113	..	..	3.846	..	..	..
Switzerland	2004	156	..	..	2.792	..	..	..
United States	2004	2 582	290 639.4	..	6.223	..	9%	..
	2005	2 749	338 995.2	..	7.415	..	10%	..
	2006	3 301	474 968.4	..	6.517	..	8%	..

Sales by biotechnology firms in the United States is a significant portion of global activity in this sector.

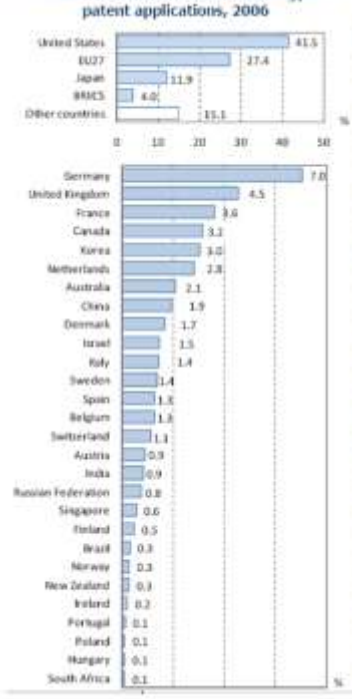


Table 7.1. Top 50 regions[1] in biotechnology PCT patent applications, 2004-2006

Region (Territorial Level 2)		Biotechnology patents	Share (%) in total
San Jose-San Francisco-Oakland	US	1 510	5.5
Boston-Worcester-Manchester	US	1 422	5.2
New York-Newark-Bridgeport	US	1 090	4.0
Washington-Baltimore-N Virginia	US	811	3.0
Tokyo	JP	792	2.9
San Diego-Carlsbad-San Marcos	US	782	2.9
Los Angeles-Long Beach-Riverside	US	613	2.2
Philadelphia-Camden-Vineland	US	597	2.2
Nordrhein-Westfalen	DE	506	1.9
Hovedstadsregionen	DK	454	1.7
Capital region (Seoul - Incheon - Gyeonggi-do)	KR	404	1.5
Ile de France	FR	376	1.4
Bayern	DE	370	1.4
Osaka	JP	359	1.3
West-Nederland	NL	351	1.3
Raleigh-Durham-Cary	US	336	1.2
Ontario	CA	302	1.1
Baden-Württemberg	DE	294	1.1
East of England	GB	282	1.0
Seattle-Tacoma-Olympia	US	281	1.0
Ibaraki	JP	248	0.9
South-East (England)	GB	246	0.9
Chicago-Naperville-Michigan City	US	235	0.9
Québec	CA	226	0.8
Houston-Baytown-Huntsville	US	219	0.8
Minneapolis-St. Paul-St. Cloud	US	213	0.8
Hessen	DE	209	0.8
London	GB	201	0.7
Berlin	DE	198	0.7
Vlaams Gewest	BE	196	0.7
Rhône-Alpes	FR	196	0.7
Kyoto	JP	186	0.7
Denver-Aurora-Boulder	US	186	0.7
Victoria	AU	176	0.6
Detroit-Warren-Flint	US	169	0.6
St. Louis-St. Charles-Farmington	US	162	0.6
Zuid-Nederland	NL	151	0.6
New South Wales	AU	150	0.6
Atlanta-Sandy Springs-Gainesville	US	148	0.5
Madison-Baraboo	US	144	0.5
Niedersachsen	DE	139	0.5
Chiba	JP	138	0.5
Beijing	CN	137	0.5
Chungcheong region	KR	134	0.5
Aichi	JP	128	0.5
Hyogo	JP	116	0.4
Stockholm	SE	116	0.4
Indianapolis-Anderson-Columbus	US	110	0.4

The U.S. far outpaces any other country in “new” patents for biotechnology. A few regions dominate the global activity. This represents a golden opportunity for Ohio and the greater Midwest region to become more active in biotechnology innovation and economic growth.

Madison Wisconsin- UW Biotechnology

Biotech Highlights:

257 biotech firms (broadly defined) employ over **10,000 people in the Madison Region, up 64% since 2000**

The Madison Region increased biotech jobs by 95% from 2000 to 2007, and grew from 22% of the jobs in the state to 34%. Wages also increased by 42%.

The Madison Region lead the state with 64% growth in 2007, making up 87% of the total statewide growth from 2000 to 2007, and up to 38% of the total statewide sector employment.

Biotech adds $1.74 billion to the regional economy, up 31.4% from 2003 to 2006, outpacing productivity growth in all other industries combined.

UW Master of Science in Biotechnology
- Launched in 2002 ,
- First and only in the U.S.
- Over 150 alumni/students
- 95% retention in WI

Wisconsin's investor tax credits law has been cited as a national model

http://www.thrivehere.org/media/documents/Sector_snapshots/BIO%20Sector%20Snapshot%20-%20FINAL%203-18-09.pdf

Biotechnology has been an important growth industry in neighboring states and offers a possible model for growth in Ohio.

Ohio BioProducts Innovation Center (OBIC)

The Ohio BioProducts Innovation Center (OBIC) is a new research initiative that integrates academia and industry toward the development of renewable specialty chemicals, polymers/plastics and advanced materials. The Center was funded in 2005 by the Ohio Department of Development through an $11.5 million Wright Center of Innovation (Third Frontier) award, leveraged with matching funds from external partners.

http://bioproducts.osu.edu/

Goals of Ohio BioProducts Innovation Center

Develop Novel Germplasms which have desired market traits along with required agronomic characteristics including adaptablity to biotic and abiotic stresses

Establish a critical bridge

- Agricultural and specialty chemical industries
- Genetic and chemical research capabilities

Accelerate commercialization

- Business / research linkage via “Cell to Sell” Pipeline
- Market-based research agenda

Increase jobs and economic growth/stability

- Research leveraged into biobased product sales
- Strengthen Ohio’s competitive position in biobased chemicals and materials

Catalyze Strategic Investments in Renewable Feedstocks and Value-Added Chemicals and Polymers

Work with Industry to Create New Value Chains for BioProducts

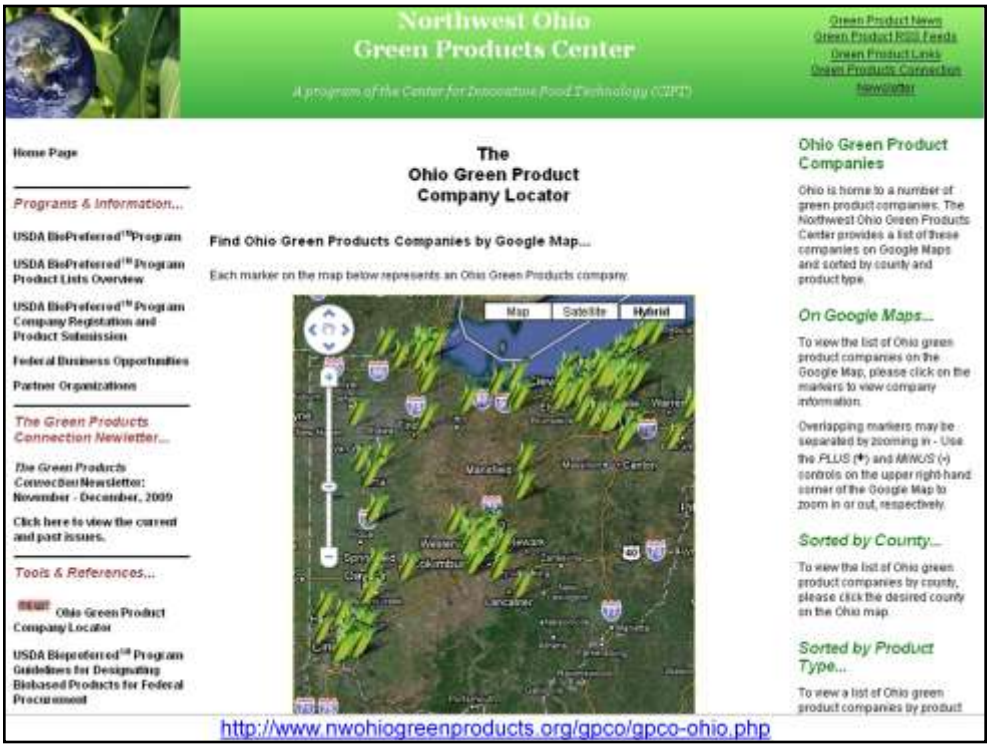
Leverage Platform Building Blocks/Chemicals to create a BioProducts Innovation Pipeline

Create Platform Technologies resulting in Value-Added BioProducts and BioProduct System Solutions

The mission of BioOhio is to accelerate bioscience discovery, innovation, and commercialization of global value, driving economic growth and improved quality of life in Ohio.

BioOhio, founded in 1987 as Edison BioTechnology Center and formerly Omeris, is a non-profit organization designed to build and accelerate bioscience industry, research, and education in Ohio.

As Ohio's bioscience membership and development organization, they are focused on networking the distributed and outstanding bioscience assets of Ohio to accelerate growth of a globally competitive bioscience industry.

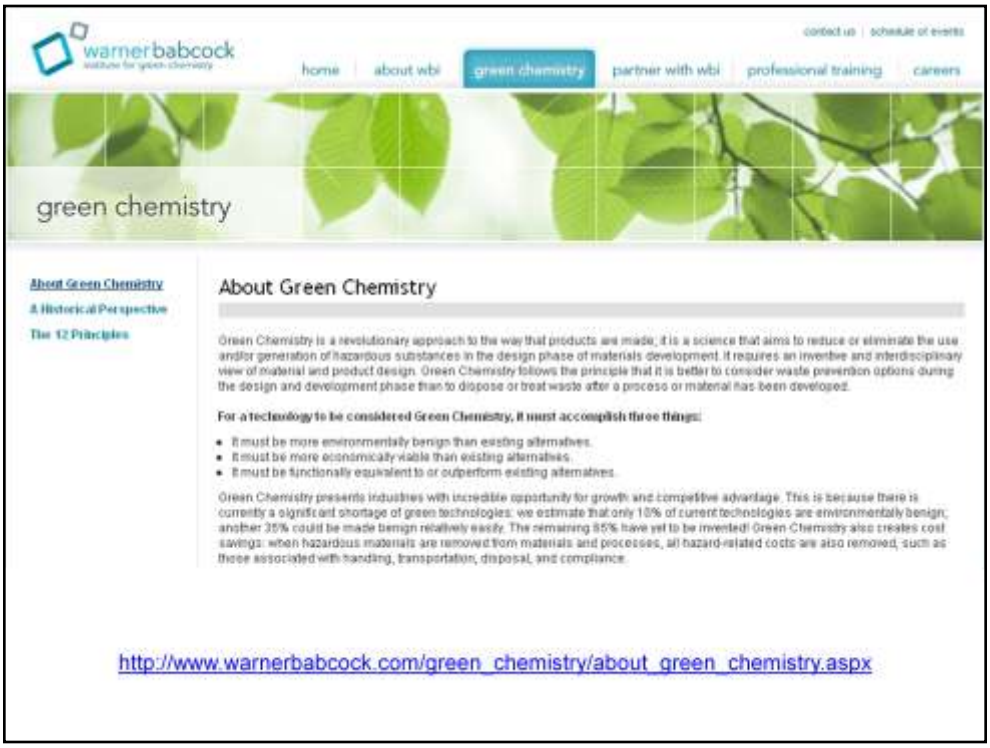


Ohio is home to a number of green product companies. The Northwest Ohio Green Products Center provides a list of these companies on Google Maps and sorted by county and product type.

