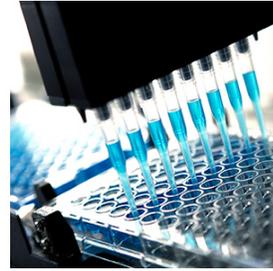


**Ohio Third Frontier:  
An Update on Targeted Growth  
Opportunity Areas for the Next  
3-5 Years**



**Performed For:**  
Ohio Third Frontier

**Performed By:**  
Battelle, Technology Partnership  
Practice (TPP)

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## Purpose

Created in 2002, the Ohio Third Frontier represents an unprecedented and bipartisan commitment to build on the State's strengths in technology and innovation to create high-wage jobs, new growth companies, and globally competitive products. A nationally recognized model for technology based economic development, the Ohio Third Frontier is helping shape the future economy of the state through a portfolio of programs to support research & commercialization, cluster development, entrepreneurial assistance, and expansion of the pool of risk capital. Now in its twelfth year of operation, the Ohio Third Frontier is living up to its original intent. Through its strategic initiatives, the Ohio Third Frontier has directly created more than 10,000 new jobs, leveraged nearly \$9 billion in additional funding, and created, attracted or capitalized over 500 companies since the program's inception in 2002.<sup>1</sup>

More than a decade has passed since its initial conception, and still the economic imperative for the Ohio Third Frontier remains strong. While the U.S. economy remains sluggish, global investment in technology and innovation is escalating and Ohio cannot afford to be left behind. It is well understood that innovation is a critical driver of the growth of high performing economies in today's competitive, global economy. As the National Research Council in its highly touted Rising to the Challenge Report explains: "the capability to innovate is fast becoming the most important determinant of economic growth and a nation's ability to compete and prosper in the 21st century global economy."<sup>2</sup>

The success of the Ohio Third Frontier is rooted in its disciplined, market-oriented approach that is tailored to Ohio's areas of specific existing and emerging technology industry strengths and the growth opportunities within them. This structured approach requires periodic updates to ensure that the Ohio Third Frontier's investment priorities are focused on the near-term opportunities in which the state is best positioned for industry growth.

The fact-based, independent assessment by the Battelle Technology Partnership Practice laid out in the pages of this report examines if existing priority growth opportunity areas established in 2011 are still appropriate or need to be refined, and also analyzes whether there are new emerging, high growth opportunity areas that need to be incorporated into the Ohio Third Frontier investment priorities.

Specifically, the assessment evaluates the following eight existing targeted growth opportunity areas:

- Advanced Materials
- Aero-Propulsion Power Management
- Fuel Cells and Energy Storage
- Medical Technology
- Sensing and Automation Systems
- Situational Awareness and Surveillance Systems
- Software Applications for Business/Healthcare
- Solar Photovoltaics/Energy

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<sup>1</sup> Reported by the Ohio Third Frontier through its semi-annual metric collection as of December 31, 2012.

<sup>2</sup> Charles W. Wessner and Alan Wm. Wolff, Eds. "Rising to the Challenge: U.S. Innovation Policy for the Global Economy" 2012. The National Academies Press, Washington, D.C.

Plus it considers two new growth opportunity areas that have been raised by the Ohio Third Frontier Commission and Advisory Board for assessment:

