Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force

Report and Recommendations to the General Assembly and the Governor

June 14, 2008

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Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force

Honorable Ted Strickland
Governor

Honorable Bill Harris
President, Ohio Senate

Honorable John Husted
Speaker, Ohio House

Dear Governor and Legislative Leaders:

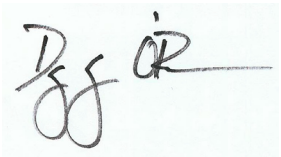
On behalf of the Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force, we are pleased to present this report and these recommendations regarding the alignment of Ohio's agricultural industry and its chemicals, polymers, and advanced materials industries. As required in H.B. 233 (127th G.A.), this report provides an overview and the trends of these industries, as well as recommendations on how these sectors could be aligned to create a new agbioproducts industry.

The members of the Task Force are unanimous in our recognition that Ohio is poised to be a leader in this burgeoning field. We commend you for your vision in creating this legislative task force to help make this opportunity a reality.

Thank you for this opportunity to work on this crucial issue and to hear from the citizens of Ohio. We received approximately 40 recommendations on how the two sectors can align, all of which are included in an appendix to the report. The members of the task force considered these recommendations and chose ten that deserve particular attention – four first tier recommendations and six second tier recommendations.

The members of the Task Force stand ready to work on any of these recommendations you deem appropriate.

Sincerely,



Doug O'Brien
Chair
Asst. Director, Ohio Department of Agriculture

Senator Capri Cafaro
Vice-Chair
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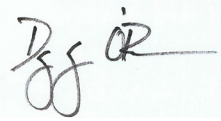
Task Force Members

Members of the Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force



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Ohio House of Representatives

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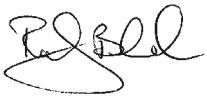

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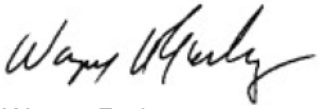
Ohio Department of Development



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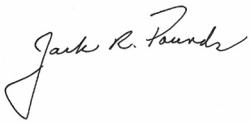

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Ohio Chemistry Technology Council

Mark Shanahan
Governor's Energy Advisor

Ohio Department of Agriculture Staff
Michael Bailey, Task Force Report Coordinator
Kristen Jensen

Excerpt from H.B. 233, 127th General Assembly
Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force

SECTION 2.

A. There is hereby created the Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force, which shall consist of thirteen members as follows:

1. Three members of the House of Representatives appointed by the Speaker of the House of Representatives, two of whom shall be members of the majority party and one of whom shall be a member of the minority party;
2. Three members of the Senate appointed by the President of the Senate, two of whom shall be members of the majority party and one of whom shall be a member of the minority party;
3. A representative of the Ohio Chemistry Technology Council appointed by the Speaker of the House of Representatives;
4. A representative of PolymerOhio appointed by the Speaker of the House of Representatives;
5. A representative of the Ohio BioProducts Innovation Center appointed by the President of the Senate;
6. A representative of the Ohio Farm Bureau Federation appointed by the President of the Senate;
7. A representative of the Department of Agriculture appointed by the Director of Agriculture;
8. A representative of the Department of Development appointed by the Director of Development;
9. The energy advisor to the Governor appointed by the Governor.

Appointments shall be made, and the Task Force shall hold its first meeting, not later than fifteen days after the effective date of this section. The representative of the Department of Agriculture shall appoint a chairperson, and the Task Force shall elect from its members a vice-chairperson.

B. Not later than four months after the effective date of this section, the Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force shall submit a report to the General Assembly and the Governor. The report shall do all of the following:

1. Provide an overview of the agriculture industry and the specialty chemicals and polymer industry in this state;
2. Describe the conditions of and trends in those industries in this state;
3. Identify and describe potential alignments between the agricultural industry and the specialty chemicals and polymer industry in this state;
4. Include recommendations to the General Assembly for expanding the agriculture industry and the specialty chemicals and polymer industry in this state and for providing methods to increase alignments between those industries.

Following submission of the report, the Task Force shall cease to exist.

Executive Summary

Ohio is a leader in the agricultural industry, as well as in the polymer, chemical, and advanced materials industries. By aligning these two sectors, the state is poised to be the world leader in a new market – products made from biobased materials. This report looks at the current state and trends of these sectors, and then presents recommendations on how the two sectors could align.

Ohio's Agricultural and Food Sector

Ohio is home to a varied and substantial agricultural and food sector. Ohio ranks among the top ten states in many agricultural commodities, including corn, soybeans, winter wheat, eggs, chickens, and hogs, as well as a number of crops in the fruit and vegetable industry, such as sweet corn, fresh tomatoes, cucumbers, apples, and strawberries. The diverse nature of Ohio's agricultural production reflects its varied growing regions and natural resources.

When the agricultural sector is aggregated with the food sector, the economic contribution to the state is staggering. The food and related agricultural cluster accounted for $98.2 billion of economic output in 2006. Ohio's agricultural processing sector is one of the fastest growing subsectors in Ohio's economy.

Just as Ohio is home to a diverse set of crops used for food or feed, it also hosts a wide variation in biomass sources. The state's inventory of biomass resources includes crop residues, wood biomass, livestock manure, municipal and food processing wastes.

As far as farming operations, Ohio parallels national trends in that the number of mid-size farms is decreasing and the numbers of small and large farms are increasing. U.S. and Ohio farm income has generally trended upward in the last few decades, but the trend is decidedly volatile. Farming continues to be an inherently high-risk endeavor.

Some of the most recent prospects available to farmers are opportunities to invest in value-added ventures and the ability to participate in the new energy economy. Industry observers project that Ohio will have seven ethanol plants in production by the end of 2008, as well as a number of biodiesel plants. Producers of biomass are also likely to see increased demand from the energy sector because of state and federal policies encouraging greater use of renewable resources.

Another important trend in agriculture is increased research and development of genetic engineering, yielding crops with particular traits that create added value. Ohio hosts a number of world class research institutions, both public and private, that work on genetic engineering and other issues in agriculture.

Specialty Chemicals and Polymer Industry

Ohio's specialty chemical and polymer industry continues to grow in Ohio, while many other manufacturing sectors are in decline. Meanwhile, certain market dynamics both challenge and provide opportunities to the chemical and polymer sectors. In particular, the increasing cost of petroleum affects these industries because not only do these sectors rely on petroleum as a source of energy required in production and for transportation, but petroleum also serves as a primary raw material for the industry.

The chemical industry has seen varied growth in recent years. Though the overall production of chemicals has declined, the production of specialty chemicals has increased, and those surviving facilities are usually very efficient. The chemical industry is generally located along the coast of Lake Erie and the Ohio River, with a significant presence along the I-71 corridor.

The polymer industry is Ohio's largest manufacturing industry and involves between 2,500 and 3,000 separate companies. The industry has grown in recent years, and this growth is predicted to continue. Along with the traditional polymer industry, the composite industry, which provides components that have capabilities such as replacing steel-based parts, is another strong growth area. Cuyahoga, Summit, and Hamilton Counties lead the state in polymer firms.

While the commodity chemical industry has experienced decline in the past decades, the polymer industry has experienced robust growth. Each of these industries is directly affected by the increased cost of petroleum and the increased demand for sustainable products. These dynamics suggest an alignment of the agriculture industry and the chemical and polymer industries.

Because Ohio is a historical leader in chemicals and polymers, the state also boasts some of the best research institutions in this field.

Alignment of Ohio Agriculture and Chemicals, Polymers, and Advanced Materials Sectors

The time is right for the agricultural sector and the chemicals and polymers sectors to align. The primary drivers of this dynamic are (1) increased cost (and decrease of consistent supply) of petroleum; and (2) increased research and development of feedstocks that can replace or improve upon traditional petroleum-based feedstocks.

The link between energy and bioproducts is significant. Consider an analogy with the petroleum industry, which extracts the greatest amount of value from its raw product by not only producing a relatively low-cost commodity product (motor fuels), but also producing higher value products (specialty chemicals and polymers) that require much more research and development to bring to the market, while also reaping much higher returns. In the same way, the growing biofuel and bioenergy sectors will need to extract the most value from its biomass resources, which will mean not only creating biofuels and energy, but will also mean producing higher value materials such as specialty chemicals and polymers.

Ohio's diverse agriculture and strong foundation in chemicals and polymers, along with its significant research and development capacity, provide the state with a unique opportunity to be the leader in the industry. Some examples of opportunities include utilizing soybeans for plastic additives or print toner, using natural fibers to reinforce plastic, and growing a new crop in Ohio that could be turned into high performance rubber, a material that the U.S. currently must import.

The Task Force received approximately 40 recommendations on how to encourage the alignment of the agricultural and chemicals, polymers, and advanced materials industries. While all of these recommendations appear in an appendix to this report, members of the Task Force chose eleven that merit priority consideration involving research and development, workforce training, biorefinery capacity, formalized collaborative efforts, and state development programs.

Task Force Recommendations

The Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force makes these recommendations with the goal of leveraging Ohio's agricultural and industrial foundation to position it as the world leader in "agbioproducts". The recommendations are categorized into two tiers:

First tier recommendations: This category is devoted to recommendations that are most crucial to make Ohio the best place in the world to engage in bioproducts development and commercialization.

Second tier recommendations: These recommendations are also important to the development of the industry and deserve serious consideration.

Tier One Recommendations

The State of Ohio should:

- Position ongoing efforts into a coordinating organization for agbioproduct development and commercialization. For example, a joint ODOD/ODA Agbioproducts Technology Center could manage the overall effort. A leading candidate for such a center would be an established Wright Center like the Ohio Bioproducts Innovation Center (OBIC). The center could:
  - Involve colleges and universities already involved in University Clean Energy Alliance of Ohio (UCEAO) in this effort;
  - Examine opportunities to align efforts of H.B. 371's Fuel Production Task Force;
  - Have state entities align or provide an inventory of resources available to education or business development pertaining to agbioproduct development to the Ohio Department of Development;
  - Coordinate interaction between those researchers who have knowledge about Ohio's biobased resources and those who are developing new chemicals, polymers and advanced materials;
  - Increase communication of the needs of specialty chemicals, polymers and advanced materials industries to providers of genetics in agricultural industry; and
  - Recruit new team members to the industry collaboration mentioned above, such as University Clean Energy Alliance of Ohio and other Third Frontier Participants.
- Conduct material flow and techno/economic analyses to inform and target potential commercialization opportunities. Create a network of development capabilities and associated technical management to qualify new agbiobased materials in various chemical/polymer applications in order to accelerate commercialization.

- Expand agbiorefining capacity to meet the need for innovators to make large samples of new materials for pilot and pre-production scale runs of candidate agbiobased products. Consider utilization of existing and additional infrastructure assets in Ohio.

- Continue support of entrepreneurs in the agbioproducts sector through existing programs in the Third Frontier through:
  - Initiating meetings that bring together entrepreneurs, investors, R&D companies, universities, etc.;
  - Leveraging assets and processes established in relevant centers to assist entrepreneurs; Providing early stage funding to assist entrepreneurs;

Tier Two Recommendations

The State of Ohio should:

- Promote and facilitate production, transportation and storage of biomass on more marginal Ohio lands (for example, reclaimed strip mines).

- Consider targeted provision of financial incentives to the agbioproducts supply chain; consider modeling after biofuel tax incentive.

- Through the Department of Administrative Services, examine the potential for creation of a Bio-based Preferred Procurement Program for Ohio, which will include consideration of USDA's BioPreferred Program.

- Promote and support agricultural development within existing ODOD Thomas Edison Centers, working with agricultural companies to develop additional production processes to enhance agbioproduct activity in Ohio.

- Encourage research at agricultural universities for enhancing agronomic yields (for example, more biomass per acre), and how such research interacts with the needs of the chemical and polymer industry; support OSU-Extension research collaborating with industry.

- Provide incentives to universities and community colleges to create academic and training programs for agbioproducts development and production; evaluate such programs as the Ohio Scholars Program.

