The goal of the study was to provide a community planning group in Northwest Ohio with the information needed to understand and take advantage of the opportunities that may avail themselves with the construction of a biorefinery. Commercialization of biobased chemicals is evolving rapidly and is poised to transform the production of industrial chemicals. Ohio has a unique opportunity to be an emerging leader in developing a bioeconomy base because Ohio’s leading agriculture and polymer industries provide an enviable infrastructure that positions the State to rapidly and successfully leverage biobased product production. This will revitalize the chemicals and polymer industries while creating opportunities for business growth, particularly in rural areas, through the development of biomass supply systems. Such an outcome is expected to create a significant number of new jobs, new companies, and bring added economic security to rural sectors.

Northwest Ohio has significant competitive advantages as a biorefinery location. It is in close proximity to biomass from agriculture, food production, and municipal solid wastes. Superior transportation logistics provide an edge in the transport of diverse feedstocks and delivery of products to market. It has a highly skilled workforce in many key areas of the value chain, and is supported by research and education from world-class universities.

The study recommendation is to continue defining options for a biorefinery hub located at the Port of Toledo. The early vision is of a bio-demo facility operating alongside a commercial scale, “anchor” biorefinery. The infrastructure needed to support the anchor biorefinery would be leveraged by small to mid-sized technology companies operating within the bio-demo facility to accelerate their scale-up. As these companies reach scale, it is believed that they would consider the Port as a prime location for a full-scale commercial enterprise. A bio-demo facility would not only support scale-up but should be broad enough in its mission to accelerate the coordinated development of the entire bioproduct value chain – leading to substantial growth in jobs and economic development in the region.

Challenges Impacting Biorefineries in OH

- Ohio is not viewed by external groups as an environment that is encouraging the development of bio-based assets. The pieces are available but the state government is not an advocate.
- Access to and competition for biomass in sufficient quantities to ensure long-term viability
- Defining sustainable practices for the appropriate growth, collection, and conversion of biomass
- Identification of biobased products capable of direct substitution or replacement in existing chemical industries
- Access to sufficient capital to establish new biorefineries or to retrofit existing facilities

The Biorefinery Concept

- Ag Biomass
- Energy Crops
- Forest Biomass
- Waste Processing
- Algae

Feedstocks

- Micro-organism
- Fermentation
- Digestion
- Thermochemical
- Syngas
- Gasification
- Combustion
- Chemical
- E.g., Hydrolysis

Technologies

- Chemicals
- Fuels
- Heat
- Materials

Markets

Ohio Economic Impacts

- Farms
- Biorefinery
- Chemical Industry
- Product Manufacturers
- Retailer

Biomass Available in NW Ohio

- Available Now
  - Grain crops (corn, wheat)
  - Oil crops (soybeans)
  - Wheat middlings
  - Wheat straw
  - Dried Distillers Grains and Solubles (DDGS)
  - Pulp biomass and waste water of pulp & paper mills

- In Development
  - Corn stover, other ag residue
  - Miscanthus in Northeast Ohio (commissioned by Aleris)
    - 1800 acres planted in 2013, goal of 5000 acres
    - Miscanthus produces (1 to 1.5) 12 tons/acre - 4x the weight of corn stover
    - Food & beverage waste
    - Cellulosic portions of MSW
    - Algae and Cyanobacteria (from algae blowdowns)
    - Animal Manure

Crop Residue near NW Ohio

<table>
<thead>
<tr>
<th>Distance (Mil)</th>
<th>U.S. crop residue available (Dry ton/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 Miles</td>
<td>16,960.56</td>
</tr>
<tr>
<td>150 Miles</td>
<td>19,654.01</td>
</tr>
<tr>
<td>200 Miles</td>
<td>26,023.106</td>
</tr>
</tbody>
</table>

Crop residue 100 miles from Toledo could produce 1 billion gallons/year of cellulosic ethanol or 8 million tons/year of chemicals or some combination

Global Market for Renewable Chemicals

- Chemicals
- Fuels
- Heat
- Materials

Estimated Direct Job Creation

- Construction
- R&D
- Operations
- Feedstocks
- Distribution

Transportation Logistics

- Abundant water supply for water-intensive industries, such as chemical and fuel/biofuel manufacturing
- Recent property acquisitions have more than doubled the size of the seaport - making it the largest land mass seaport on the Great Lakes.
- Synergies with existing petro refineries: BP Husky, BP Toledo Refinery, Toledo Refining Company LLC

Why both Fuels & Chemicals?

The general consensus of the industry is that platform chemicals with fuel production are essential to deliver the benefits of biomass transformation economically.
**Long Term Vision For a Biorefinery Hub**

**Concept of Co-located Biorefinery and Bio-Demo Facility**

**Bio-Demo Facility Benefits**

**Growers**: opportunity definition and potential to invest in new technologies for residue recovery

**Transportation**: understanding of technical needs and necessity to invest (and get return) from dedicated or specialized systems

**Operations**: handling, storage, yield, and flexibility of the input and output streams to be adjusted based on market demands and needs

**Customers**: knowledge and assurance of the product quality and available quantity to make the conversion from current supply sources

**Roadmap to Integrated AgBiorefinery**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Comments</th>
</tr>
</thead>
</table>
| 1 Form R&D/Demo Facility to research and scale-up drop-in chemicals and unique polymers/materials | • Large need in bio companies, esp small to mid-size  
• Will help attract companies  
• Leverage proximity to UT, MSU, MBI, OARDC, etc  
• Create high-paying jobs |
| 2 Establish ‘Anchor Biorefinery’ as an Aviation/Jet Fuel BioRefinery w/ coproduct streams | • Attain economies of scale necessary to be profitable  
• Government funding for these initiatives  
• Local markets for aviation/jet fuel  
• Jet fuel certification at WP  
• Potential to use existing buildings |
| 2a Establish ‘Anchor Biorefinery’ as a drop-in chemical manufacturer | • Attain economies of scale necessary to be profitable  
• Margins for biochemicals much better than for fuels |
| 3 Anchor Biorefinery develops coproduct streams to become sustainable | • Local markets for coproducts  
• Great transportation options for shipping products out and supplies in |
| 4 Leverage developing infrastructure to bring in more feedstock options | • Feedstock flexibility is key to long term viability  
• Creates more jobs and broadens reach |
| 5 Complex recruits new chemical/polymer manufacturers and expands product portfolio. | • Expanded portfolio catalyzes local manufacturing of ‘biobased end-user products’  
• Enhance local markets for products  
• U.S. and Ohio Biopreferred programs create market pull  
• New and retained local jobs |
| 6 Build greenhouses to use CO₂ and heat from pyrolysis or gasification systems | • High employment  
• Leverage all “products” from integrated facility |
| 7 Build anaerobic digesters to dispose of wet waste | • Expands biorefinery reach |
| 8 Build pyrolysis or gasification units to dispose of solid waste | • Expands biorefinery reach and utility |
| 9 Integrate biorefinery processing with petro refinery processing | • Alternative input streams for full range of petrochemicals |

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