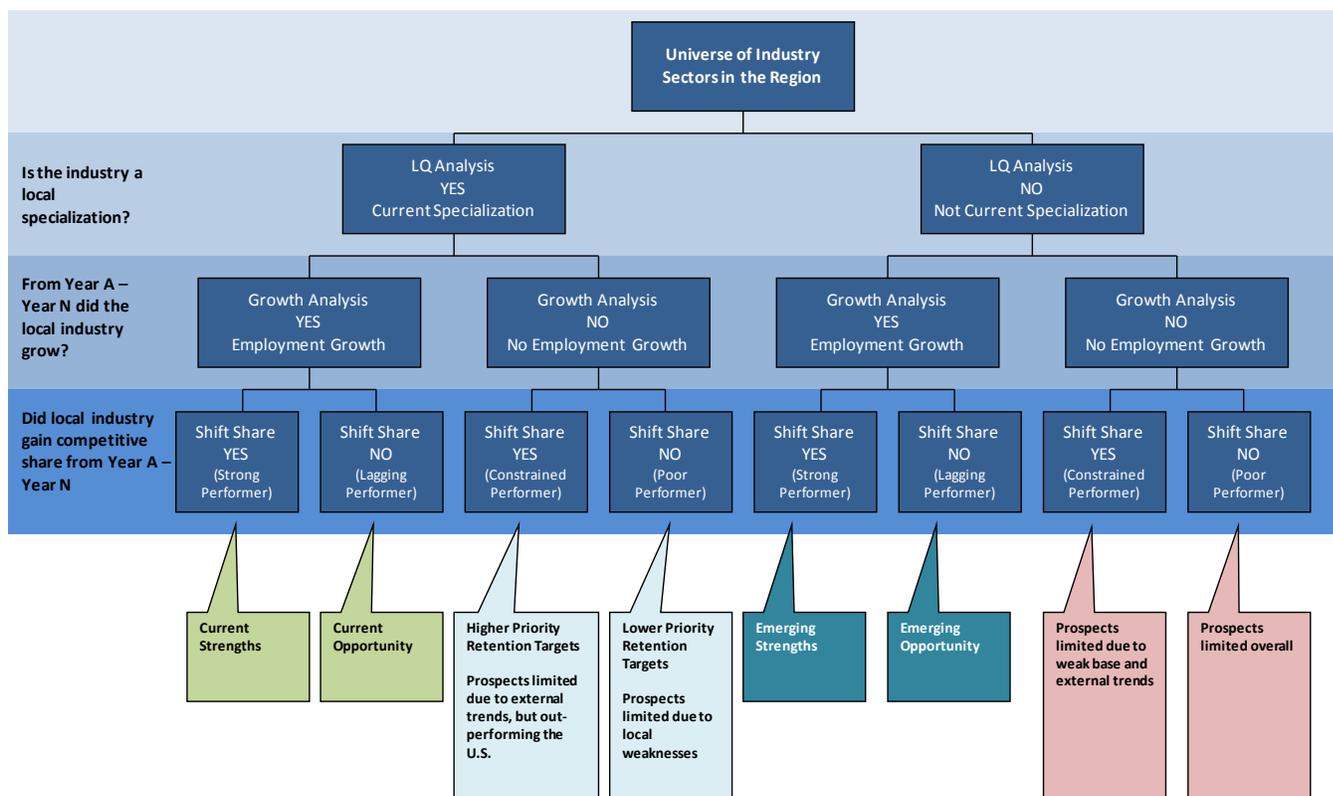
- Agbiosciences
- Unconventional Oil and Gas

## Approach

The approach undertaken to update and assess recent data regarding Ohio’s performance and position in existing and emerging growth opportunity areas involved integrating three key assessment components:

- **Component One: What has been the industry performance of Ohio’s existing and emerging growth opportunity areas?** This component examines where Ohio’s existing and growth opportunity areas stand today using a comprehensive regional industry analysis approach - Industry Targeting Analysis. Industry Targeting Analysis provides a solid understanding of the current position and trajectory of key economic sectors within Ohio’s economy. By deploying the tools of industry targeting analysis (see Figure 1), Battelle objectively and quantitatively identifies industry sectors that are “current strengths and opportunities”, “high priority retention targets”, more challenging or “lower priority retention targets” and “emerging strengths and opportunities.”