- Create an Office of AgBio-Business Competitiveness, engaging in activities such as:
  - Providing state and local resources to help small and/or large businesses or entrepreneurs to innovate;
  - Ensuring Ohio's basic business infrastructure are globally competitive; and benchmarking Ohio's Performance against leading states and nations.

These recommendations reflect the collective view of the Ohio Agriculture to Chemicals, Polymers, and Advanced Materials Task Force, and do not necessarily reflect the views of its individual members.

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Ohio's Agriculture Industry

A. Overview of Agriculture Industry

1. Profile of Ohio Farms

According to the 2002 Census of Agriculture, 14.6 million acres of Ohio's total land area of 26.2 million acres are classified as farmland. Within the farmland acres, 11.4 million are defined as cropland, while 1.69 million are woodland. Additionally, 800,000 of Ohio's farmland acres are in pasture and 680,000 acres are in houselots, ponds, roads, or miscellaneous wasteland. The amount of land in farms has consistently dropped over the years tracing back to 1978, when Ohio reported 16.3 million acres in farms (Ramey, 2008). The drop of 1.7 million acres in Ohio is significant, as it represents a 10.4% decrease.

The average size of an Ohio farm is 187 acres with 58% of Ohio's farms at 99 acres or less, and 91% of Ohio's farms less than 500 acres. In comparison, the national average farm size is 441 acres, which illustrates Ohio's relative abundance of small farms. Nearly 82% of Ohio's farms have sales of less than $50,000 per year, and only 1.5% of farms have sales over $500,000 per year.

The 2002 Census also revealed that the overwhelming majority of Ohio's farms are family farms. Of the 77,797 farms in Ohio, 91% are organized as individual/family sole proprietorships. The next most common ownership structure is partnerships (5.8%), followed by family held corporations (2.2%). Only 154 farms (0.2%) are owned by non-family corporations. The remaining 0.7% of farms are miscellaneously organized as cooperative, estate or trust, institutional, or other. Ohio's composition of farm ownership is consistent with nationwide figures, where 98% of farms are defined as "family farms," being either proprietorships, partnerships, or family corporations that do not have hired managers (Hoppe et al, 2007).

Of the approximate total of 78,000 farms in Ohio, almost 10% of principal farm operators are women. The average age of all principal operators of Ohio farms is nearly 54 years old. Ohio is fairly reflective of national demographics, as 90.7% of all U.S. farm operators are male, and the average age of a farm's principal operator is 56 years (Hoppe et al, 2007).

2. Economic Impact of Agriculture to Ohio

In addition to the production of agricultural commodities, it is also important to evaluate the significance of Ohio's value-added agricultural processing capabilities. One comprehensive estimate of the impact of the food and agricultural industry on Ohio's economy is "OHFOOD: An Ohio Food Industries Input-Output Model," authored by Dr. Thomas Sporleder of the Department of Agricultural, Environmental, and Development Economics at the Ohio State University. The most recent version of OHFOOD uses 2006 data. The model's "food and related agricultural cluster" is comprised of five sectors:

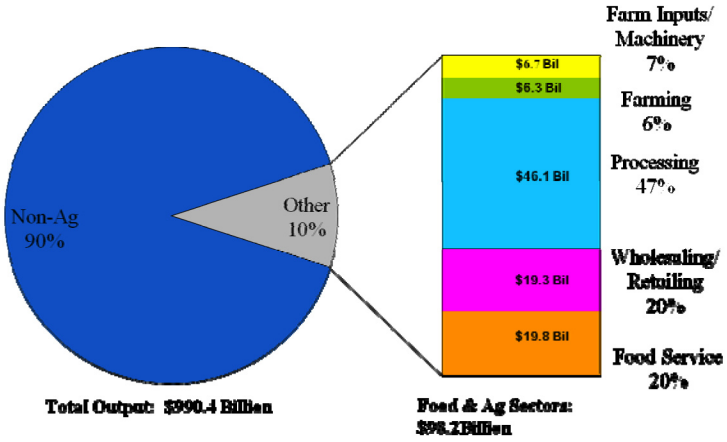
1. Farm inputs, equipment & professional services;
2. Farming;
3. Processing;
4. Food & forestry wholesale/retail; and
5. Food services.

The net findings of OHFOOD are that, in aggregate, these five sectors comprising the "food and related agricultural cluster" account for 924,000 jobs in Ohio, or almost one of every seven jobs in the state *(Sporleder, 2008)*. The bulk of these jobs are found in the food services sector, which which alone contributes 416,000 jobs. The food services sector contains

away-from-home food service jobs, primarily found in restaurants and institutions (e.g., schools, hospitals, prisons).

Following food services, the next sector containing the most jobs is the food & forestry wholesale/retail sector, at 256,000 jobs. As the farming sector accounts for nearly 96,000 jobs in Ohio, approximately 1.4% of Ohio's work force of 6.7 million is employed in farming. The farm inputs, equipment and professional services (e.g., veterinary services) sector contributes 33,000 jobs in Ohio.

In addition to jobs, another useful metric by which the significance of the food and agricultural cluster can be analyzed is total economic output. In terms of total economic out put, the food and agricultural cluster generates a total of $98.2 billion, which is almost 11 percent of Ohio's economic output, or $1 out of every $9. The single largest contributing sector is the processing sector (e.g., food and wood processing), which accounts nearly half of the $98.2 billion output, at $46 billion.



The food processing portion of the processing sector includes not only the processing of meat, fish, poultry, eggs, dairy, food and kindred products, but also grain milling and flour production, fats and oils processing, and beverage processing. The forestry processing portion includes the processing and production of wood and paper, as well as wood furniture manufacturing. After processing, the next most significant sectors in terms of contributing toward the $98.2 billion in economic output are food services ($19.8 billion) and food and forestry wholesale/retail ($19.3 billion).

The farming sector generates a total output of $6.4 billion, or almost 7 percent of the total output of the food and agricultural industry. The highest contributing portion of this sector is the production of livestock (e.g., beef, dairy, milk, poultry, eggs, hogs), which generates almost $2.1 billion of that output. Oil crop production (i.e., soybeans) is the next highest contributor ($1.2 billion), followed by the value of grain production (e.g., wheat and corn) at $1.1 billion.

The combined economic output of each of the four remaining components of the farming sector is slightly less than the economic output of Ohio's livestock industry. The forestry, hunting, and fishing component of farming adds $652 million in output, followed by nursery and horticultural production's value of $601 million, and the category of miscellaneous crops, hay, sugar, tobacco, and nuts ($454 million). Finally, the fruits and vegetables portion of the farming sector generates $284 million in economic output.

3. **Significance of Agricultural Processing in Ohio**

As the previous section had detailed, the agricultural processing sector is a significant economic driver in Ohio. It contributes $46 billion to the state's economy and employs 124,000 Ohioans. In this context, agricultural processing includes food processing and wood, paper and furniture manufacturing. Food processing is further defined to include

1. Processed meat, fish, poultry & eggs;
2. Dairy processing;
3. Processed food & kindred products;
4. Grain milling & flour;
5. Fats & oils processing; and
6. Beverage processing.

Another important source of data is the agbioscience sector in Ohio. The Ohio Agricultural Research and Development Center (OARDC) hired Battelle's Technology Partnership Practice to conduct a study which evaluated, in part, the state of the agbioscience sector in Ohio in 2004. While there is no universally acceptable definition of "agbioscience," it is defined within the context of the study as being comprised of eight distinct components

1. Agricultural processing (e.g., agricultural milling, livestock oil milling);
2. Organic & agricultural chemicals (e.g., fertilizers);
3. Agricultural services (e.g., soil preparation, planting services, etc.);
4. Agricultural machinery & equipment (e.g., farm machinery, food product machinery);
5. Agricultural research & testing (e.g., food and seed testing, veterinary testing, etc.);
6. Food processing (e.g., fruits and vegetables, meat processing, beverage production);
7. Drugs & pharmaceuticals (e.g., medicines & botanicals, pharmaceutical preparations, etc.); and
8. Biological research & testing (e.g., biological research, medical research, medical laboratories).

These eight components comprise an agbioscience industry that is much narrower than the overall "food and agriculture cluster" examined by the OHFOOD model. This is because these eight sectors were specifically selected as enabling the study to "focus solely on those industry sectors that are driving the agricultural technological advances within the state" (Battelle Memorial Institute, 2004).

This study found that Ohio was home to 2,839 agbioscience firms, which collectively employed over 92,000 Ohioans. Furthermore, the number of firms grew by 23% between 1998 and 2003.

As the Battelle study broke the category of "agbiosciences" into eight subsectors, two of those subsectors were directly related to processing: agricultural processing (agricultural milling, malt manufacturing, livestock oil milling) and food processing (fruits, vegetables and grains preparation, meat processing, beverage production). Agricultural processing was determined to be the leading subsector in Ohio in terms of growth and employed 6,220 people in 2003, an increase of 287% from 1998.

The study found that Ohio's food processing subsector had a 12 percent drop in employment, while the subsector grew by 1.5 percent nationally. In spite of this substantial downward trend, food processing is still the largest of the eight subsectors in terms of employment, with nearly 53,000 Ohioans employed in this subsector. In other words, over one-half of all employment in Ohio's agbioscience industry can be found in food processing.

In addition to the processing subsectors, the next two leading subsectors of Ohio's agbio science sector were agricultural research and testing, and agricultural machinery.

Employment in Ohio's agricultural research and testing subsector grew by 36 percent between 1998 and 2003, whereas employment decreased by 3.8 percent nationally. The agricultural machinery subsector grew by over 4 percent during the same time period, which is twice the growth rate nationally.

Ohio's single largest drop in an agbioscience subsector can be found in agricultural services, which had a 42 percent drop in employment between 1998 and 2003. When viewed within the context of national growth in agricultural services, which noted this subsector surpassing 6 percent, the decline in Ohio appears all the more impactful.

4. **Ohio's National Position in Agricultural Production (ODA, 2006)**
Located at the eastern edge of the U.S. cornbelt, Ohio is a leading producer of a large variety of livestock and grains, as well as fruits and vegetables.

Ohio's 2006 production of crops made it the nation's fifth highest producer of winter wheat (65 million bushels) and the sixth highest producer of both corn (471 million bushels) and soybeans (217 million bushels). It is the nation's second highest egg producing state, and eighth in the number of chickens sold. Additionally, Ohio has the nation's 10th highest number of hogs and pigs (1.7 million) and milk cows (274,000). Ohio's milk cow numbers position it to annually produce 4.9 million pounds of milk, which is the 11th highest producing state.

A thriving fruit and vegetable industry exists in Ohio. The state is fifth in the nation in the production of both sweet corn and fresh tomatoes. Ohio is sixth in the production of cu cumbers and ninth in the production of both apples and strawberries. Additionally, Ohio is home to over 2,200 acres of vineyards which produce 31,000 tons of grapes per year, making it 10th in the U.S. in grape production.

Seven million pounds of tobacco are annually produced in Ohio, earning it the eighth highest ranking in total production. Ohio produces 78,000 gallons of maple syrup per year, which is fourth in the nation.

In terms of agricultural processing, Ohio's 147 livestock slaughter plants and 46 manufactured dairy plants position it as the nation's fourth and fifth leading state, respectively. The strong presence of dairy manufacturing facilities enable Ohio to be a top ten state in the production of milk, sherbet, ice cream and cottage cheese, as well as the first state in the nation in Swiss cheese production.

5. **Ohio's Inventory of Biomass Resources**
Ohio's agricultural industry also offers substantial biomass resources. Researchers at the Ohio State University led a 2004 geographic assessment of Ohio's biomass energy potential (Jeanty et al, 2004). The study evaluated Ohio's biomass resources in the following categories:

1. Crop Residues;
2. Wood Biomass;
3. Livestock Manure;
4. Municipal Solid Waste; and
5. Food Processing Waste.

The research found that Ohio has tremendous potential in this area and is ranked nationally as having the 11th highest total amount of biomass potential (although this ranking is thought actually to be higher than 11th , due to the fact that detailed data is currently not available on food processing waste; Ohio ranks fourth nationally in total food processing production). The study further concludes that, through Ohio's use of renewable biomass sources, enough energy could feasibly be generated to "fully supply the annual needs of 2,758,000 average homes, or 64% of the residential electricity use in Ohio" (Jeanty et al, 2004)

The study found that municipal solid waste is the single largest potential source of biomass energy, comprising 68% of Ohio's total biomass potential. The agricultural source of Crop Residues composes 19% of Ohio's biomass potential. Key components of Ohio's biomass potential can also be found in Wood Biomass (12%) and Livestock Manure (1%).