Biobased Material Substitution

- Resins
- Polymers
- Coatings
- Lubricants
- Solvents
- Cleaners
- Green Building Materials
- Manufacturing Raw Materials
- Fuels

Many significant economic opportunities exist for Ohio companies to adapt existing manufacturing processes to produce and to utilize biobased materials and capture new markets for biobased products. Ohio companies can achieve additional environmental cost benefits by utilizing these materials to reduce their operating costs and their environmental, safety & health costs. Biobased products often have dramatic improvements in both environmental impact and worker exposure and safety.



For a technology to be considered Green Chemistry, it must accomplish three things: It must be more environmentally benign than existing alternatives.

It must be more economically viable than existing alternatives.

It must be functionally equivalent to or outperform existing alternatives.

Green Chemistry presents industries with incredible opportunity for growth and competitive advantage. This is because there is currently a significant shortage of green technologies: we estimate that only 10% of current technologies are environmentally benign; another 35% could be made benign relatively easily. The remaining 65% have yet to be invented! Green Chemistry also creates cost savings: when hazardous materials are removed from materials and processes, all hazard-related costs are also removed, such as those associated with handling, transportation, disposal, and compliance.

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2. It must be **more economically viable** than existing alternatives.

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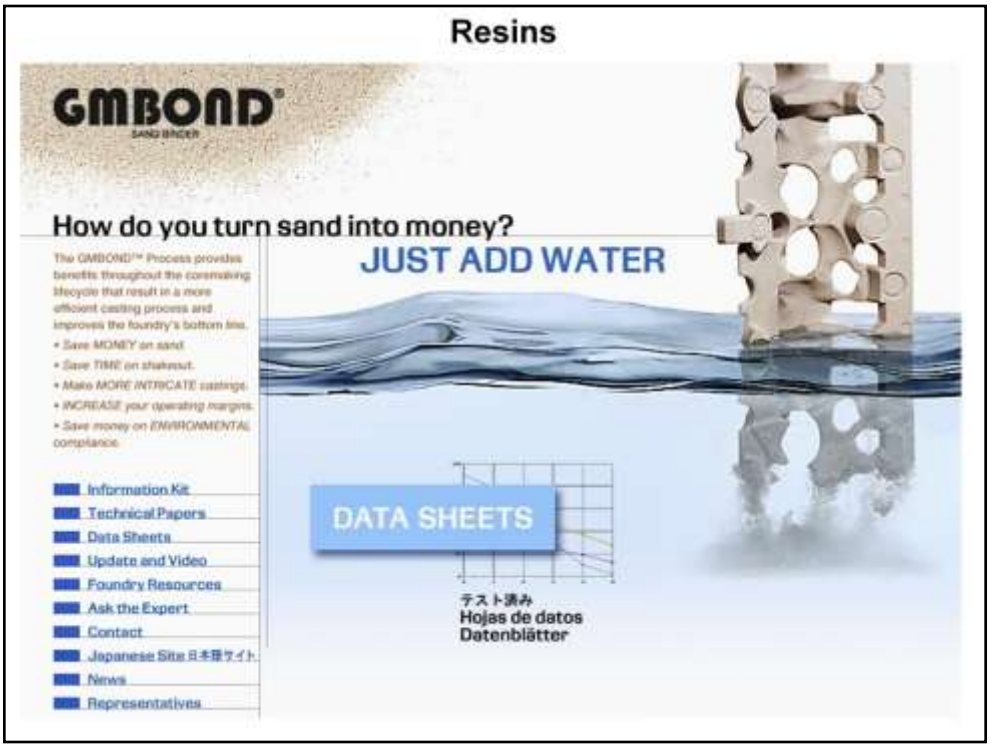
http://www.warnerbabcock.com/green_chemistry/about_green_chemistry.aspx

It must be **more environmentally benign** than existing alternatives.

It must be **more economically viable** than existing alternatives.

It must be functionally equivalent to or **outperform existing alternatives**.



A prime example of the multiple environmental and economic advantages that may be obtained by utilinzing biobased materials is biobased core/mold resins. Resins based on biological materials (in this case proteins) have excellent long term potential to reduce costs both from emissions and from a raw material cost vs. resins based on petroleum feed stocks.

Resins

Biobased Foundry Resins Reduce Air Emissions & Allow Sand Reuse

Example: GMBOND® Core Sand Binder technology reduces VOCs: GM Powertrain Saginaw Malleable Iron Plant is utilizing core making process using GMBOND®-coated sand. GMBOND® is the trade name for a new environmentally friendly core sand binder. It is animal protein-based, and significantly reduces VOC emissions from the core making process and the pouring, cooling and shakeout operations in foundries. Because GMBOND® is a protein-based binder, sand reclamation and reuse are additional significant environmental advantages. The U.S. Army sponsored the GMBOND® project in conjunction with Technikon LLC, and the Casting Emission Reduction Program (CERP). The initial GMBOND® project demonstrated greater than 90% emission reductions and significant cost savings .

"The technology will be transferred to other foundries in the future, and it will help save 400 jobs at the Saginaw Foundry."

— Rep. Gil Gutknecht (R-Minn.)

Specifically, biobased foundry products are being sought by the cast metals industry as a long term strategy to reduce their environmental costs and to simultaneously increase product quality.

Case Study: Pride Cast Metals, Inc. Cincinnati, OH

The original foundry was founded in 1892

GMBOND® Cores

Benefits:

Using pre-made cores molded with GMBOND® sand binder,

Pride Cast Metals was able to:

- Achieve significantly lower costs per casting
- Significant reduction of toxic emissions released during the casting process
- Significantly reduce the time spent manually removing cores, thereby increasing the number of castings processed
- Maintain good surface finish

http://www.gmbond.com/pdfs/info/PrideCastCasestudy.pdf

A foundry in Cincinnati Ohio has implemented a change to a biobased resin which had significant economic and environmental benefits while increasing their productivity.

An integral principle of green chemistry is that the "replacement" formulation/product must not only meet the specifications, properties and performance of the existing formulation/product, but exceed it in performance and life-cycle cost. This soy-based transformer fluid by Cooper Power Systems is an example of green chemistry which outperforms the existing formulation/product.

Today's customers are demanding more from their dielectric fluid. No wonder more and more customers are switching to Envirotemp® FR3TM fluid, the revolutionary new transformer fluid that helps achieve higher levels of public and workforce safety, performance, and reliability, while keeping costs and liability down. More than 12,000 new and retrofilled transformers are in use today.

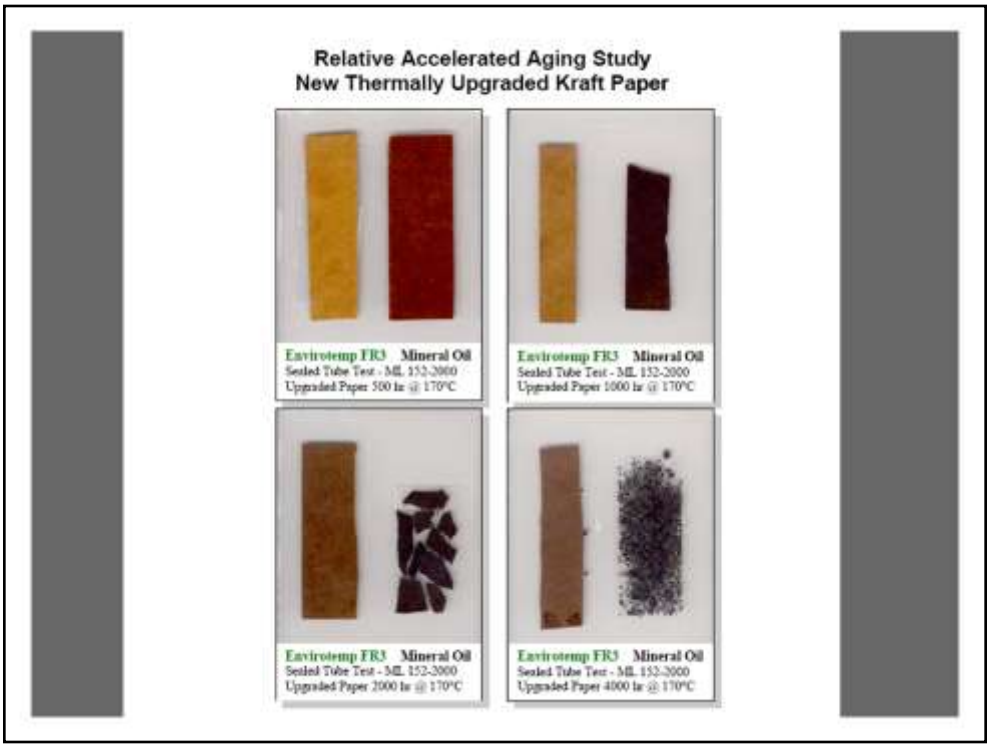
Envirotemp FR3 fluid offers:

Enhanced fire safety

Superior environmental profile

Enhanced transformer insulation life

Enhanced transformer performance



Envirotemp® FR3™ fluid extends insulation life by a factor of as much as 5-8 times because it has the unique ability to draw out retained moisture and absorb water driven off by aging paper. It also helps prevent paper molecules from severing when exposed to heat. These properties can result in an increase of overloadability and/or longer transformer insulation life, resulting in both lower life cycle cost and delayed asset replacement.

Polymers

Market Opportunity Summary

Soy-Based Thermoset Plastics

January 2006

The Product

Building materials, components of foam insulation and molded mill work; parts for cars, trucks, trains, planes, tractors, tractor trailers and recreational vehicles; furniture, mattresses, carpet pads and carpet binders; insulation for coolers, water heaters and vending machines; packaging and pallets; materials for ships, boats and flotation devices; industrial insulation and sealing; shoe and boot soles – all are end uses for either soy-based polyurethane and polyester thermoset plastics or both. The United Soybean Board (USB) continues to support the success of soy-based thermoset plastics.