Figure 1. Industry Targeting Analysis: Decision Tree



- **Component Two: What has been the level of innovation activity undertaken by industry and universities in Ohio in the existing and emerging growth opportunity areas?** This offers insights into how active is Ohio’s industry, as well as its universities, in generating advances in “know how” to support new product development as well as the formation of emerging companies positioned for growth markets and new commercialization opportunities.
- **Component Three: What is the market outlook for the existing and emerging growth opportunity areas?** This component focuses on the specific drivers, market niches, and overall position of the existing and emerging market opportunities as growth drivers. While Ohio may stand out and continue to gain market share in slower growing markets, there is a bigger upside if Ohio can focus on those markets with more positive outlooks.

Table 1 sets out the specific measures used to assess how Ohio is positioned in each of these three fact-based, objective assessment components.

**Table 1. Focus of Assessment Analysis**

<i>Ohio Industry Performance</i>	<i>Ohio Level of Innovation</i>	<i>Market Outlook</i>
<b>Level of Specialization</b> (relative concentration of industry)	<b>Patent Activity</b> – Since 2010; both applications and awards (Source: Thomson-Reuters Delphion Patent Analysis database)	<b>By Leading Industries in Ohio</b> – Source IBISWorld
<b>Job Growth or Decline</b>	<b>Emerging Innovation Companies (2006–2013)</b> – <b>Post-Seed Venture Capital Companies</b> (Source: Thomson Reuters ThomsonOne) – <b>Pre-Seed and Seed Venture Capital Companies</b> (Source: Ohio Third Frontier) – <b>SBIR Companies</b> (Source: SBIR Federal database sbir.gov)	<b>By Leading Growth Markets</b> – Sources includeFreedonia, Frost & Sullivan, BCC Research, and others
<b>Relative Job Growth of Industry</b> (compared to U.S. job growth—measure of competitiveness)		
<b>Examples of Leading</b> (large and established) <b>and Emerging</b> (founded after 2000) companies are provided for context, but are not exhaustive.	<b>Significant Investments</b> (since 2010) in research-related activities and infrastructure are identified when possible.	

## Summary Findings

Based on the three fact-based, objective assessment components, the position of each of the eight existing and two emerging growth opportunities were identified. Table 2 offers a high level assessment across all of the measures. It reveals that each of the potential growth opportunity areas has their own mix of strengths and weaknesses that the Ohio Third Frontier Commission and Advisory Board needs to weigh to determine the priority to be placed on each of these growth opportunity areas. (Please see Appendix A for a detailed explanation of the assessment criteria ratings.)

**Table 2. Assessment Summary of Ohio Target Growth Opportunity Areas**

Target Growth Opportunity Area	Industry Performance, 2009-2012			Innovation Activity		Market Outlook	
	Industry Specialization	Job Generation	Competitive Position	Patent Activity	Presence of Emerging Companies	Industry Sectors	Niche Markets
Advanced Materials	●	○	○	●	◐	◐	●
Aero-Propulsion Power Management	◐	◐	◐	○	◐	◐	◐
Fuel Cells and Energy Storage/Management	◐	◐	○	◐	◐	◐	●
Medical Technology	◐	●	◐	●	●	◐	●
Sensing and Automation Systems	◐	○	○	●	○	◐	◐
Situational Awareness & Surveillance Systems	○	●	●	◐	◐	◐	●
Software Applications for Business and Healthcare	◐	◐	○	◐	●	●	●
Solar Photovoltaics and Solar Energy	●	●	●	◐	○	○	●
Agbiosciences	◐	●	◐	◐	○	◐	●
Unconventional Oil and Gas	○	●	◐	○	○	◐	◐
<b>KEY:</b>	● Top Tier	◐ Middle Tier	◐ Lower Tier	○ No presence			

The key insights from this assessment are presented for each of the existing and emerging growth opportunity areas as follows:

### **Advanced Materials**

- While still a specialized industry sector in Ohio, it has continued to decline post-recession at a rate faster than the nation, culminating in nearly 1/3 of its jobs being lost over the past decade. Despite, these significant employment losses, the advanced materials industry in Ohio continues to raise its productivity at a faster rate than the U.S. suggesting its overall competitiveness.
- Continues to be strongly innovative in terms of patents, emerging companies, and significant research investments.
- While modest growth is forecast at the industry-wide level, there are significant high growth niches involving advanced technology areas, including additive manufacturing, an area of growing industry-university research partnerships in Ohio.