In addition to Crop Residue, Wood Biomass, and Livestock Manure, another critical part of Ohio's agricultural industry, Food Processing Waste, was not accounted for in this estimate. Although sufficient data was not available, this source is estimated to be a very significant source of biomass in Ohio.

The assessment also offers spatial analysis of biomass distribution in Ohio, as it evaluated Ohio as eight geographic regions. The net result is that the Northwestern portion of Ohio (Williams, Fulton, Defiance, Henry, Paulding, Putnam, Hancock, Van Wert and Allen Counties) has the greatest comparative advantage in terms of Crop Residue biomass potential. In the context of this study, Crop Residue was limited to wheat straw and corn stover (cobs, stalks, leaves, etc.).

Northeastern Ohio (Ashtabula, Columbiana, Cuyahoga, Geauga, Lake, Mahoning, Medina, Portage, Stark, Summit and Trumbull Counties) has the most Wood Wastes biomass inventory. Wood waste is a function of not only forest residues, but also wood processing residues, wood debris from construction and demolition, and the wood and paper recovered from municipal solid waste.

The Western region of the state (Auglaize, Champaign, Clark, Darke, Logan, Mercer, Miami and Shelby Counties) is the leader for Livestock Manure biomass. This portion of the state has large number of large livestock farms, giving it a comparative advantage in producing this source of biomass.

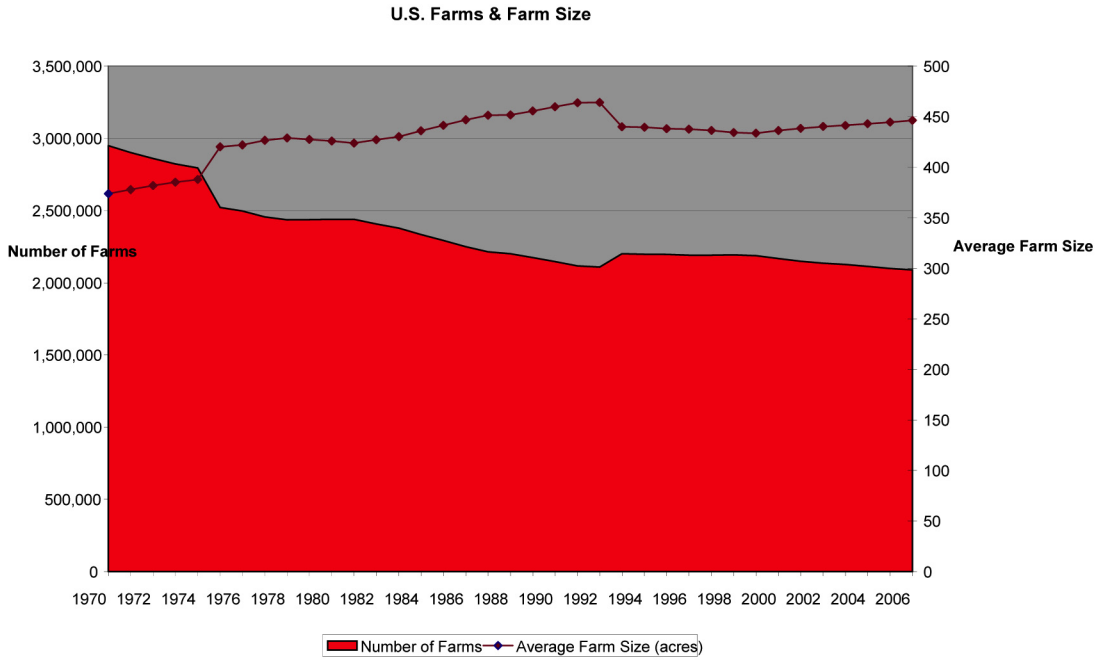
Given the overwhelming advantage in biomass energy potential derived from Municipal Solid Waste, Northeastern Ohio is estimated to be the overall leading region in Ohio in terms of total biomass potential (Jeanty et al, 2004).

B. Conditions and Trends in Agriculture Industry

1. Historical Farming Trends

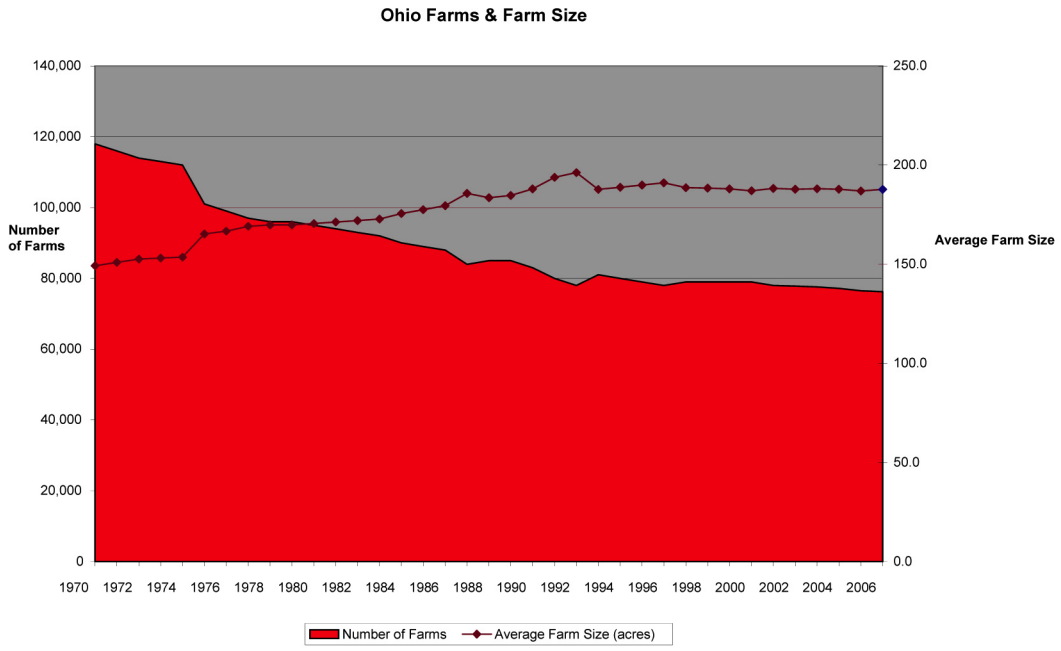
Nationwide, two factors of significance have had an impact on the number of farms in the United States. Since the mid-1930s, while the opportunities for non-agricultural jobs began steadily growing after the unemployment peak of the Great Depression, the productivity of U.S. farms had steadily increased (Hoppe et al, 2007). This increased farm productivity allowed workers the opportunity to leave the farming industry for employment in the expanding non-farm sector. As net agricultural productivity increased, the number of U.S. farms correspondingly decreased.

In 2006, there were approximately 2.1 million farms in the U.S., with an average size of 446.4 acres. In 1970, the U.S. had 2.95 million farms, with an average size of 373.8 acres per farm. Between 1970 and 2006, the number of farms in the U.S. decreased by 29%, while the average farm size increased by 19% *(Ramey, 2008)*.



Ohio serves as a clear illustration of this national trend. In 2006, there were approximately 76,000 farms in Ohio, with an average size of 187.7 acres. In contrast, Ohio had 118,000 farms, with an average size of 149.2 acres per farm, in 1970. By 1980, the number of farms decreased to 95,000, while the average farm size increased to 170.5 acres. This trend continued in 1990, as there were 83,000 farms remaining, with a mean size of 188 acres *(Ramey, 2008)*.

Between 1970 and 2006, the number of farms in Ohio shrunk by 35%, and the amount of farmland decreased 19%. During the same period, the average size of an Ohio farm grew by 26%, and the average value of Ohio farmland increased by 875%.

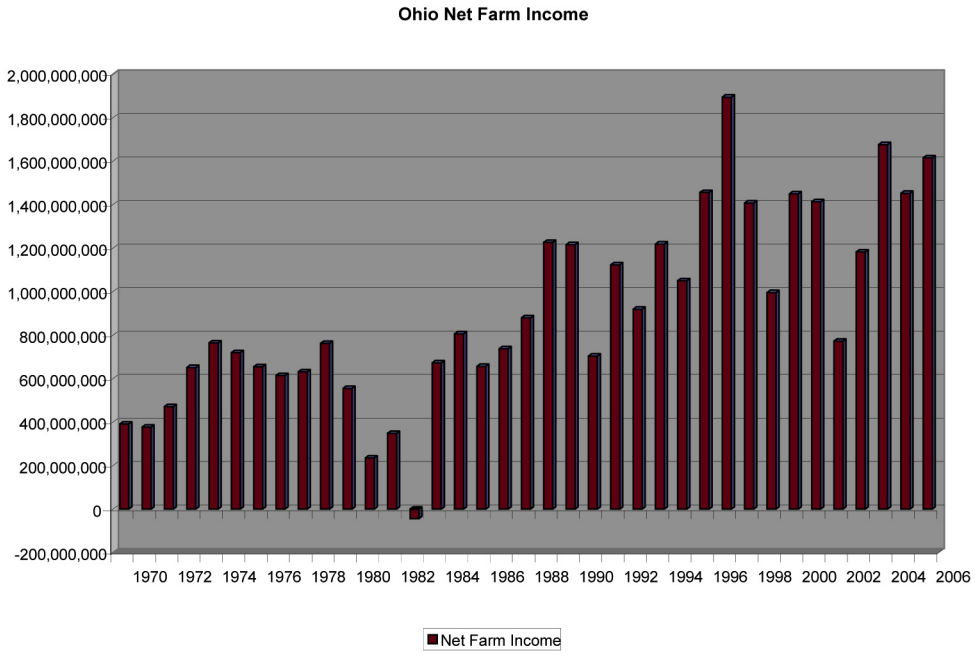


2. Ohio Farm Income Trends

Large farms (those with sales of at least $250,000) have increased in their relative share of U.S. production. These farms accounted for 76% of all sales in 2002, as compared to only 47% in 1982. At the same time, small farms with sales of under $10,000 decreased in their respective share of sales, down from 3% to 1%. Although small farms decreased in their overall share of total sales, they comprised 59% of all farm operations in 2002, up from 49% in 1982 (Hoppe et al, 2007). In summary, America's large farms are producing a greater share of the total U.S. production, middle size farms (sales between $10,000 and $249,999) are producing a lesser share, and small farms are becoming a more common farm-size.

Since 1970, the aggregate nominal value of net farm income on Ohio's farms has generally trended upward. However, this value has experienced significant periods of volatility and fluctuation during that time period.

Ohio net farm income gradually increased from $390.5 million in 1970 to $761.8 million in 1979 (Ramey, 2008). In 1981, this value dropped to $234.6 million, and it further plummeted to negative $43.6 million by 1983. By the end of the 1980s, Ohio net farm income had rebounded to $1.22 billion. By 1997, net farm income reached a new peak of $1.89 billion. The net farm income level of 2002 had fallen to $771.8 million, a nearly $1.1 billion decline from the value of just five years prior. By 2006, net farm income had increased to $1.61 billion.



3. **Trends in Ohio Agricultural Production** ***(Ramey, 2008)***
In 1976, Ohio's cash commodity cash receipts were $2.74 billion. This value had grown to $3.6 billion in 1986, $4.8 billion in 1996, and $5.5 billion by 2006. In 1976, the top five commodities in Ohio were corn, soybeans, dairy, hogs, and cattle & calves. These five commodities were alone responsible for 75% of receipts in 1976. The composition of Ohio's commodity landscape has changed significantly in the past 30 years.