3) **Carpet** – Flexible foam underlayment and fiber binder coatings.

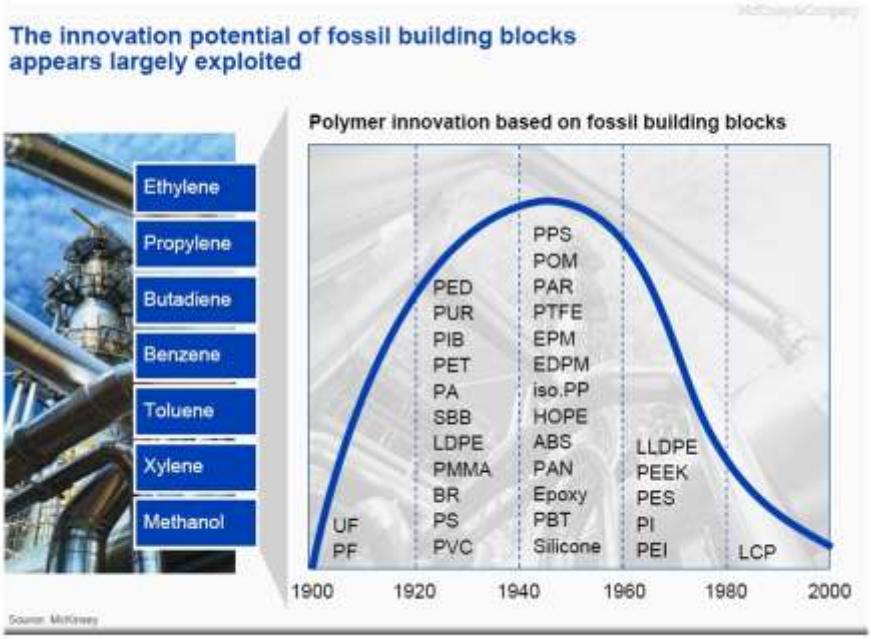
4) **Furniture and Bedding** – Flexible foam cushioning applications.

5) **Coating, Adhesives, Sealants** – Window seals, industrial adhesives and paints.

6) **Binders** – Rubber and wood products.

Penetration of the six priority polyol end use market segments is estimated to be (in millions of pounds of polyol products):

Ohio is also an important center for polymer production and polymer based manufacturing. Ohio companies produce a wide range of plastics, fibers, coatings, adhesives and a wide variety of process chemicals. The utilization of biobased feed stocks for these products could greatly stimulate the Ohio economy while also providing significant environmental benefits.



The innovation potential for new biobased polymers is dramatic compared to existing chemistries.

ESTIMATES

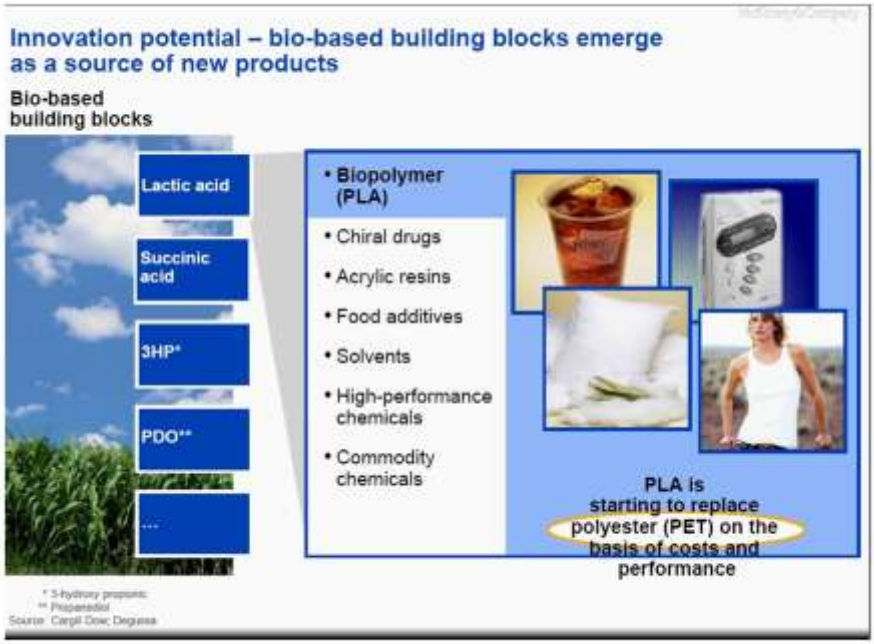
Also, existing polymers can become "bio" by using bio-based monomers or intermediates

Polymers	Sales USD billions	Biotechnology inroad
• Polyurethane	~ 14.1	• Bio-based polyols
• ABS*	~ 8.0	• Butadiene from succinic acid
• Acrylic fibers	~ 4.0	• Acrylonitrile from 3HP
• Nylon 6.6	~ 3.7	• Adipic acid from succinic acid
• Unsaturated polyester resins	~ 3.0	• Maleic anhydride from succinic acid
• Polyacrylamide**	~ 2.2	• Acrylamide from 3HP
• Polybutadiene	~ 2.2	• Butadiene from succinic acid
• Nylon 6	~ 1.7	• Caprolactam from fermentation

Technically feasible, but not cost-competitive to date

* Acrylonitrile-butadiene-styrene resins
** Excludes superabsorbent applications
Source: SRI; CMAI; McKinsey analysis

Additional opportunities exist for incorporating biobased feed stocks into already established polymers.



Ohio is a national leader in the production of plastics and molded plastic products. The ability to produce both feed stocks and finished plastic products could provide significant economic and environmental benefits for Ohio businesses.

Chemical companies and technology players start to move against opportunities

	Players	Activities (examples)
Fine	• DSM	• 50% of all life science chemicals sales based on biotech (USD 2 billion)
	• BASF	• 30% of all fine chemicals using biotech
	• Others	• Tripling of biologics manufacturing capacity announced
Polymers	• Cargill Dow	• PLA plant running and market being developed
	• Dupont	• PDO plant for Sorona biopolymer under construction
	• BASF	• Collaboration with Metabolix around PHAs
Bulk	• Ciba	• Introduction of enzymatic process for acrylic acid
	• BP	• Several research projects on fermentation routes
	• Shell	• Investment in logen for ethanol production from biomass
	• Cargill	• Exploring 3-HP as a new building block
Specialty	• Givaudan	• Exploitation of biotech for new flavors and aroma chemicals
	• Degussa	• Project houses for biocatalysis and fermentation
	• Novozymes	• Strong growth in enzymes
	• DSM	• New biotech-based food and feed specialty products

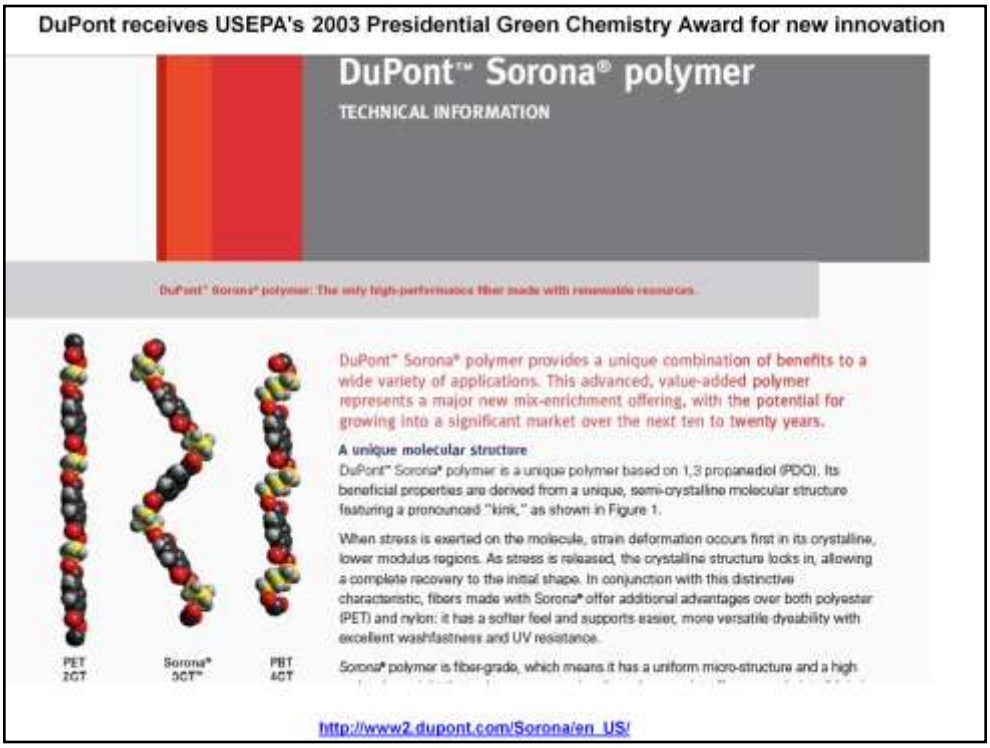
High level of cooperation with technology partners such as Diversa, Codexis, and Genencor as well as agriprocessors

Source: Press clippings, McKinsey

There is a evidence that the business case has matured for incorporating biobased chemistries into short and long term product/process strategies.

http://www.natureworksllc.com/Product-And-Applications.aspx

Recent advances, such as successful commercial scale biobased processing facilities, have paved the way for numerous other opportunities to produce similar products. As markets develop, as seen with the rapid growth in demand for PLA™, opportunities rapidly expand for competing biobased materials.



As broad acceptance of these materials becomes a dominant market force, companies who strategically align their product strategies can take full advantage of larger market share. The opportunity for product innovation also increases dramatically a new materials offer additional economic, physical or chemical properties to meet consumer needs.