Nevertheless, in terms of cash receipts, soybeans and corn have consistently been the top two agricultural commodities in Ohio for the past 30 years. In 2006, soybeans produced $1.2 billion in receipts, or 21.2% of total receipts from commodities in Ohio, followed by corn's value of $990 million (18.0% of receipts). Collectively, these two commodities accounted for nearly 40% of all agricultural commodity receipts in Ohio in 2006.

Milk production has consistently been the third highest commodity in Ohio in terms of receipts, with a 2006 value of $670 million, or 12.2% of total commodity receipts. The growth in the value of milk's cash receipts has been slight, and its share of Ohio's total commodity receipts has thereby decreased from 16 % in 1976.

Perhaps the single greatest upward surge by a farm commodity has been in the green house & nursery sector. While it was valued at only 3.6% of Ohio's production in 1976, and 4.3% in 1986, it produced $604 million in receipts in 2006, or 11% of Ohio's total farm receipts.

Another commodity of significant growth in Ohio has been the poultry & eggs sector. Poultry and eggs contributed only 4.6% of Ohio's agricultural receipts in 1976, and it produced nearly 9% by 2006, or $470 million. Additionally, the value of vegetable production in Ohio has witnessed a trend of growth. Vegetables have grown from a value of $94 million in 1976 to a 2006 value of $275 million, which is 5% of Ohio's commodity receipts.

Both hogs and cattle & calves have traditionally been significant livestock sectors in Ohio agriculture. By 1996, however, both hogs and cattle & calves had declined in their relative contribution toward Ohio's agricultural receipts and had fallen out of the top five commodities in Ohio. While they have not experienced the growth of other commodities, each of the two produced around $400 million in receipts in 2006, or roughly 7% of the state's commodities value. By comparison, hogs provided 10% of Ohio's commodity receipts in 1976, and cattle & calves provided 11%.

Wheat in Ohio has experienced a similar trend to that of hogs and cattle & calves: mild growth in absolute value of production, which results in a decline in its relative share of the value of Ohio's agricultural production. While wheat's 1976 production value of $183 million accounted for nearly 7% of agricultural receipts, its 2006 value had grown to only $203 million, and its share of Ohio's total commodity receipts dropped to less than 4%.

The sheep & lambs industry has been nearly flat in the value of its production. While the nominal cash receipts of the industry has varied between $11 million to $13 million since 1976, the sheep and lambs industry has decreased in its relative share of receipts, shrinking from 0.4% in 1976 to 0.2% today.

In the past 30 years, several other commodities have seen much more significant decline in their relative and absolute economic significance to Ohio's agricultural industry. Potatoes generated $13.5 million in receipts in 1976 and only $8.4 million in 2006. Having fallen in their absolute value of production, potatoes have correspondingly decreased in their relative production, down from 0.5% of Ohio's commodity receipts in 1976 to 0.2% in 1976. Tobacco's total cash receipts have decreased significantly, as its 1976 nominal value of production of $22.2 million had declined to $11 million by 2006. Oats have consistently declined in total cash receipts in Ohio, from nearly $21 million in 1976, to $5 million by 1996, and $4.6 million in 2006.

Sugar beets and popcorn have both disappeared as significant Ohio commodities. Production of sugar beets was valued at nearly $13 million in 1976, and popcorn brought in $5.1 million in receipts that year. By 1996, neither commodity had measurable receipts in Ohio.

4. Trends in Values of Ohio Farmland

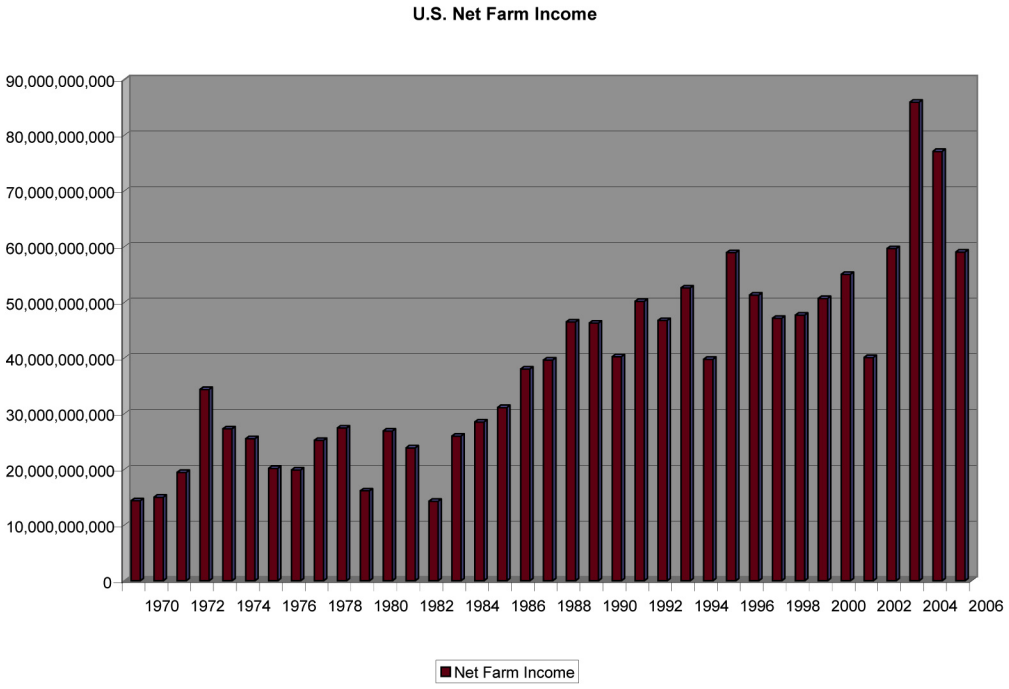
The value of farmland in Ohio is an indication of the present value of future cash flows to the owner of the land, which often takes the form of annual rents or operating returns *(Forster et al, 2003)*. As in the case of net farm income, farmland values in the state have generally undergone steady increases, yet experienced significant volatility.

The average value of Ohio farmland in 1970 was $399 per acre. This value more than doubled by 1976, and doubled again by 1980. In 1981, farmland values in Ohio reached a new peak of $1,831 per acre. This value tumbled throughout the rest of the decade, and the 1981 value of farmland was not realized again until 1997's average value of $1,890 per acre. Since 1997, Ohio farmland prices have consistently increased every year, to a new high of $3,490 per acre in 2006.

A recent survey conducted by OSU Extension of landowners, farmers, prospective buyers, and lenders, revealed a more extensive breakdown in the values of Ohio farmland. This research found that Ohio's most productive crop land averaged $4,001.79 per acre in 2006, average land was $3,371.17 per acre, while marginal land averaged $2,759.81 (Ward, 2007). The highest producing cropland in northeastern Ohio averaged $4,630.77 per acre.

In those regions of the state in which agriculture is historically stronger, the two factors which directly affect the annual rents (or operating returns) of farmland include soil productivity and drainage improvements *(Forster et al, 2003)*. In regions of the state with stronger demands to convert farmland to other uses (residential, commercial or industrial), development pressures shape the values of farmland much more so than any other farmland attributes.

5. **Trends in U.S. Farm Income (Ramey, 2008)**
The trends of U.S. farm income have paralleled those of Ohio net farm income. That is, farm income levels have generally increased over time, but they have also been subject to significant fluctuations and volatility. U.S. farm income levels more than doubled from $14.3 billion in 1970 to $34.3 billion in 1973. However, by 1983, this income level had dropped down to $14.26 billion. Farm income levels surpassed $46 billion by 1989, and had reached $58.9 billion by 1996. Year-to-year fluctuations in income continued, as farm in come had reached $85.9 billion in 2004, and dropped to $59 billion in 1996.



The USDA is projecting record high prices in major farm commodities for the 2007/2008 crop season, which should support stronger farm income levels. For example, the season average farm price for the 2007/2008 corn crop is $4.30 per bushel, a 94% increase over the previous five year average. When compared to the previous five year average of prices, current soybean prices have increased 70%, wheat prices are up 55%, and rice prices have increased 69% *(Schnepf, 2008)*.

6. **Developing Investment Opportunities in Value-Added Ventures**
   Another developing area in Ohio agriculture is the opportunity for farmers to diversify their respective investments in agriculture. For example, producer alliances like Heartland Agdeavor provide Ohio farmers with the opportunity to invest in businesses that further process agricultural commodities. This model enables farmers to join for an initial $800 fee, plus a $200 annual fee (White, 2005). Heartland Agdeavor provides extensive screening, research and review on various project proposals, and then provides its members the opportunity to invest in those projects which are deemed to have the highest chance of success.

   Should the farmer-members elect to move forward with a specific investment, the organization also provides the added service to its farmer-members of setting up the legal structure needed to make a specific investment, such as an LLC (Reese, 2006). As minimum investment levels in bioenergy or other value-added projects may easily exceed $1 million, it is largely cost prohibitive for individual farmers to invest *(Reese, 2006)*. Given the proper legal structure, however, several members may be able to join together in leveraging their resources to provide capital for a project.

   Ohio organizations like Heartland Agdeavor enable farmers to diversify their investments beyond the farm gate and capture more of the increased value as commodities leave the farm. At the same time, such organizations also provide a potential source of venture capital for the entrepreneurial bio-processors in Ohio, thus building upon the financial bridge linking agriculture and advanced materials.

7. **Trends in Energy and Ohio Agriculture**

   a. **Introduction**
      The degree to which agriculture can satisfy our nation's energy needs continues to rapidly grow. One of the primary ways is through the production of agriculturally-based motor vehicle fuels (ethanol and biodiesel), which serve as an alternative to petroleum-based fuels. Other emerging technologies include everything from wind turbines to anaerobic digesters which convert livestock waste to energy, to the co-firing of biomass with coal through anaerobic digestion. These and future technologies offer new ways in which agriculture can contribute to satisfying the energy needs of Ohio and the nation.

   b. **Food vs. Fuel**
      As policymakers consider the development of Ohio's agbioproducts industry, it is important to be cognizant of the current dialogue surrounding the correlation between the developing biofuels industry and global increases in food prices.

      Without question, global food prices have dramatically risen in a very short amount of time. The World Bank estimates that global food prices have risen by 83% in the past three years (Martin, 2008). According to the United Nations' Food and Agricultural Organization (FAO), international food prices have risen 18% in just the first quarter of 2008 (Schnepf, 2008). Furthermore, the FAO has recently identified 37 nations, the majority of which are in Africa, as being in food crisis.

      The aggregate increase in global food prices is a function of many complex supply and demand factors, and cannot be attributed to one factor alone. On the supply side, adverse weather conditions in major grain exporting nations such as Australia, Canada, the European Union (EU) and the Ukraine have reduced the aggregate supply of crops

which can be exported and sold on the global marketplace *(Jiang, 2008)*. The EU, which has traditionally been a net exporter of grain, became a net importer in 2007, due to its inability to produce enough grain for its livestock producers *(Schnepf, 2008)*.

Further affecting the available supply of grains are the policy decisions by food exporting countries to restrict exports. While these policies are intended to hold domestic prices in check, and thereby ensure the internal availability of food, they serve to further limit the supply of food available to other nations. For example, Argentina and Russia have each increased export taxes on soybeans and wheat to over 40%, and Kazakhstan and Indonesia have completely halted exports of wheat and rice, respectively *(Faiola, 2008)*. Over one-third of the world's available rice export supplies have been removed due to the export restrictions imposed by the governments of Vietnam, India, China, Egypt and Cambodia *(Schnepf, 2008)*.

At the same time that world food supplies are decreasing, demand is increasing. In nations with booming economies, most notably India and China, the dietary demand for food has significantly shifted. The demand in these countries has transitioned to favor higher-value foods, like meats and dairy, which require more grain to produce via the production of livestock *(Schnepf, 2008)*. These nations can afford to satisfy such a shift in demand because the value of the U.S. dollar continues to weaken abroad, thereby increasing the buying power of these economies.

As China and India are importing more grains than ever before to satisfy their evolving tastes, many other nations must continue to maintain their historical dependence upon agricultural imports to meet their staple nutritional needs. Poorer nations such as Senegal and Haiti annually import 80% of the rice that they consume *(Bradsher, 2008)*, and Mauritania must import 70% of all the food needed to sustain its 3 million people *(Failoa, 2008)*.

Further increasing the demand for commodities are government mandates for the use of biofuels. The "Energy Independence and Security Act of 2007" mandates that the U.S. produce 36 billion gallons of ethanol by 2022, with 15 billion of those gallons being produced from corn. By comparison, the U.S. produced approximately 6.5 billion gallons of ethanol in 2007, and it is estimated that 24% of the 2007/2008 U.S. corn crop will be converted to ethanol *(Schnepf, 2008)*.

Other agricultural exporters also have biofuel mandates in place, including Brazil and the EU. Brazil's policies favor ethanol produced from sugarcane, and the EU favors vegetable-oil based biodiesel, which ultimately incents the production of rapeseed. Rapeseed production is then increased at the expense of other grains, including wheat and barley *(Schnepf, 2008).*

In addition to government mandates, historically high petroleum prices are further enhancing the economic competitiveness of biofuels. The increased demand for biofuels then correspondingly contributes to the increased demand for their feedstocks *(Jiang, 2008)*.

Also adding upward pressure on global prices is the fact that the costs of production are significantly increasing. Between 2007 and 2008, fertilizer costs for producing corn in the U.S. have more than doubled, from $80 per acre to $175 per acre. At the same time, fuel costs have increased by 58%, crop insurance costs have doubled, and land rents and seed costs have both increased by 16% *(Los Angeles Times, 2008)*. Grain farmers are not the only agricultural producers facing severely rising input costs. Because of higher grain prices, U.S. livestock producers are projected to face feed costs this year valued at $45 billion, which is an 18% increase in feed costs over 2007 *(Schnepf, 2008)*.

Not only have the production costs increased for growing agricultural commodities, but so have all the other costs in the entire food marketing chain. Only 20% of retail food prices facing U.S. consumers is attributed to the price of the actual farm-produced commodity. The remaining 80% of the cost of food is a function of processing, transportation, packaging, handling and advertising *(Schnepf, 2008)*. All of these costs are highly sensitive to the increased fuel and energy costs.

c. Ethanol Production in Ohio

An emerging portion of advanced agricultural processing in Ohio is its ethanol industry. As a major producer of corn, Ohio has in fact lagged behind many of the major agricultural states in ethanol production, as there were no operational ethanol production facilities in Ohio until January of 2008. As of April 30, 2008, the following plants are already in operation (Ohio Department of Development, 2008):

1. The 60 million gallons per year Summit Ethanol LLC/POET Energy (Leipsic);
2. The 110 million gallons Andersons/Marathon Ethanol (Greenville);
3. The 60 million gallons Coshocton Ethanol LLC/ Altra (Coshocton);
4. The 54 million gallons per year Greater Ohio Ethanol (Lima); and
5. The 110 million gallons VeraSun Energy (Bloomingburg).

At initial capacity, these five facilities will collectively produce approximately 394 million gallons of ethanol per year from 140 million bushels of corn *(Ohio Department of Development, 2008)*.

In addition to these five plants, two additional POET Energy facilities at Marion (60 million gallons) and Fostoria (60 million gallons) will be opened within the next year. With the addition of these two facilities, Ohio's annual ethanol production will be close to 500 million gallons, and its ethanol industry will utilize nearly 182 million bushels of corn.

In terms of economic investment in Ohio, POET Energy is alone investing approximately $400 million in Ohio through the construction of its three facilities in Leipsic, Marion, and Fostoria.

d. Soy Biodiesel Production

Another emerging portion of advanced agricultural processing is the production of soy biodiesel. While not all biodiesel uses soybean oil as a feedstock, approximately 80-90% of biodiesel made in the United States is soy-based *(Ohio Soybean Council, 2008)*. This sector uses the number one cash crop in Ohio, soybeans.

Production capacity of this renewable fuel has grown considerably over the past five years with Peter Cremer North America in Cincinnati being the largest producer, with over 40 million gallons produced per year. There are also a number of smaller biodiesel production facilities in Ohio including:

1. American Ag Fuels in Defiance;
2. PK Biofuels in Woodstock;
3. JatroDiesel in Miamisburg;
4. Chieftain Biodiesel in Logan;
5. Agrifuels in Bremen; and
6. Center Alternative Energy in Cleveland *(Ohio Soybean Council, 2008)*.

Together these smaller producers provide an additional 25 to 30 million gallons of annual biodiesel capacity.

Ohio's Specialty Chemicals and Polymer Industry

A. Overview of Specialty Chemicals and Polymer Industry

Ohio's robust food and agricultural industry sits next to a thriving industry in the production of chemicals, polymers, and advanced materials. The production of chemicals, polymers, and advanced materials contributes over $13.8 billion in revenue and employs over 120,000 citizens. The production of chemicals, polymers, and advanced materials in Ohio has increased over 15% (combined) from 1999-2005. At the same time that this surge in production has occurred, other manufacturing industries in Ohio have realized significant declines. Non-primary metal production has fallen nearly 3% in the same period, and the production of primary metals and minerals has decreased over 25% *(Ohio Department of Development, 2008)*.

The exports of chemicals, polymers, and advanced materials represent $5.3 billion to Ohio's economy. The impact of chemicals, polymers, and advanced materials is far-reaching, demonstrated by the fact that they are key components in the production of transportation equipment and vehicles. Furthermore, materials from these segments are components in 90% of all manufactured goods produced in Ohio. The production of chemicals, polymers, and advanced materials therefore directly affects 90% of Ohio's primary source for income and employment, and manufacturing. While these numbers may sound extraordinary, it is important to note that this study uses the following well-accepted North American Industry Classification System (NAICS) codes in its definitions:

- 325000 through 325999 (Chemical Manufacturing);
- 326000 through 326999 (Plastics and Rubber Products Manufacturing);
- 333220 through 333229 (Plastics and Rubber Manufacturing Machine);
- 327200 through 327299 (Glass and Glass Product Manufacturing); and
- 327900 through 327999 (Other Materials Manufacturing).

Chemicals, polymers, and advanced materials segments are directly affected by the cost of oil. They utilize petroleum in three important ways, as a:

1. Raw material;
2. Source of energy required in their production; and
3. Fuel source required to transport them to their destination.

Note that the manufacturing sector consumes 70% of all energy usage nationwide *(National Association of Manufacturers, 2008)*, and over 40% of this energy is derived from petroleum and natural gas (20% and 21% respectively).

1. **Chemicals Industry**

A working definition of "chemical" is important to the overall discussion of the special chemicals industry. Base chemicals, those from which all other chemicals are derived, are either:

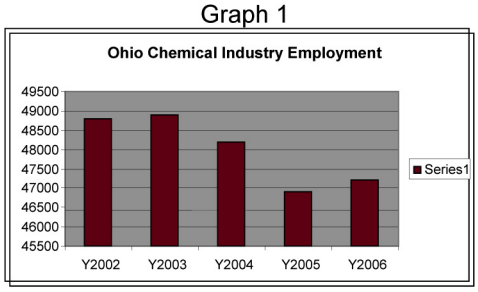
1. Petrochemicals, or
2. Inorganic chemicals (Ohio Chemistry Technology Council, 2008).

Petrochemicals are created through the refining of petroleum or processing of natural gas. These are the building block chemicals: ethylene, propylene, butadiene, toluene, xylenes, and methanol. Inorganic chemicals are derived from non-organics, principally minerals. They include ammonia, caustic soda, sulphuric acid, chlorine, sulphur, soda ash, bromine, fluorine and phosphorus.

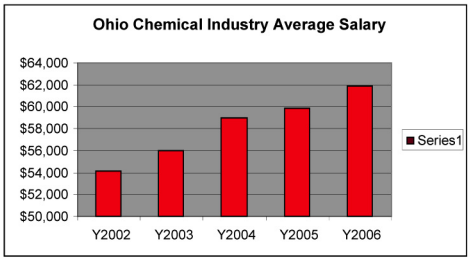
The Ohio Chemistry Technology Council (2008) has noted that, in general, the chemical industry "does not sell products directly to the final consumer," because chemicals generally "lose their identity as they become building blocks for industrial and consumer products." On one hand, this fact diminishes the perception of "local" economy as the industry suffers from the increases in oil costs. But on the other hand, changes to chemical products are essentially "blind" to consumers. These "building blocks" can be effectively substituted unbeknownst to consumers, as long as the products ultimately purchased by the end con sumer are unaffected.

The chemical industry is significant to Ohio's employment with 47,000 citizens employed in this industry in 2006. Graph I depicts the decline of employment in the chemical industry from 2002 through 2005, but then an increase occurred in 2006 *(Ohio Chemistry Technology Council, 2008)*. Though the overall production of chemical production has declined, the production of specialty chemicals has increased and surviving facilities are usually very efficient. Labor productivity has improved significantly over the last two decades, rising at an average of about 2% between 1989 and 1999.

Graph 1

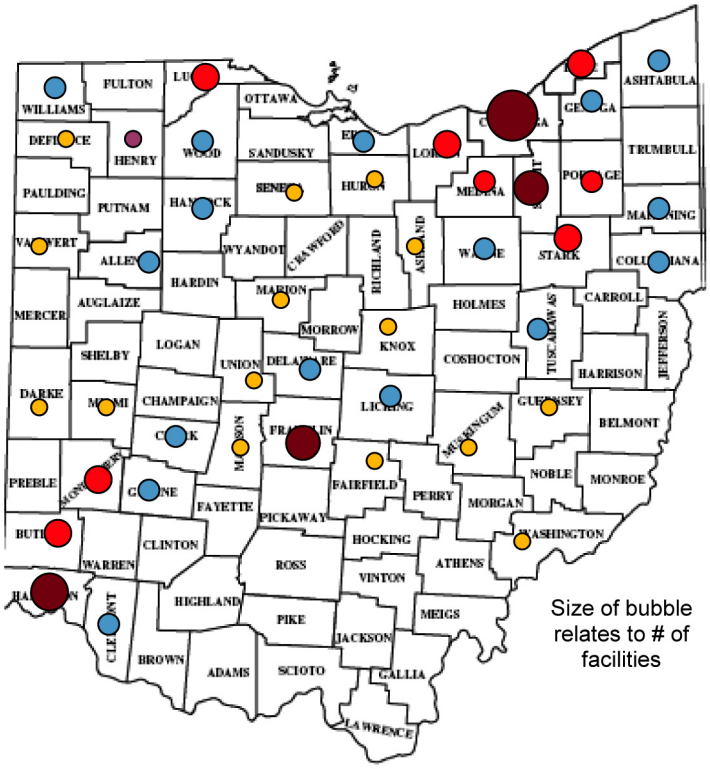


Graph 2



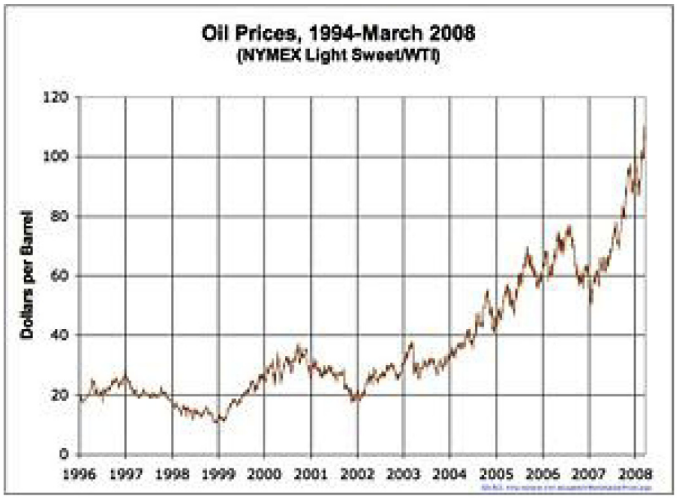
Not only has the number of employees declined in the chemical industry, but so has the number of establishments as older facilities become obsolete. Even as the number of facilities and employees has declined, the salary for employees has risen significantly, as depicted in Graph II above.