The American Chemical Society (ACS) 2007 Heroes of Chemistry award was presented to the research teams involved in the development of Bio-PDO™

The joint venture uses a proprietary fermentation process developed jointly by DuPont and Tate & Lyle to produce Bio-PDO™ using corn sugar instead of petroleum-based feed stocks. The production of Bio-PDO™ **consumes 40 percent less energy** and reduces greenhouse gas emissions by 20 percent compared to petroleum-based propanediol. Annual production of 100 million pounds of Bio-PDO™ will **save the energy equivalent of over 15 million gallons of gasoline** per year, or enough to fuel more than 27,000 cars

"**We began looking at bio-based, renewable materials in 1993 as the natural evolution of DuPont science**," DuPont Chairman & CEO Charles O. Holliday, Jr. said. "Today, the growth opportunity is exponential with applications in personal care, automotive, paints, athletic equipment, apparel and more. Bio-PDO™ has demonstrated that our approach to integrated science works. **We are seeing further evidence of this in the development of advanced bio-fuels and other renewable products in our pipeline. I am more confident than ever that we as a society are making progress toward building a global economy that addresses energy challenges in a sustainable way."** June 12th 2007

Mr. Holliday was presented with the **George Washington Carver Award for Innovation in Industrial Biotechnology at the sixth annual 2009 World Congress on Industrial Biotechnology and Bio-processing**

DuPont Environmental Performance

Global Energy Consumption												
(Indexed to 1990 = 100)												
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
All Global Regions	100%	98%	97%	99%	101%	104%	96%	93%	94%	92%	94%	94%
MMMM BTU's	158.8	156	154	157	160	165	152	148	149	146.1	149.7	148.7
Global energy consumption is down 6% since 1990, despite a 41% increase in production. All years adjusted to reflect Invista divestiture.												

Greenhouse gas emissions, use of ozone depleting substances, NOx emissions:

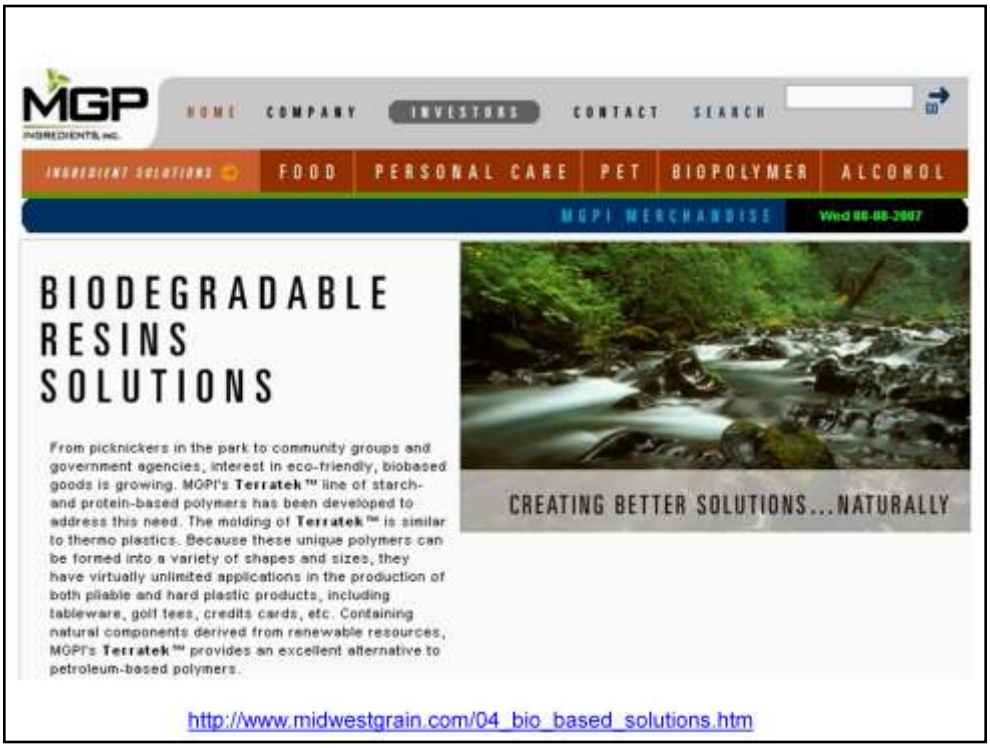
Global Greenhouse Gases											
(billions of pounds of Carbon Dioxide Equivalents)											
	1990	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Carbon Dioxide	22.3	22.2	21.4	22.5	21.6	20.9	21.2	20.5	21.8	22	21.5
HFC's, PFC's, CH4	52.6	69.7	56.6	59.7	46.7	25.9	12.5	14.7	11.5	10.4	9.4
Total, Kyoto Basis	74.9	91.9	78	82.2	68.3	46.8	33.7	35.2	33.3	32.4	30.9
1990 baseline and all years adjusted to reflect Invista divestiture. Reflects a 60% reduction since 1990.											
Prior to the Invista separation, DuPont achieved a 72% reduction below the original 1990 baseline.											

Global hazardous wastes:

Global Hazardous Waste (millions of pounds)												
	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Europe	95	25	23	24	8	25.8	40.7	49.6	66.2	72.9	52.8	56
Latin America	205	204.9	141.9	180.2	252.9	191.2	206.4	1.9	1.8	2.9	8.3	1.8
Asia/Pacific	6.8	1.1	1.2	6.1	4.3	1.5	6.3	4.3	3.6	4.5	3	3.3
United States	1,929	1,539	1,566	1,542	1,111	881	916	851	931.7	961.7	1013.9	869.5
Total, All Regions	2235.8	1770	1732.1	1752.3	1376.2	1099.5	1169.4	906.8	1003.3	1042	1076.0	931
All years adjusted to reflect Invista divestiture.												

http://www2.dupont.com/Sustainability/en_US/assets/downloads/gri.pdf

58 percent reduction in hazardous waste generation, 72 percent reduction in greenhouse gas emissions and 6% net decrease in energy use **while increasing production output by 41 percent**



http://www.midwestgrain.com/04_bio_based_solutions.htm

Additional environmental benefits may also be gained for developing new products which may have desirable properties such as the ability to be composted or reprocessed in innovative ways.

Solvents and Cleaners

Market Opportunity Summary

Soy-Based Solvents

January 2006

The Product – Methyl Soyate

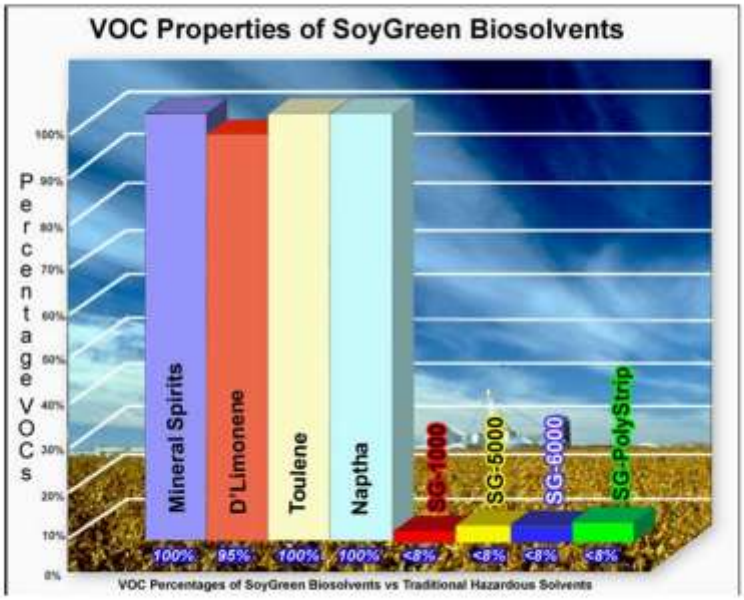
Methyl soyate, a methyl ester derived from soybean oil, offers good potential as an industrial solvent for use in parts cleaning, paint and ink removal and formulated specialty consumer products. It is a low-cost, readily biodegradable, low-toxic, high-flash-point alternative to the traditional chlorinated and petroleum solvents under increasing regulatory pressure such as ozone-depleting chemicals (ODCs), hazardous air pollutants (HAPs) and volatile organic compounds (VOCs).

Cleaning Market Segments

The industrial cleaning solvent market consists of four primary segments.

- Parts cleaning is the largest market involving the removal of oils and greases used in the fabrication of metal parts. Competitive solvents are TCE, PCE and mineral spirits. The market is fragmented with many small end users.
- Precision cleaning requires more stringent cleaning and consists largely of the aerospace industries. The major

Ohio companies have excellent opportunities to produce and utilize a rapidly growing market segment of environmentally friendly solvents and cleaners. These products have been proven to be cost effective alternatives for a class of chemicals that have been considered hazardous to workers and the environment. These alternative have reduced operating costs by through environmental health & safety costs and reduced raw material costs. As petroleum costs continue to increase the cost savings achieved through both producing and utilizing biobased solvents and cleaners will become even greater.



http://www.soytek.com/pages/viewPage.php?id=4

The environmental advantages to switching to biobased solvents is enormous. Not only is worker health and safety greatly improved, these products provide cost effective alternatives to existing products.

Solvents and Cleaners

Safely Cleaning Planet Earth®

GEMTEK Products

http://www.biobased.com/products.html

Numerous formulations and process specific chemicals are becoming available for a wide variety of industrial applications. This market segment will continue to grow as these products gain wider acceptance. Ohio industries have rapidly begun to employ these materials in a variety of cleaning, coating, metal finishing and other processes. Businesses have reduced their environmental costs and improved worker health & safety.

Case Study- United States Postal Service Mastic Removal

The U.S. Postal Service's Jim Hennessey found that a soy-based mastic remover saves him 300 percent since the product's environmental and performance qualities allow USPS to remove cove base without the services of outside remediation firms that specialize in removing materials containing asbestos.

This product removes mastic, which often contains asbestos. The cost for us to do it is sixty cents a square foot. The cost for an outside contractor to do it is $1.76 per square foot—that's a savings of almost 300 percent.

Based on several months of analysis, BEAN–e–doo® gained approval for Class Three asbestos removal (which means USPS employees can use the product without a respirator) because it is biodegradable,contains no volatile organic compounds, has a mild odor and is user friendly.

http://www.biopreferred.gov/files/BEAN-e-doo_Does_It_All.pdf

Biobased solvents and cleaners save businesses money in a number of ways including disposal costs, personal protective equipment costs and lower environmental hazards.

A PROFILE IN BIOBASED SUCCESS **BIOBASED PAINT STRIPPER GETS THE JOB DONE**

Protecting Workers and the Environment...

Biobased Paint Stripper Helps Submarine Repair Facility

When a U.S. Navy submarine comes to Portsmouth Naval Shipyard (PNS) to be renovated and updated, it gets a total overhaul inside and out right down to the smallest detail. For example, doors are removed and stripped of whatever kind of paneling (Formica, wood, etc.) they might have. But that's just step one. Eventually, bare metal will be exposed with the removal of the panel adhesive and metal's base paint.