Currently, there are over 950 chemical industry facilities in Ohio (NAICS codes 325000 – 325999 *(Selectory.com, 2008)*. The map below demonstrates a wide-spread support of the chemical industry with placement of facilities in many counties. While the concentration of production facilities is along the I-71 corridor, nearly every county can contribute to the overall success of chemical production in Ohio.



The concentration of chemical production facilities is along the coast of Lake Erie and the Ohio River—with other pockets of chemical production existing along the I-75 and I-71 corridors. The lack of a substantial rail system prohibits sustainability to chemical facilities in other sections of the state. This is also true for production supporting the polymer and advanced materials industry.

Production of chemicals is capital intensive, and petroleum is often a raw material for many chemical products. Furthermore, many production facilities use petroleum energy in production processes. An increase in the price of oil has reverberating responses in the cost to produce chemical products.



In a relatively short amount of time, oil prices have risen dramatically *(Bloomberg.com, 2008)*. With this marked increase in oil production, the cost to produce and sell chemical products also increases.

At the global level, China is now the largest growing market for oil consumption. Closely following China's surging consumption is India. China, India, and other emerging economies will increase consumption of oil in the world by 57% over the next 15 years.

2. The Polymer and Advanced Materials Industry

The polymer industry, which includes rubber, plastics, coatings, adhesives and many specialty products, is a large component of Ohio's economy, in both the dollar value of products shipped from Ohio and the number of people employed.

PolymerOhio Inc., a statewide industry organization, reports that the polymer industry is Ohio's largest manufacturing industry, providing over 140,000 jobs and $49 billion in shipments annually. Depending upon how the polymer industry is defined in Ohio, it involves between 2,500 and 3,000 separate companies.

As an industry that has grown at annual rates of 5 to 10 percent, it has the advantage over start-up industries of creating incremental economic impacts that are valued annually in billions of dollars and thousands of new jobs. For Ohio's economic future, it is vital to bring novel technologies and new business opportunities into this critical sector. A recent Battelle study cited as one of the most relevant choices of connecting a broad-based and comprehensive polymer and an agriculture renewable products center (2004). This was again confirmed in the unpublished Battelle "technology platforms" study (2005). As the leading polymer and advanced materials state in the nation, Ohio needs to be the main player in this high-potential field.

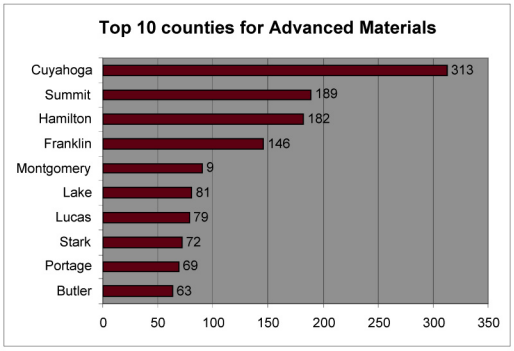
Banfield, Mullins, and Myers (2008) point out that because plastics are in a relatively early stage of their product life cycle, the production of plastics is experiencing significantly high growth rates worldwide. The authors cite that plastics production in the EU annually grew by 4.4% between 1985 and 2000, while the total production of all bulk materials

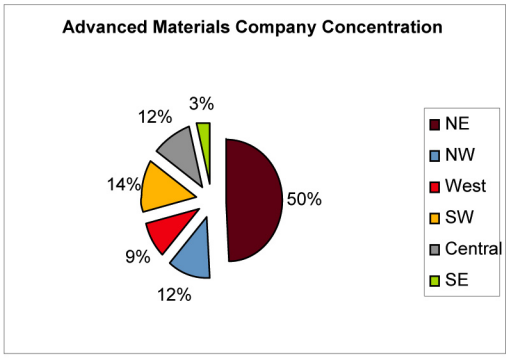
(without roundwood and bricks/tiles) increased by merely 1.4%. The significantly high growth in plastics production is projected to continue into the future *(Banfield, Mullins, and Myers, 2008)*.

The plastics industry also includes composites, which are replacing many steel-based components in the power and propulsion industry. This growth in composites is going to be dramatically affected by Boeing's composite use in their new aircraft (American Composites Manufacturing Association, 2008). The recent growth in composites usage is of particular importance to Ohio, as it is the leading producer of composites in the U.S.

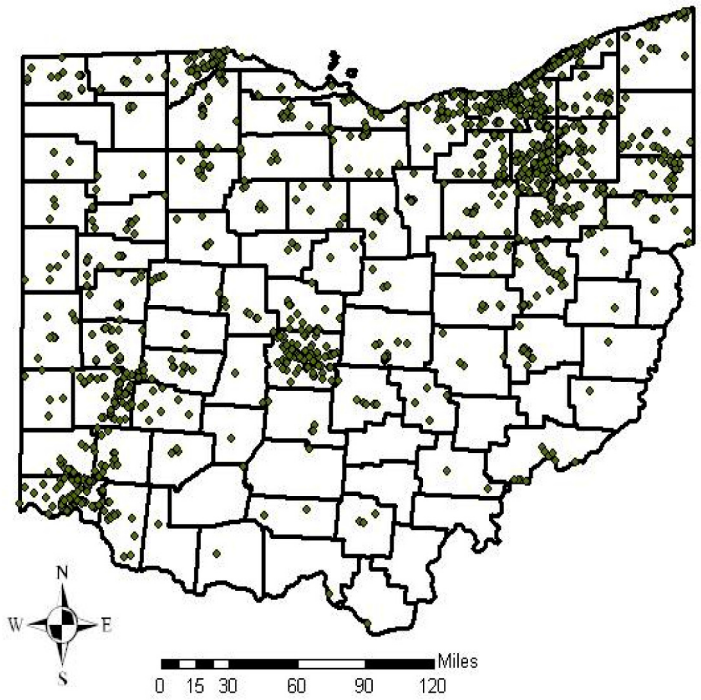
Like the chemical industry, the production of polymers and advanced materials relies heavily upon petroleum as a raw material, as a source of energy for production, and for the transportation of goods.

The charts below depict the concentration of polymer and advanced materials production in Ohio.





Much like Ohio's chemical companies, Ohio's polymer and advanced materials companies are geographically concentrated along the I-71 corridor. The infrastructure of Ohio road ways and access to Lake Erie are conducive to polymer and advanced materials production facilities on this diagonal through Ohio.



B. Conditions and Trends in Specialty Chemicals and Polymer Industry

1. Trends and future conditions

The trends in Ohio's chemical industry have been decidedly negative over the past 20 years (Ohio Chemistry Technology Council, 2008). The traditional dominance of chemical production by the U.S. and Europe is challenged by changes in feedstock availability and price, labor cost, energy cost, differential rates of economic growth and environmental pressures. The economic growth in China, India, Korea, the Middle East, South East Asia, Nigeria, Trinidad, Thailand, Brazil, Venezuela, and Indonesia has also been instrumental in the changing structure of the global chemical industry.

Leaders of the U.S. chemical industry recognize several global trends that threaten the existence of their companies. Such trends include:

1. Commoditization, wherein every product and service that we today consider a specialty is becoming more commodity-like every year;
2. Continued globalization, where production and jobs shift overseas closer to the customer in emerging markets (most notably Asia);
3. Spikes in the values of hydrocarbons and energy, which cannot be solely absorbed by the chemical industry and must be passed along to consumers;
4. The demand of retailers and consumers for lower prices and higher performance products (also known as the"Wal-Mart effect");
5. Increasing regulatory pressures;
6. Pressures upon companies in the industry from shareholders to take aggressive action to maintain profitability and market share;
7. Consolidation by corporate leadership of duplicative production assets to fewer and more efficient facilities, which often leads to the closure of older facilities in Ohio; and
8. An established chemical industry infrastructure in Ohio that has been characterized by many older facilities built before energy costs and environmental regulations were significant cost factors.

These industry-wide consolidations, shutdowns, product discontinuations, and acquisitions have resulted in Ohio being hit especially hard. Employment in Ohio's chemical industry has declined by more than 30,000 jobs in the past 20 years.

Contrary to the recent trends that have challenged the chemicals industry, the polymer and advanced materials industries have a favorable outlook for new products. Marscheider-Weidemann Utrecht/Karlsruhe (2004) note that the historically high growth in the production of plastics derived from fossil fuels will continue until 2020. Furthermore, plastics derived from renewable resources, could serve a limited role in offsetting the non-renewable energy use and greenhouse gas emissions of the EU plastics industry, "as well as having other advantageous socio-economic effects such as diversifying agricultural land use" *(Marscheider-Weidemann Utrecht/Karlsruhe, 2004)*.

The above study goes on to report that in the next three decades, plastics are projected to gain important market share in the glass market and to continue to be a substitute for steel and aluminum.

With legislative and citizen awareness, large retailers are driving environmentally-friendly production and products. For example, Wal-Mart, has taken a significant stand on green products. It has become the world's largest buyer of organic cotton, introduced "fair trade" coffee at its Sam's Clubs, began selling some organic foods, and is pushing suppliers to use smaller packages to cut waste *(USA Today, 2008)*.

2. The Emergence of a BioBased Industry

Even before the increased consumer preferences for environmentally-friendly products, companies that produce chemicals, polymers, and advanced materials have been researching and developing products based on sources other than petroleum, particularly since the high oil prices of the 1970's. Today, the research and development has only intensified.

Given rising crude oil prices, coupled with dwindling oil supplies, the biobased foci of the Carver-Eastman generation are being reexamined, remodeled, and given a new valued position in today's economy *(Banfield, Mullins, and Myers, 2008)*. The state of Ohio is a major participant in biobased initiatives.

Strong linkages between industry and research currently foster a research and development portfolio that will form the foundation for the emergence of a bio-based chemicals industry centered on two key Ohio technical assets with the capacity to:

1. Enhance genetic design capability to create novel building blocks;
2. Develop fundamental processes and products related to energy and materials; and
3. Demonstrate and commercialize the technologies and products synergistic with Ohio biorefinery activities based on Ohio feedstocks.

The main drivers for this projected utilization of renewable feedstocks are: Diminishing supply of fossil-based sources and reliable supply at reasonable cost; and potential impact of plant biotechnology to develop low-cost oils, proteins, and carbohydrates with target functionality to produce value-added adhesives, coatings, polymers, composites, and other industrial products with differentiated properties and performances *(Banfield, Mullins, and Myers, 2008)*.

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Appendix A: Summary of Task Force Meetings and Activities

The Ohio Agriculture to Chemicals, Polymers and Advanced Materials Task Force held its first meeting on **February 27, 2008**. Task Force members were introduced, the charge of H.B. 233 was presented to the Task Force, and a work plan was established. The Task Force also elected a vice-chair from its membership.

On **April 3, 2008**, the Task Force heard a presentation from Mr. James Ramey, Ohio Field Director of USDA's National Agricultural Statistics Service. Mr. Ramey gave a comprehensive overview of Ohio agriculture, and outlined the trends and conditions within the industry.

The Task Force next met on **May 1, 2008**. Dr. Stephen Z.D. Cheng, Dean of the College of Polymer Sciences and Polymer Engineering at the University of Akron delivered a presentation to the task force on the current trends in the chemical industries, and opportunities for alignment between Ohio's agricultural and chemical and materials industries.

Mr. Tom Fontana, Director of New Use Development for the Ohio Soybean Council, and Dr. Bhima Vijayendran, Director of Technology in Advanced Materials Applications at Battelle Memorial Institute, presented testimony to the Task Force on **May 15, 2008**. The testimony consisted of recommendations for aligning Ohio's agricultural and specialty chemicals and polymer industries.

On **May 22, 2008**, the Task Force met to receive additional testimony from Mr. Dale Arnold, Director of Energy Services for the Ohio Farm Bureau Federation; Mr. Dwight Rust, consultant for the National Composite Center and Omni Tech International LTD.; and Dr. Prabhat Krishnaswamy, President of Natural Fiber Composites Corporation.

The Task Force met for the last time on **May 29, 2008**. The task force evaluated all proposed recommendations which were submitted to the Task Force for its consideration, and voted on the final recommendations to make to the Governor and to the General Assembly.

Appendix B: Recommendations Submitted to the Task Force

The Ohio Agriculture to Chemicals, Polymers and Advanced Materials Task Force received a large volume of recommendations for consideration, from a broad spectrum of sources. The task force evaluated all submitted recommendations, which were broadly grouped into nine different subject categories in the order appearing below:

A. Coordination of collaborations and alignments;
B. Enhancing Ohio's competitive business environment;
C. Entrepreneurial support;
D. Intellectual property and tech transfer;
E. Market and consumer acceptance;
F. Biopolymer applications development;
G. Refining and conversion capabilities;
H. Feedstock development and processing; and
I. Workforce development and education.

Under each of the nine different categories of recommendations, each specifically submitted recommendation is presented in bold font. The source(s) to which each submitted recommendation can be attributed is indicated in parentheses.

A. Coordination of Collaborations & Alignments

The potential impact of this opportunity, renewable specialty chemicals, polymers and advanced materials from biomass sources, on Ohio's economy is well-established. Close coordination of efforts as well as facilitation of appropriate alignments and associated activities is warranted. This targeted coordination will increase the probability of success and reduce risk towards enhancing Ohio's leadership in the emerging bioeconomy.

1. **Establish a joint ODOD/ODA Agbioscience Technology Center (OBIC, ODOD).**
   The formal establishment of a new Agbioscience Technology Center dedicated to bio-based products and associated biobased energy activities at a state-wide level is recommended. This Technology Center would be dedicated to:

   - Advancing Research and Development initiatives to Commercialization opportunities
   - Accelerating developing technologies with high potential and success
     - Coordinating pilot development
     - Assisting with capital investment
     - Matching technology with industry capabilities
   - Enhancing Ohio's economy relative to bioproducts
     - Attracting international technologies and companies to Ohio
     - Creating opportunities for growth with existing technologies
   - Analyzing supply and demand for feedstocks
   - Facilitating appropriate linkage between biobased materials and energy
   - Capturing and maintaining data and recommend strategies to accomplish job growth, sales, and bioalternative initiatives

   This Agbioscience Technology Center should utilize existing Third Frontier investment to accelerate commercialization of bioproducts. This includes Third Frontier investments which have established statewide alliances of corporate, university, and policy leaders from across Ohio's agricultural, polymer, and materials industries. Existing industry leadership

which has guided development of market-pull business model and implementation strategies which have effectively targeted investments and fostered innovation should be leveraged by this Center. Likewise, this Agbioscience Technology Center should leverage existing experience, networks of industry and research capabilities, and existing projects as a logical and efficient means to rapidly maximize public/private returns on investment to enhance economic growth and create jobs in the emerging bioproduct industry.

To maximize economic impact associated with creating a new bioproducts industry in Ohio, the Agbioscience Technology Center can assist the corporate community as it makes the critical investment choices necessary to grow jobs. Consequently, the Economic Stimulus Package must be strategically directed so as to attract and maximize near-term industry participation in job creation. The Bio-based Products Economic Stimulus Package can be best leveraged to spur private sector investments and job creation by utilizing:

1. Established networks of industry leaders to identify, attract and leverage private sector investment;
2. Established portfolios of core capabilities to address barriers and increase bioproduct industry development; and
3. Existing market-pull business model and implementation strategies to accelerate commercialization and foster job creation.

- **Conduct Material Flow Analysis and Techno/Economic Analyses (OBIC).**

The utilization of biobased specialty chemicals and polymers will be driven by industry. Ultimately, the production and utilization of these materials will involve a comprehensive supply chain of industry members. Ohio has an extensive portfolio of supply chain members across the agricultural and polymer industry sectors. However, one key alignment question relates to the specific materials which refineries should produce. Important information which would help inform and target potential commercialization opportunities would be the result of Material Flow Analysis of the basic chemicals, specialty chemicals, polymers and additives currently being used by Ohio's polymer and manufacturing industry.

In order for industry to make the capital investments required to utilize new materials, such material must represent significant improvements or advantages compared to previous materials. As such, industry may be hesitant to consider new emerging materials or actual development of new materials until such time as there is sufficient information available to indicate that such materials may provide sufficient value to justify further development. Typically, there is insufficient risk/benefit information available to industry relative to new materials. As potential commercialization opportunities emerge, including those identified by Material Flow Analysis, a rapid analysis of the technical and economic factors would provide important information about the feasibility of such opportunities. The ability to rapidly conduct preliminary Techno/Economic Analyses on potential biobased materials will help to inform industry about risk concerning potential opportunities and alignments. Likewise, such information would enhance Ohio industry's ability to be "first to market" with new products developing from these new opportunities and alignments. Such assessments can be utilized to understand and overcome bottlenecks.

- **Involve colleges and universities already involved in University Clean Energy Alliance of Ohio (Ohio Farm Bureau).**

Ohio-based colleges and universities, which are already involved in the University Clean Energy Alliance of Ohio (UCEAO), should be contacted and actively urged to expand their current networking and research activities in energy development to support bioproduct efforts.

- **Examine opportunities to align efforts of Fuel Production Task Force with ours (Ohio Farm Bureau Federation).**

The 126th General Assembly also passed H.B. 371, and created the Fuel Production Task Force. That group is currently meeting to "study opportunities for and barriers to increasing the number of refineries and to increasing fuel production from agricultural products in the state in order to maximize the fuel supply and to create jobs for its citizens." Their final report is expected to be submitted to the Ohio General Assembly within the next few months, and opportunities exist to align the efforts of their task force with ours.

- **Have all state agencies align or provide to the Ohio Department of Development an inventory of resources available to education or business development pertaining to bioproduct development (Rep. Reinhard).**

- **Coordinate knowledge between those researchers who have knowledge about Ohio's bio based resources and those who are developing new chemicals, polymers and advanced materials (Rust).**

- **Increase communication of needs of specialty chemicals, polymers and advanced materials industries to providers of genetics in agricultural industry (Ohio Seed Improvement Association).**

- **Recruit new team members to industry collaboration, such as University Clean Energy Alliance of Ohio and other Third Frontier Participants (Rep. Reinhard).**

2. **Create an Agriculture Development Office within the Ohio Department of Development (Rep. Reinhard).**
   Create an agriculture development office within ODOD to work with agricultural companies to develop additional production processes to enhance bioproducts activity in Ohio.

3. **Implement mechanism for interagency communication and cooperation (Rust).**
   Implement a mechanism within the state government to create communication and cooperation between the various agencies to create alignment between agriculture (Ohio Department of Agriculture) and those trying to bring industrial jobs in chemicals, polymers, and advanced materials (Ohio Department of Development).

B. Enhancing Ohio's Competitive Business Environment

4. **Establish goal for Ohio to become "the best possible location for high-technology investment in the world (Ohio Chemistry Technology Council {OCTC}).**"
   To realize the full potential synergies of the states' agriculture, chemicals, polymers, and advanced materials/manufacturing sectors, Ohio must establish the goal of being "the best possible location for high-technology investment in the world." Ohio must remove every unneeded obstacle possible from the paths of entrepreneurs—be they individuals, partnerships, or global corporations.

5. **Establish an Office of Business Competitiveness (OCTC).**
   The state should develop an Office of Business Competitiveness—a one-stop center that will provide ALL existing and prospective businesses with information, support, incentives and intervention in regulatory matters to make it as easy as possible to select Ohio as a business's global location. This department should be staffed with professionals selected by a roundtable committee that includes executives of high-tech companies, for their abilities and experience in the business world. These professionals should have a significant portion of their compensation dependent upon the results achieved by the Office of Business Competitiveness—using meaningful metrics such as jobs created, investment dollars brought into the state, retention of existing jobs/investments at risk of moving from Ohio, etc.

   Every year, Ohio's Office of Business Competitiveness should have an independent survey conducted to determine how Ohio rates in terms of its competitiveness—and that survey should include businesses in Ohio and businesses that Ohio would like to see invest in Ohio. This survey should focus on Ohio's standing with regards to the key factors that create the state's "business climate". This would be far more meaningful than the Site Selection magazine rating that has little relationship to the state's image in the global business community.

6. **The legislature should provide state and local incentives to help small and/or large businesses or entrepreneurs to innovate (Rust).**

7. **Ensure Ohio's Basic utilities are globally competitive (OCTC).**
   Ohio has a good rail and highway system, and access to the Great Lakes and the Ohio River-Mississippi basin. Ohio has, at best, "second tier" airports. Ohio's ability to provide energy to high-technology businesses is more predictable today than it was just a few months ago. However, the state must push forward to implement the energy policies in SB 221—including an aggressive approach to pushing development of new energy supplies for the state, as well as meaningful assistance to all energy users in identifying ways to conserve energy.

8. **Benchmark Ohio's Performance against leading states and nations (OCTC).**
   Ohio's leaders should benchmark the state's taxes, regulatory programs, "utilities" avail ability and costs, and services to high-tech businesses against not only the best states in the U.S., but also the leading nations competing with Ohio for high-tech investment in the fields of agriculture, chemicals, polymers, and advanced materials.

C. Entrepreneurial Support

9. **Support Entrepreneurs (OBIC, Rep. Reinhard, Natural Fiber Composites Corporation).**
   There is recognition that entrepreneurs can drive economic development and attract investment support to niche markets. Many of these entrepreneurs do have sufficient "proof of product" to attract venture capital. There is a need for "pre-seed" funds to assist entrepreneurs towards development which enhances their ability to commercialize new materials and products. Alignments which will assist entrepreneurs to find potential partners, venture capital and R&D capabilities include:

   - **Initiate meetings that bring together entrepreneurs, investors, R&D companies, universities, etc.**

   - **Leverage assets and processes established in relevant Centers**

- **Offer early stage funding to assist entrepreneurs**

- **Encourage government and state programs to support new business development**

- **Focus on small, entrepreneurial companies in combining technologies**

An agriculture-to-polymer industry needs to leverage existing technologies and methods from both the agriculture industry and the specialty chemicals & polymer industries. Companies with innovative technologies resulting from combinations of the two industries must be recognized and encouraged in the creation or expansion of potential alignments.

As smaller firms are capable of creating two-to-nine times the jobs that large businesses do in the Midwest, small entrepreneurial manufacturing companies should be of particular focus.

D. Intellectual Property and Technology Transfer

10. **Create a database that describes existing IP in bioproducts (OBIC).**
The development and commercialization of new biobased materials is limited in part by difficulties in sharing business sensitive information, notably across university/corporate relationships and small/large businesses. A corporate culture change is needed to foster collaborative agreements with suggested terms and principles for win-win. Alternative strategies have been suggested that provide for shared expertise and IP by field of use and cost savings. In addition, industry indicated that the creation of a database that describes existing IP in bioproducts would accommodate the transition to new biobased materials.

11. **As the specialty chemicals & polymer industry identifies a unique variety that adds value to their system, they should release these varieties through the Ohio Seed Improvement System so that it can be identity preserved (Precision Seed Company).**

E. Market & Consumer Acceptance

Ultimately, consumers decide if products are successful. As such, the utilization of new bio based materials and bioproducts must provide value to consumers in the marketplace. How ever, a concerted effort including public and private concerns may be an asset to informing consumers about the emerging benefits of biobased materials. In order to support green initiatives, companies need to be willing to split the "out of pocket" costs associated with new, biobased materials across multiple cost centers such as R&D, Investor/ Customer Relations, Production, etc.

12. **Inform and educate consumers about bioproducts, create a branded logo and test for consumer acceptance (OBIC).**
Emphasis should be placed on the concept of "renewable" as the industry and consumers lack understanding and common agreement on terms such as "biodegradable" and "compostable." A major issue which may impact consumer acceptance is the potential backlash due to the "Food vs. Fuel" argument which is being associated with higher food costs. As such, there is a significant need and opportunity to inform and facilitate public debate concerning this issue.

A suggested next step is to consider a branded logo for Ohio bioproducts similar to "Ohio Proud."