For the last two-plus years, most paint crews at PNS have relied on a biobased product to remove both the paint and adhesive on these doors and hundreds of other painted areas on the sub. "Doors and the like can be taken off the ship and brought into our shops, but many other surfaces cannot, so we need a stripper that we can work safely within confined areas that won't contaminate the sub," says Foreman of Paint Shop 71 Bob Moors. "We have to use chemical strippers rather than mechanical methods, such as sanding, because of the dust they produce. The internal environment of a sub—especially instrumentation—is extremely sensitive to dust particles that result from sanding and scraping so a chemical stripper is extremely important," Moors says.

"In the past we had no choice but to use a harsher methylene chloride product. It worked well but was classified as a Volatile Hazardous Air Pollutant which means it's bad for the environment. It also required extensive controls

"This is good stuff. It saves a lot grief," says Bruce Trent about Soy Strip, a biobased paint remover, he uses on submarine renovations at Portsmouth Naval Yard. Trent is work leader in Paint Shop 71 and is shown applying product to a door panel that was removed from a sub and taken into the shop for stripping and re-painting.

ABOUT PORTSMOUTH NAVAL SHIPYARD

"this department's confidence in biobased approaches is not based on theory alone. DoD facilities, from Washington State to Texas to Georgia to Maine, are using biobased products. And there's already a number of great success stories, and I'm just going to mention three of those.

The first is at the Portsmouth Naval Shipyard. In the past, if you wanted to remove paint and adhesives from ships, which is a big job if you're at the naval shipyard, they used methylene chloride product. It was a volatile, hazardous air pollutant. And then we made the switch to a soy-based paint stripper.

It has fewer health risks. It's environmentally friendly. And, by the way, it's a lot easier to do. You don't have to do all the protective measures. You don't have to have ventilators, don't have to have respirators. And so it just makes good sense -- better, and again, costs us less money. " -Deputy Secretary of Defense Bruce England- Sept. 13, 2006

DoD Biobased Showcase and Educational Event at the Pentagon

Deputy Secretary of Defense Gordon England September 13, 2006

"**Biobased products are an integral part of our overall strategy**. Some people call it a green strategy. I just call it the department's strategy, a very central part of our strategic approach to national security. Many of these products are substitutes for products based on nonrenewable natural resources like oil and natural gas.

So **when we have substitutes, it supports** the President's initiatives and **the national interest to reduce our dependence on foreign sources of energy.** It makes our nation more secure, and that's what the Department of Defense is all about is making our nation more secure.

Our strategy also supports our long-term national security interest by protecting and preserving the environment for future generations so they, too, can enjoy life, liberty and the pursuit of happiness to the fullest here in America.

And, by the way, when we do this right, **in almost every case we end up saving the taxpayers' money.** Invariably, if you are more effective at what you do, you're also more efficient at what you do. And this is all about being effective."

http://www.defenselink.mil/transcripts/transcript.aspx?transcriptid=3717

Existing companies are seizing the momentum in this expanding market and repositioning themselves as leaders in new product development.

Soy Technologies is a privately owned manufacturer headquartered in Nicholasville, Kentucky. Originally founded in Delray Beach, Florida in 2001, the company's original charter was to develop renewable (bio-based) chemistries meeting or exceeding upcoming emission regulations. Now, seven years later, the company maintains that original charter, and has invested well over $3m in the research, development, and marketing of environmentally friendly finished products and raw materials.

Soy Technologies' patented technology is marketed under trademarked company and private label brands, and sold to manufacturers and distributors. Product families include the following:

Soyanol™ Intermediary Blends (Solvents and Emulsions)

SoyGreen® Bio-Solvents

SoyStop™ Anti-Graffiti Barrier System

SoyFast™ All Purpose Cleaners

SoyDerm® Waterless Hand Cleaners

Specialty Products

In 2005, to meet the upcoming stringent emission regulations in the paint and coatings sector, Soy Technologies expanded their R&D and successfully developed and introduced new bio-solvents sold to manufacturers of paints, coatings, cosmetics, and related markets. And in 2007, that R&D and subsequent products were expanded to include (water-based) emulsion technology, now marketed and sold to paint and coatings manufacturers interested in truly environmentally responsible products, products that go beyond 'low VOC', and focus on renewable and recyclable materials.

Product Information Sheet

SoyGreen®
POWER DEGREASER

Description

SoyGreen® Power Degreaser is a unique soy-based emulsion that offers the cleaning performance and safety of a soy based degreaser, but the cost effectiveness of a water based cleaner. This formulation successfully mixes oil (soy) and water into a stable white emulsion ideal for degreasing all types of surfaces. The formulation also is designed to remove paint overspray, magic marker, scuff marks, and more. **SoyGreen® Power Degreaser** is low VOC*, safer than any product on the market today, non-flammable, bio-based, biodegradable, and contains no petrochemical raw materials. For a more aggressive formulation, including parts washing, try Soy Green® SG5000.

http://www.soytek.com/admin/uploads/Power_Degreaser_3-01-08.pdf

http://www.soybiobased.org/resources/2008CTCWinners.pdf

This is a good example of a non hazardous degreaser that has been tested extensively in Department of Defense maintenance facilities.

Flash Point: >200°F

High Sheer Viscosity: 100 - 300 cps

Low Sheer Viscosity: Not Determined

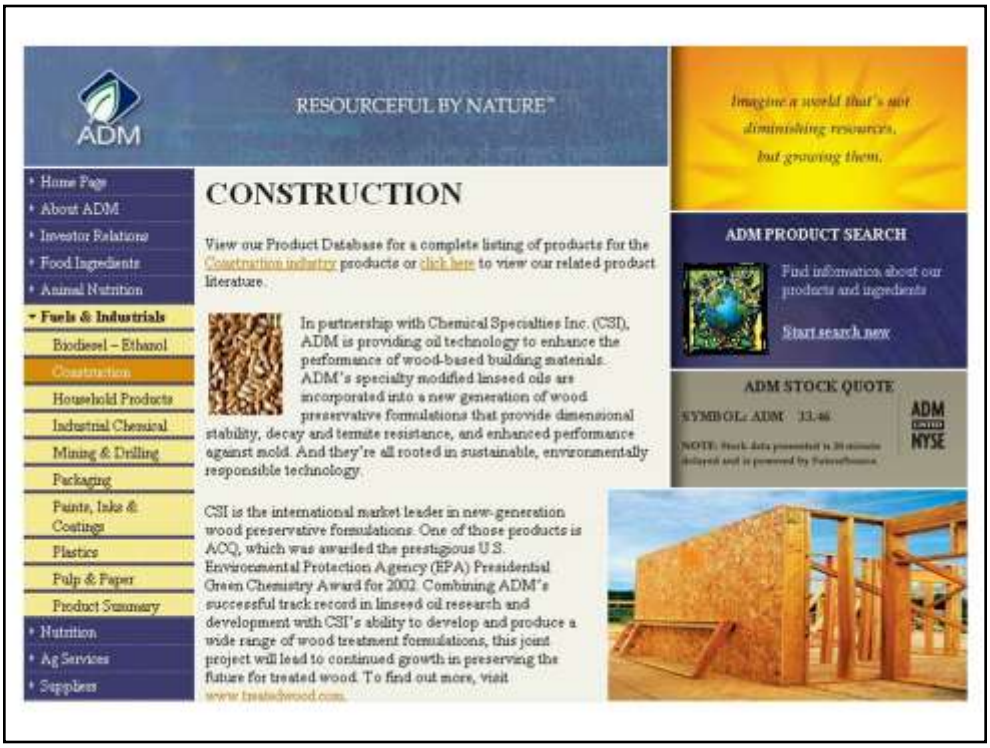
Specific Gravity @ 25ºC: 1.000

VOC Percentage: < .5%

Green Building Materials

Green building is a growing market segment for a broad spectrum of products from building materials to cleaning products. Leadership in Energy and Environmental Design (LEED) has gained wide acceptance as a national green building standard. LEED projects award points for products with biobased, recycled and locally produced content.

http://biobased.net/products/index.php



Opportunities exist for replacing many preservative, sealant, adhesive and other components in traditional building materials.

Coatings

Market Opportunity Summary

Soy-Based Paints and Coatings

January 2006

Total U.S. Coatings Market

The market for paints and coatings was 1.33 billion gallons in 2004. While the market is cyclical, it is expected near term to grow at about the rate of growth of the U.S. Gross Domestic Product. An increase in volume of 7 percent in Architectural Coatings offset declines in the Industrial and Specialty Products segments. The United Soybean Board (USB) is looking to increase the use of soy in these product segments.

Market Segment*	2004 Million Gallons
Architectural	826
Industrial/OEM	370
Specialty	138

*Other: footware, marine, packaging, foundry, machinery, and industrial, misc.

Waterborne paints are less expensive per gallon and lower in odor than alkyd-containing solvent-borne paints. Solvent-borne paints have retained market share based on superior performance characteristics, including good film formation and durability. In the long term, the conversion of most architectural paints to waterborne will occur as advancing technology for manufacturing waterborne paints enables scientists to further reduce or eliminate odor and to make paints that are less temperature-sensitive. This conversion will be further hastened by state bans of solvent-borne paints to eliminate volatile organic compound (VOC) emissions. The architectural paint segment has continued to consolidate with AKZO Nobel, ICI, PPG, Henkel and Sherwin-Williams now controlling an estimated 50 percent of total volume. Lower-tier consolidations and mergers are also expected to continue.

Biobased chemistries can be important components of newer waterborne coatings which are becoming preferred formulations for a variety of applications. Biobased components greatly reduce VOC emissions and odor offering environmental and economic advantages.

It is important to point out that biobased materials are not only applicable to interior coatings but also commercial products such as roofing and patching compounds.

Lubricants

Market Opportunity Summary

Soy-Based Lubricants

January 2006

Driving Issues

The market for soybean oil in lubricants will be driven by a combination of environmental concerns, economics and performance issues. Petroleum- or mineral-based oils have historically been, and will likely continue to be, the economic choice for many manufacturers to satisfy performance, logistic and cost targets in many applications. Soybean oil, especially enhanced varieties, and other vegetable oils show the ability to compete in significant segments of this market.

The need for readily biodegradable and low-toxicity lubricants in environmentally sensitive areas has been recognized in Europe. Regulations have been adopted in some European regions, and both synthetic ester and rapeseed oil lubricants have been developed to meet these needs.

The combination of growing regulatory pressure to reduce or eliminate certain emissions of petroleum lubricants and Executive Order 13101, which instructs federal agencies to use environmentally preferable biobased products, should encourage increased use of renewable oils. Soy-based lubricants have the potential to capture a significant share of this emerging market segment and are a research priority of the United Soybean Board (USB).

Soybean oil can have an advantage over rapeseed oil if the base oil can be modified to improve stability. Developing a cost-effective, commercially viable source of economic and stable basestock is key to wider commercialization of soy-based lubricants.