13. **Create a Biobased Preferred Procurement Program (OBIC).**
    A state-based "Biobased Preferred Procurement Program" modeled after the Federal program may an opportunity to accelerate utilization. There is a need for Ohio to create and support success stories of bioproduct business ventures. The concept of "one success at a time" was emphasized.

14. **Create a "Green Ohio" Purchasing Program (Sen. Cafaro).**
    This program should be administered by the Ohio Department of Administrative Services, and should incorporate the Ohio School Facilities Commission's Leadership in Energy and Environmental Design (LEED) Green Building Rating System. It should require the State of Ohio to purchase a minimum of 20% "green" or recycled products by the year 2020, one third (1/3) of which should be manufactured within Ohio. This program should also require the Ohio Department of Administrative Services to submit to the Governor an annual report that highlights their progress toward the goal of 20% by 2020. Additionally, this program should require the General Assembly to reevaluate the program's goals sometime before the year 2020.

    The Ohio Department of Administrative Services should be involved in the assessment and future development of such a program (DAS).

15. **Subsidize the import of feedstock until feedstock can be grown locally (ODOD).**

16. **Subsidize development scale up of products and consumer acceptance testing (ODOD).**

17. **Create tax incentives for bioproducts transition (ODOD).**

18. **Remove legislative regulations that hinder state universities that may bar research and development in cooperation with business and industry (Rep. Reinhard).**

F. Biopolymer Application Development

19. **Focused effort on Applications Development which balances material properties, processing and market economics (OBIC).**
    There are economic opportunities to create value-added composites using biobased renewable resins and fibers for niche applications. Biomaterials with specific performance advantages are beginning to replace conventional materials such as petroleum, glass & metal in many applications. Performance and market utilization will be enhanced by developing new "coupling" approaches for these new material systems. There is a need to link plant geneticists with polymer chemists and application engineers to define and genetically modify desired properties and functionality. Ohio has the strategic assets as well as the vision to develop into the leading state for biomaterial application engineering. After consideration of the many stakeholders and their specific biopolymer needs, a number of focused applications emerged as linked to key Ohio feedstocks: adhesives, paints/inks/coatings, rubber, foams, fibers, and films.

    Many of the developing biorefineries may be operated by companies without previous experience marketing to the polymer and materials industry. Likewise, the polymer and materials industry may have limited experience in linking to agricultural industry which may be establishing biorefineries. A need exists to bridge these market sectors such that supply chain members are informed with the drivers associated with the manufacturing and the application of biobased polymers and materials. A focused effort on Applications Development which balances material properties, processing and market economics would

accelerate the commercialization of biobased chemicals and polymers. Today, there is no known center anywhere in the world for biomaterial application development or IP arbitration. An alignment of existing efforts with associated investments has the potential to develop a world-class applications research effort.

20. **Use state and industry funding to develop a virtual applications lab where data from projects can be stored and made available to participating industry, agency, and universities (Rep. Reinhard).**

21. **Provide incentives to corporations for transition from petro-based products to bio-based products (ODOD).**

22. **Create incentivized business models to link commodity producers and end users (OSIA).** Incentivized business models can be created that link Ohio commodity producers with end users. End users should consider direct vertical integration with producer groups or individual firms, or they should contract production in order to establish a stable supply base of value added IP commodities. Participants in such a value chain would include:

    1. Genomic sources of enhanced traits;
    2. Seed production firms;
    3. Identity preserved contract growers;
    4. Grain traders;
    5. Grain and oil processors; and
    6. End users.

G. Refining/Conversion Capabilities

23. **Align the need for innovators to make large samples of new materials for pilot- and production-scale runs with existing infrastructure assets in Ohio associated with agbiosciences, agricultural biotechnology, bioprocessing and biorefining (OBIC).**
    Public and private leaders must be assertive to enable Ohio's leadership role in the next materials age. A vision needs to consider an entire infrastructure based on bioproducts, not just the formulation of products with ag-based feedstocks to serve as drop-in replacements for petroleum, i.e., bioproducts should make improvements on current products to address unmet needs of customers. Ohio can be the leader in development of a total bioproduct-based industry for domestic and international markets, including having assets in place that are key in laboratory, pilot plant, toll production, and biorefinery-based scales.

    A major limitation at present is the need for innovators to make large samples of new materials for pilot- and production-scale sample runs for potential purchasers to test. There is a logical opportunity to align this need with existing infrastructure assets in Ohio associated with agbiosciences, agricultural biotechnology, bioprocessing and biorefining. There are existing toll manufacturing capabilities which have the potential to be important assets to address biorefining needs. Where there are gaps in infrastructure to address the need to develop pre-commercial volumes of novel biobased materials, the vision is for an integrated "Lego-like" array of processing capabilities that are flexible, scalable, and maneuverable. In order to build a consortium and attract state investment, the critical need for a pilot-scale biorefinery in Ohio must be articulated and a compelling vision and roadmap laid out. In OBIC's Biobased Assessment Survey, industry ranked 'refining infrastructure' as the #1 limitation to using biobased materials. 'Production of pre-commercial quantities of bio based materials' and 'A pilot scale biomass processing/refining research facility' were ranked as the #1 & #3 collaborative interests. A large number of agricultural and industrial collaborators are interested in the development of such capabilities.

24. **Build a Pilot Biorefinery (Ohio Soybean Council, Battelle).**
Perhaps the most important of these efforts is the need for a pilot scale biorefinery to speed the commercialization process along. The industry needs sample product in order to test and evaluate biobased materials before proceeding to market.

There is need for $15 million in initial funding for the construction of flexible, modular pilot facilities that could be upgraded with time as the scope of activities increases. Additional funding of $2 million per year for three years for operating the pilot facilities would also be needed.

The plant would produce pilot quantities of biomonomers, intermediates, plastic additives, polymers and formulated products derived from soybean oil and corn. The facility would be designed with inputs from all the stakeholders to cover typical seed crushing, oil refining, chemical conversion, polymer manufacture and related processes. Additional capabilities would be added, as needed, by taking advantage of the modular and flexible design.

25. **Centralize the location of a Research and Development Facility, possibly in Crawford County (Ohio Farm Bureau, Rep. Reinhard).**
Ohio agriculture, researchers, both from academia and private firms, as well as manufacturers of all sizes could find themselves becoming involved in projects sparked by this report. Given the various locations of many interested parties, a central research and development facility needs to be established early. A location and/or facility in north central or northeastern Ohio in a county along the terminal moraine should be designated.

26. **Establish an OARDC research site consisting of a prototype biorefinery (Sen. Cafaro).**
Pending necessary funding, this biorefinery should be set up at the Wooster OARDC site. This site is favorable because it already contains many of the fundamental components for a biorefinery and it would be costly to recreate its existing infrastructure in another location.

H. Feedstock Development & Processing

27. **Obtain more information concerning Ohio's biomass capacity (OBIC).**
DOE/USDA projects that U.S. agricultural and forestlands have a significant capacity to increase and sustain a supply of biomass for energy and bioproducts while still continuing to meet food, feed, and export demands. More detailed information concerning Ohio's capacity to increase and sustain a supply of biomass is needed.

Ohio has the potential to utilize substantial biomass resources, many which are currently underutilized and offer significant value-added opportunities for conversion to biobased energy and materials. Current biomass resources include crop residues, wood biomass, livestock manure, municipal solid waste and food processing waste.

28. **Leverage Ohio's existing Agricultural Processing Infrastructure (OBIC).**
Existing agricultural processing infrastructure in Ohio represents an important asset which could become an integral component of integrated biorefineries. While this industry is focused on food production at present, the presence of a bioprocessing infrastructure complements the potential development of additional valued-added uses of agricultural feed stocks for renewable energy and biomaterials. In fact, economic sustainability of biorefineries will likely be enhanced with an integrated approach where biomass feedstocks are converted to a range of goods and services including food, energy and materials.

29. **Geographic Leveraging in Feedstock Production (Ohio Farm Bureau).**
Geographically, the terminal moraine has divided Ohio into two distinct areas, each with its own agricultural characteristics. Counties east of the terminal moraine are part of the Appalachian Plateau, and many farms in this area are average sized and smaller. Farms in these counties are engaged in livestock production, as well as produce some cash grains, hay, timber, some produce and a variety of specialized crops.

The area's farmers could be relied upon by researchers to assist in projects where the need to introduce special and/or unique crops or gathering specific byproducts utilizing a small batch process is required. Moreover, smaller farming operations can invest greater time and attention to detail that could be required for development. Capitalizing on these at tributes could help Ohio agriculture compete with other states up and down the Eastern Seaboard and the Southeast using similar attributes to obtain similar ends.

Counties west of the terminal moraine are part of the Midwestern Corn Belt. Many farms located in this area are averaged sized or larger. Farms in these counties are engaged in livestock production at a larger scale than their eastern counterparts. While some produce a variety of specialized crops, many farms in this area have cash grain yields that compete with other Corn Belt states. Researchers could rely on the area's farmers to assist in projects where larger-scale production can ensure that larger quantities of crops and feed stocks possessing special traits or characteristics are obtainable. Capitalizing on these attributes could help Ohio agriculture compete with other Midwestern states using similar attributes to create similar production opportunities.

30. **Invite farming operations already working with the state on energy development to also participate in bioproduct development (Ohio Farm Bureau).**
Farming operations applying to and receiving grants from the Ohio Department of Agriculture (ODA), Ohio Department of Development (ODOD) and other state agencies for use in energy and facility development should be given additional consideration, if said facilities could be employed for agricultural feed stock research and production associated with the state's bioproduct development efforts.

31. **Focus on Feedstock Production within Existing Crop Production Infrastructure (Ohio Farm Bureau).**
In some cases, development of a specialized agricultural product is not seen as the biggest challenge. Often enough, developing special machinery and facilities to harvest, handle, store and transport agricultural materials becomes the biggest challenge. Consideration should be given to develop specialized products and feed stocks that already grow within crop production cycles and can utilize as much of the materials handling equipment and facilities currently employed on Ohio's farms.

32. **Focus on reducing raw material and manufacturing costs of bioproducts (Natural Fiber Composites Corporation).**
The commercialization of advanced bioproducts materials frequently involves challenges in the replacement of existing material based upon two factors: 1.) performance, and 2.) cost. Even as advanced bioproducts can be engineered to exceed the required performance targets, cost often becomes the prohibitive barrier for entry.

Higher priority should be given to projects which specifically support those industry alignments that shorten the timetable for optimization of material formulations to reduce raw material and manufacturing costs.

33. **Facilitate production of biomass on reclaimed strip mines (OSIA).**
    Changes in Ohio law are needed to enable reseeding of warm season grass and grass harvesting from reclaimed strip mine land for biomass production, which could also expand the size and scope of the agricultural land available for production.

34. **Provide incentives to farm owners to grow feedstock for bioproducts, such as (ODOD):**
    a. Subsidize the farm equipment differential for designated specialty products; and
    b. Subsidize the crop income differential for designated specialty products.

35. **Contract farming programs to guarantee a fair return to the risk taker on the land can create greater opportunities to expand and stabilize the agriculture industry (OSIA).**

I. Workforce Development and Education

There is currently a low enrollment in the fields of science and engineering at Ohio's universities by graduates of Ohio's high schools. As young students are interested in the environment and sustainability, these interests can be channeled to increase the enrollment in science and engineering.

36. **Focus research at agricultural universities on the needs of the chemical and polymer industry (Rust).**
    Research at agriculturally-focused universities should be focused on the needs of the chemical and polymer industry.

37. **Model successful technology transfer agents after successful university research that quickly moves science and engineering into manufacturing because of the lead of industry (Rust).**

38. **Involve business schools in universities in the discussion, so that they become more knowledgeable in identifying market needs in these areas (Rust).**

39. **Provide incentives to Universities and Community Colleges to create academic programs for Bio Products Product Development and Production (ODOD).**

40. **Provide scholarship money for students in these areas for study (ODOD).**

41. **Development of curriculum and degrees in the field (Rep. Reinhard).**
    Through coordinated industry efforts, develop a recommendation to higher education concerning curriculum and degrees in the field that will train a workforce and build bio product research in Ohio.