Market Potentials

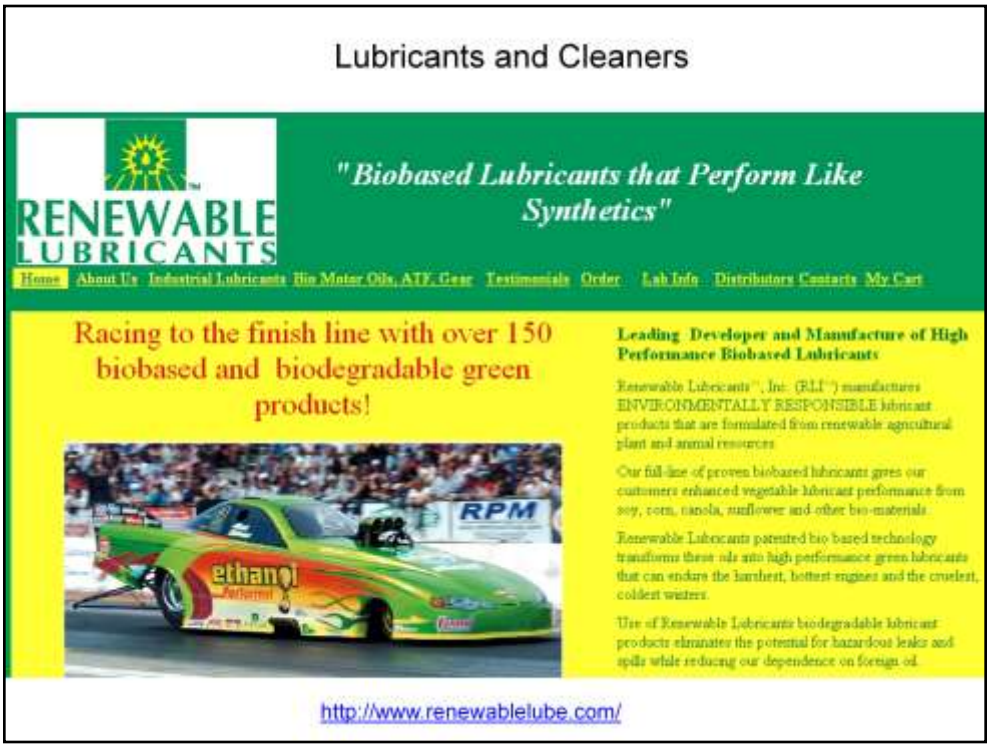
Nine areas were investigated to determine the potential acceptance of soybean oil as a commercial alternative to mineral-based oils.

Soybean Oil Opportunities

Application	Prob. of Acceptance (%)	Poss. Mkt. Share (%)	Poss. Mkt. Share (Mil. Bu.)
Hydraulic Fluid	40	5	8.0
Two-Cycle	20	10	1.5
Bar/Chain	60	50	1.0
Crankcase	10/80*	10	87.3
Drip Oil	65	80	0.8
Rail & Flange	55	50	0.4
Wire Rope	70	70	1.1
Metal Cutting	30	10	2.8
Dedusting	50	50	0.4

*Automotive water-cooled-engine use/air-cooled-engine use.

Although lubricants seems like a product category that would already be fully exploited for the economic and environmental benefits which are available, many opportunities exist for companies to create new products

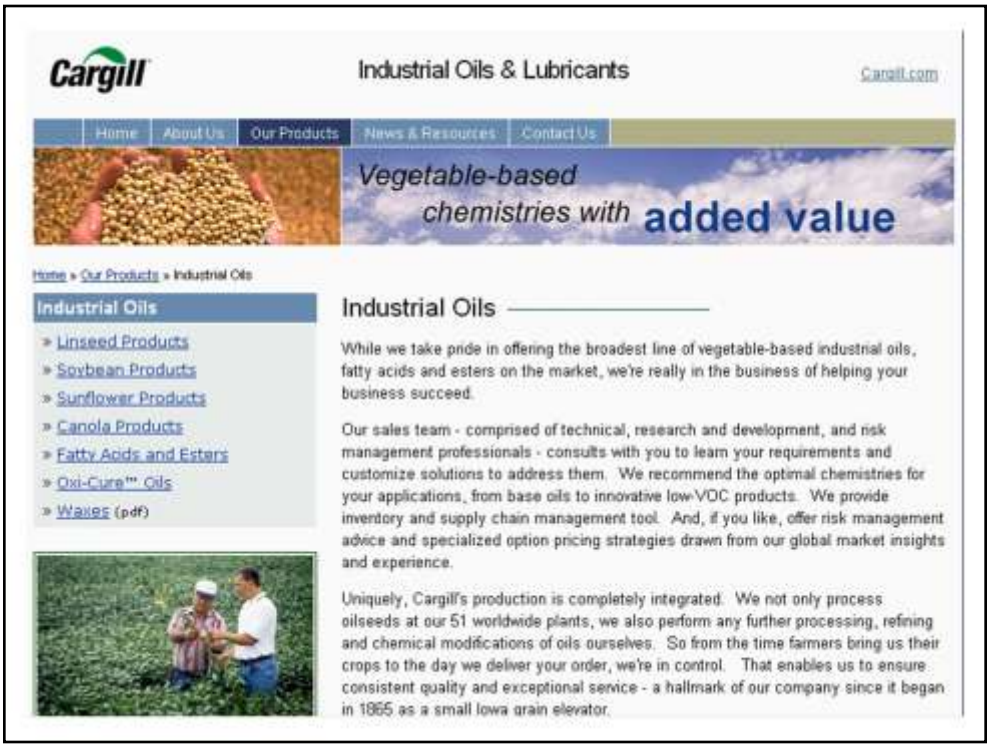


Ohio companies have taken a leading role in the development of biobased lubricant and cleaning products. Adoption of these products by manufacturers has helped yield both environmental benefits such as lower VOC emissions but also significant cost savings from reduced regulatory costs.

"Since 1991, Renewable Lubricants™, Inc. (RLI™) has pioneered an extensive research and development program of vegetable oil-based (biobased) lubricants. The program's overwhelming success is due in part to project collaborations with the Department of Defense, Department of Interior, Department of Energy, Department of Agriculture, Concurrent Technology Corporation, United Soybean Board, Dow AgroSciences, Lubrizol, Ohio Soybean Council, National and Ohio Corn Growers Associations, Penn State University, University of Lincoln Nebraska, and Chevron Phillips Chemical. Renewable Lubricants, Inc. has been under government grants, contracts, and/or working agreements with most of these organizations and companies.

Renewable Lubricants is the world's leading developer and manufacturer of high performance biobased lubricants. Our patented technology and extensive field successes in over 150 products are what place us without peers in the biobased lubricant market."

http://www.renewablelube.com/aboutus-companyhistory.htm



The rapid expansion and availability of biobased oil feed stocks for numerous industrial applications offer Ohio businesses opportunities for material substitutions and new product development.

"Green Ship Initiative" In the Great Lakes: NOAA Operates Three, 100 Percent Biobased Ships

As is often the case with people who start using biobased products, biodiesel gave Marine Superintendent Dennis Donahue his first experience with the products at the Great Lakes Environmental Research Laboratory (GLERL) in Muskegon, Michigan. Donahue's uses have come a long way since that first trial in 1999. For the last two years, three of GLERL'S diesel ships' ran completely on biobased (rather than petroleum-based) products. Those made from soybean oil are ISO 32 & 68 hydraulic oil, 90W gear lube, lithium grease, general purpose cleaners, soy 2-cycle oil, diesel crank case oil and biodiesel.

Being part of the National Oceanic and Atmospheric Administration's (NOAA) research division, Donahue says that it's not only the responsibility of his organization and his facility, but also his personal duty to do his utmost to protect the environment. Go to **www.soybiobased.org** to read a full profile on how GLERL vessels ply all of the five Great Lakes in a "Green Ship Initiative" with biobased products. These products, says Donahue, have been tested under the rigors of the marine environment in both warm and cold climates and have been found to be equivalent to petroleum-based products' performance.

PRODUCTS USED AT GLERL INCLUDE:

- BPL – Bio-Penetrating Lubricant
- Bio-TC-W 2-Cycle Engine oil
- Bio-Syn ATF
- Bio-Ultimax 1000 ISO 68 Hydraulic oil
- Bio-Synthetic SAE 15W40 HD
- Bio-Air Compressor Fluid AC30
- Bio-180 High Temperature MultiPurpose

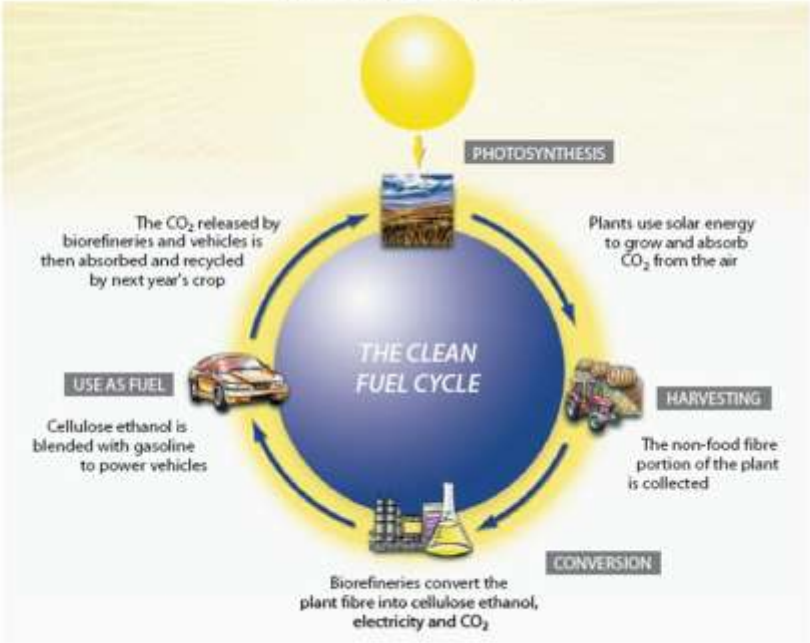
Lithium Grease NLIG #2

These products are made by Renewable Lubricants **www.renewablelube.com.**

GLERL also uses Hydro Safe ISO VG 68, which is made by Hydro Safe of Dewitt, Michigan.

The use of enzymes as a process alternative is an excellent example of the wide potential of developing biobased products to offset or replace existing non-renewable chemistries. In this case enzymes are used for the bleaching off paper pulp, reducing the potential emissions of chlorinated compounds and saving money!

Renewable Fuels



http://www.iogen.ca/cellulose_ethanol/what_is_ethanol/cellulose_ethanol.pdf

I intentionally left the discussion of renewable fuels until the end of the presentation, since this area of product development is often controversial, depending on the policy position of the manufacturing sectors involved. The following information is based on research by Argonne National Laboratory about the outstanding potential of producing cellulosic based fuels. The efficiencies, both economic and environmental hold the possibility of producing a more sustainable source of energy compared to existing sources. As with any pollution prevention strategy, the most economical energy or material use option is conservation. Every attempt should **first** be made to make any process as **energy efficient** as practicable and to **conserve energy** resources whenever possible.

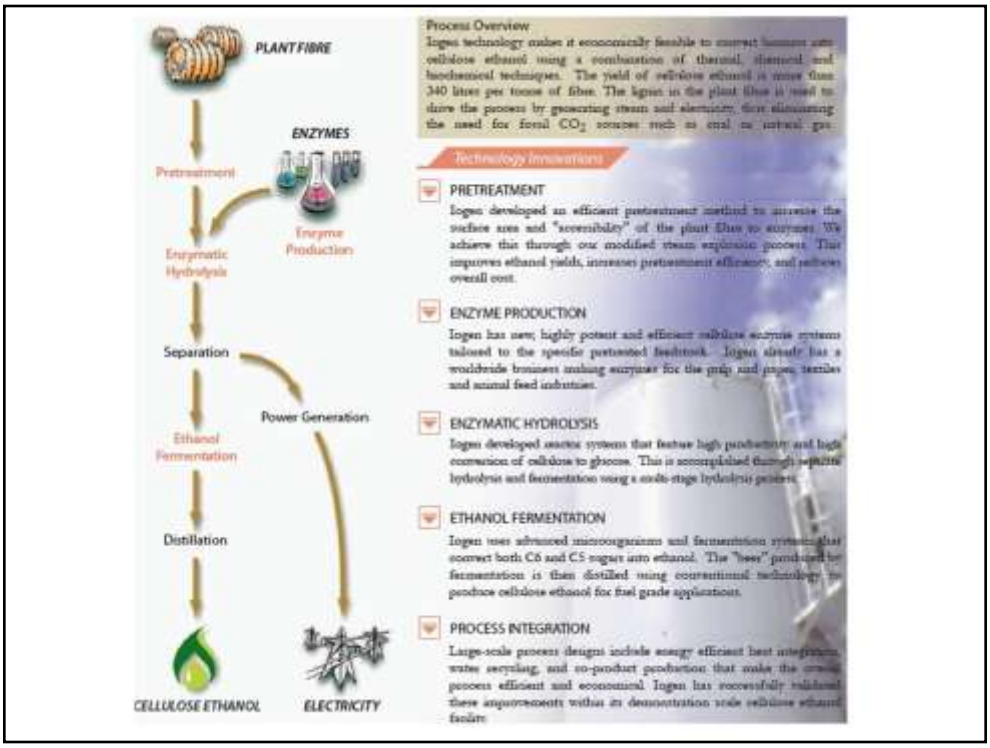
In April 2004, industrial biotechnology achieved a major milestone when Iogen Corp. made the first commercial shipment of bioethanol.

Unlike conventional ethanol made from grain, bioethanol is made from cellulosic biomass, such as wheat straw, sugar-cane bagasse, and corn stovers and stalks left over after harvest.

Iogen's breakthrough uses recombinant DNA–produced enzymes to break apart wheat-straw cellulose to produce sugars that can be made into ethanol. Several other BIO member companies are developing similar technologies.

http://www.iogen.ca/cellulose_ethanol/what_is_ethanol/process.html

The demonstration of commercial scale cellulosic fuels has already been accomplished. It will be important to continue the technological refinement of this and similar processes to increase the efficiencies and lower the environmental impacts of production.



Future adaptations of this biorefining process may yield additional co-products.

Coskata's semi-commercial facility represents the successful scale-up of Coskata's feedstock flexible biofuel technology, preparing the way for rapid commercialization of the world's first commercially viable cellulosic ethanol facility.

The facility produces ethanol from numerous non-food based feedstocks, including wood biomass, agricultural waste, sustainable energy crops and construction waste. It is a "minimum scale engineering" facility, meaning it is of sufficient size to allow scaling to 50 million and 100 million gallon Coskata facilities.

The semi-commercial facility is located in Madison, Pennsylvania, approximately 30 miles outside of Pittsburgh. It is co-located at Westinghouse Plasma Corporation (WPC). It was officially unveiled in October of 2009.

Coskata's semi-commercial FlexEthanol™ facility

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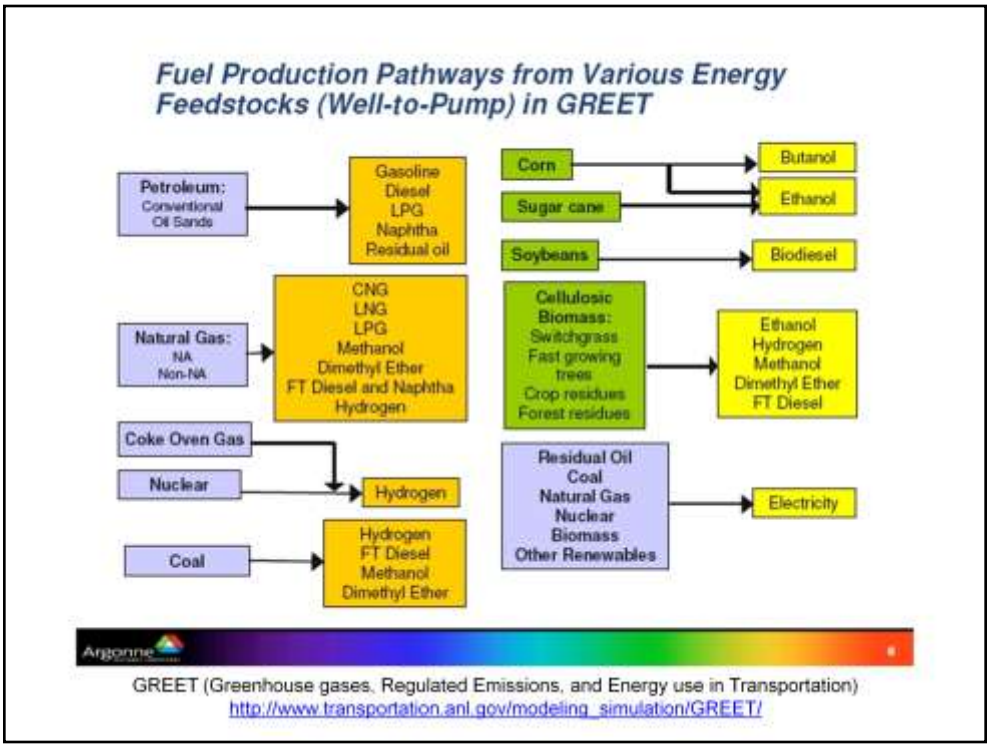
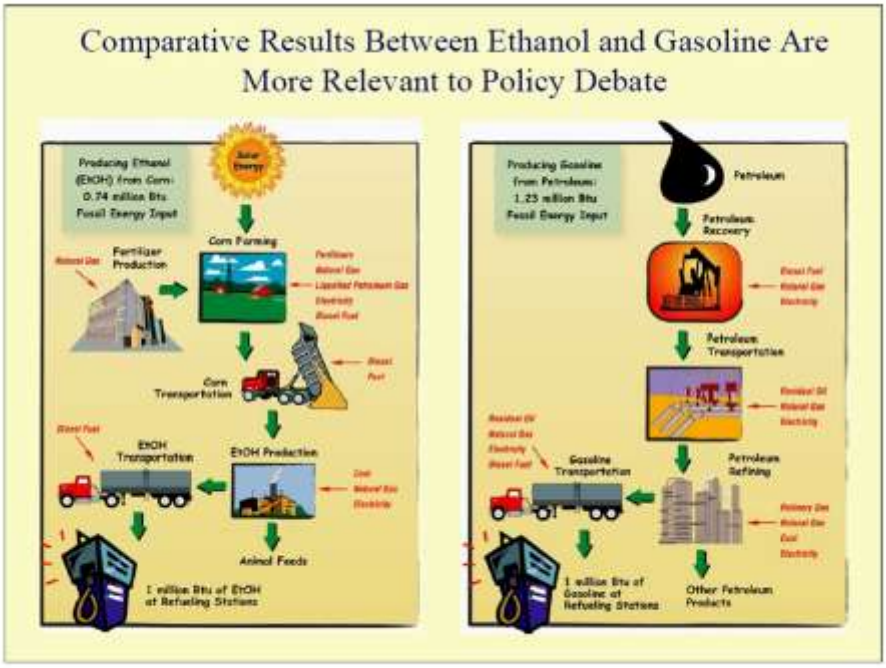
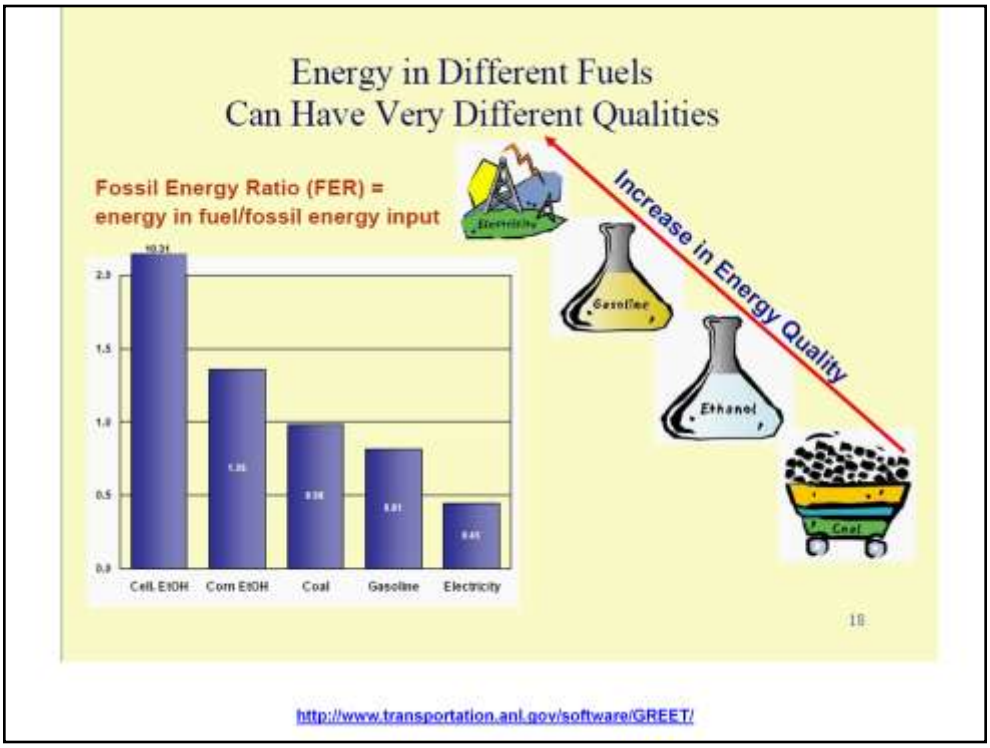
http://www.coskata.com/facilities/index.asp?source=568A3D3C-AACF-4D95-B297-7264DD2C17B5



To fully evaluate energy and emission impacts of advanced vehicle technologies and new transportation fuels, the fuel cycle from wells to wheels and the vehicle cycle through material recovery and vehicle disposal need to be considered. Sponsored by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE), Argonne has developed a full life-cycle model called GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation). It allows researchers and analysts to evaluate various vehicle and fuel combinations on a full fuel-cycle/vehicle-cycle basis.



Numerous policy and infrastructure variables often make discussions of gasoline vs. ethanol confusing to the average consumer. For businesses making decisions about future fuel production, renewable fuels such as ethanol have a lower energy input to energy output ratio. As a future strategy, this makes renewable fuels an attractive business opportunity.



This ratio makes the production of cellulosic ethanol such a promising opportunity, with a nearly ten-fold increase in output compared to gasoline or corn derived ethanol.

The **U.S. Renewable Fuel Standard** (RFS) for transportation fuels sets minimum levels of renewable
fuels that must be blended into gasoline and other transportation fuels from 2006 to 2022. Specific requirements for blending advanced biofuels,** including cellulosic biofuels and biomass-based biodiesel, begin at **0.6 billion gallons per year in 2009** and rise to **21 billion gallons in 2022**. The RFS levels for advanced biofuels production will drive the creation of a major new industry, creating a foundation for future technology development and commercial growth.
To estimate the economic implications of the emergence of this new industry, bio-era conducted a meta-analysis of nearly two dozen studies of economic impacts of biofuels production, developed a model to analyze economic output and job creation, and applied this model to analyze the economic
impact of increasing U.S. advanced biofuel production to 21 billion gallons per year by 2022.
This analysis yielded the following conclusions:

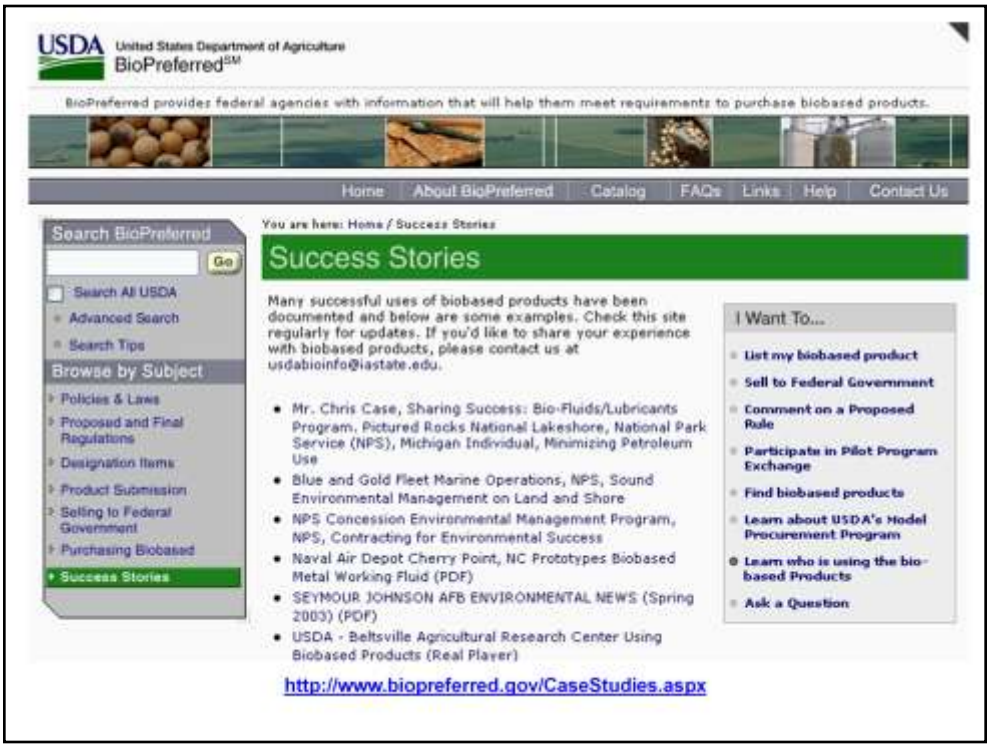
• Direct job creation from advanced biofuels production could reach **29,000 by 2012**, rising to 94,000 by 2016 and 190,000 by 2022. Total job creation, accounting for economic multiplier effects, could reach 123,000 in 2012, 383,000 in 2016, and 807,000 by 2022.

• Investments in advanced biofuels processing plants alone would reach **$3.2 billion in 2012**, rising to $8.5 billion in 2016, and $12.2 billion by 2022. Cumulative investment in new processing facilities between 2009 and 2022 would total more than $95 billion.

• Direct economic output from the advanced biofuels industry, including capital investment, research and development, technology royalties, processing operations, feedstock production and biofuels distribution, is estimated to rise to **$5.5 billion in 2012**, reaching $17.4 billion in 2016, and $37 billion by 2022.

http://www.bio.org/EconomicImpactAdvancedBiofuels.pdf

It is important to consider that bio-refineries produce numerous co-products, such as typical petrochemical refineries do. This will create enormous opportunities for new chemistries and products based on these materials/feedstock.



Case studies of companies switching to biobased products for environmental and cost saving benefits are numerous. The website above as well as the reference document at the end of this presentation will lead you to detailed case studies of biobased material substitution and biobased product development.

http://bio.org/aboutbio/

A wide variety of reference material is available for companies wishing to explore the potential of biobased product alternatives. Many organizations now have extensive information on the web regarding research and development of biobased products.

Ohio Members-

Akebia Therapeutics, Inc Cincinnati, OH

Athersys, Inc Cleveland, OH

Battelle Memorial Institute Columbus, OH

Ben Venue Laboratories, Inc Bedford, OH

BioOhio Columbus, OH

Neoprobe Corporation Dublin, OH

Reference Guide:

Vendors-

- http://www.cooperpower.com/FR3/
- http://www.natureworksllc.com/Product-And-Applications.aspx
- http://www2.dupont.com/Sorona/en_US/
- http://www.midwestgrain.com/04_bio_based_solutions.htm
- http://www.soytek.com/pages/viewPage.php?id=4
- http://www.biobased.com/products.html
- http://www.biopreferred.gov/files/BEAN-e-doo_Does_It_All.pdf
- http://www.bio-renewable.com/web/biorenew.nsf
- http://biobased.net/products/index.php

References-

- http://bioproducts.osu.edu/
- http://www.bioohio.com/business-growth/
- http://www.ieabioenergy.com/DirExco.aspx
- http://www.oecd.org/dataoecd/4/23/42833898.pdf
- http://www.biopreferred.gov/CaseStudies.aspx
- http://www.soybiobased.org/

The key references for this presentation are included in the above Reference Guide. Additionally, most slides include the specific URL from which the slide information was derived.

Questions???

Office of Compliance Assistance & Pollution Prevention

http://www.epa.state.oh.us/ocapp/ocapp.html

614-644-3469

ron.smith@epa.state.oh.us

Specific products may also be researched for pollution prevention opportunities by contacting:

Office of Compliance Assistance & Pollution Prevention (OCAPP)

http://www.epa.state.oh.us/ocapp/about.html

OCAPP is a non-regulatory office and is available to assist any Ohio company with more information on minimizing wastes.

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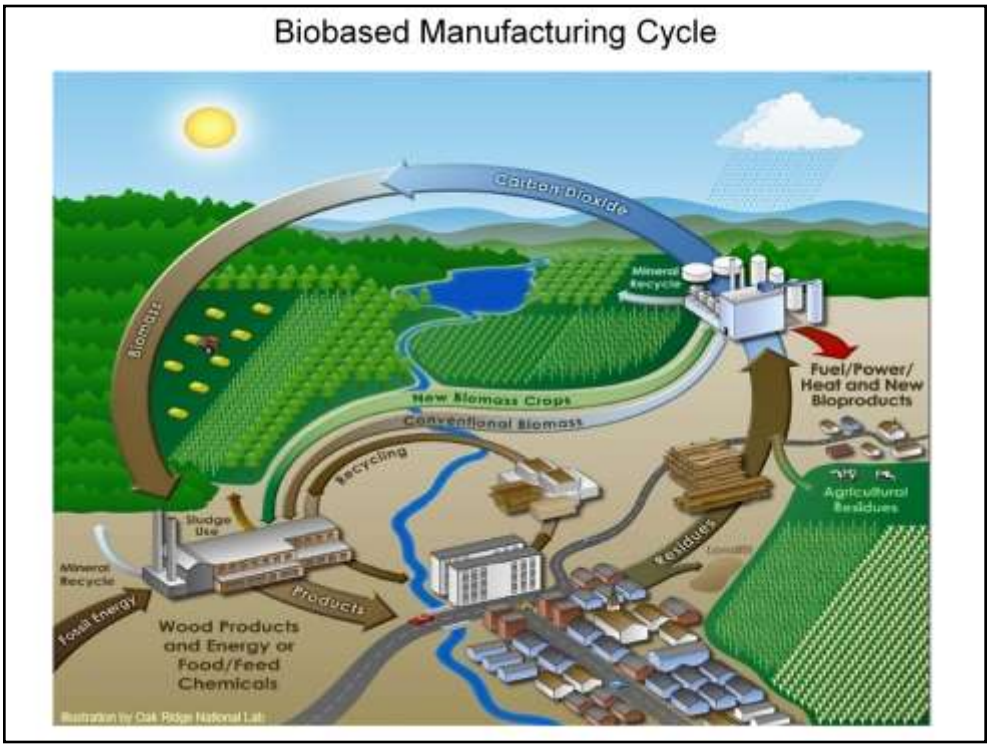

Biobased manufacturing will require rigorous discipline to achieve the sustainability goals of a growing world. It will be critical to establish a production and manufacturing cycle of truly renewable materials which efficiently “closes the loop” on inputs and outputs.