### **Aero-Propulsion Power Management**

- This is a specialized industry sector in Ohio, which recorded strong employment growth even as the nation declined in employment over the year's 2001 to 2009 – reflecting significant economic strength and increased market share in Ohio. Since 2009, it has fallen off in employment in Ohio, with a decline of nearly 4 percent from 2009-2012. This recent decline in Ohio possibly reflects the federal defense slowdown, and largely mirrors the national decline in recent years. Productivity of Ohio in this industry growth opportunity area, however, stands well above the nation, suggesting the underlying strength of the state's overall competitiveness that can fuel growth in the future.
- More limited innovation activities are found in this opportunity area in patents and emerging company formation during the recent time period, although significant research investments continue with GE's new research center and continued DoD research and development funding efforts.
- While total aircraft production is declining with flat revenue growth projected, largely reflecting federal defense spending constraints, suppliers supporting commercial aviation are likely to see stronger demand in the near future as demand for new commercial aircraft and requirements to update existing fleets grow.

### **Fuel Cells and Energy Storage/ Management**

- Despite overall growth for the past decade, Ohio did not keep pace with the nation, and has declined slightly in the post-recession years of 2009-2012, even as the U.S. grew slightly.
- When analyzed in relation to its small establishment base, this area continues to be strongly innovative with strong growth prospects in small niche markets.
- Continued development of distributed energy management systems and the evolving developments in hybrid vehicles offer potential opportunities for growth.

### **Medical Technology**

- While growing, the medical technology growth opportunity area continues to lag the growth of the nation, and as a result, continues to be less concentrated in Ohio.
- Continues to be strongly innovative in terms of patents, emerging companies, and significant research investments.

- Due to aging population and changing demographics, growth across most related industries are forecast to remain healthy – though mature markets will see slower growth.

### **Sensing and Automation Systems**

- This industry growth opportunity area is highly specialized in Ohio and involves many leading companies. Still, it is in decline over the last decade with a loss of nearly one-third of its employment base, and continued losses in the post-recession years.
- It remains a highly innovative industry area in Ohio, with strong patent growth and a base of emerging innovative companies.
- Industry growth in revenues expected to be modest, but niche markets will realize strong growth including in MEMS, machine vision, and advanced sensors.

### **Situational Awareness and Surveillance Systems**

- This smaller industry growth opportunity area in Ohio recorded strong job gains over the last decade, and continued to experience growth in the post-recession period of 2009-2012, even as the nation experienced a decline.
- Emerging innovative companies in situational awareness and surveillance systems are helping to fuel the growth of this opportunity area for Ohio. Despite its small size, there were 17 companies in this growth opportunity area receiving pre-seed and seed funding, and many emerging companies in this growth opportunity area are involved with federal research and development, which is advancing the core technologies that will serve beyond military uses to support commercial markets.
- Global markets for newly emerging commercial markets are forecast to be strong through the 2017 to 2019 period, including unmanned aerial systems.

### **Software Applications for Business and Healthcare**

- A sizable and growing industry growth opportunity area for Ohio, though not yet specialized. From 2001 to 2009, this industry sector recorded strong job growth that outpaced the nation, and continues to be a major employment engine for the state.
- Continues to be strongly innovative in terms of patents, risk capital, and emerging companies – with active involvement of Ohio Third Frontier’s pre-seed and seed funding efforts.
- Very promising future with strong growth forecast for emerging market segments, such as Big Data, cloud computing, and health IT.

### **Solar Photovoltaics/Energy**

- From a small base, continues to have exceptional growth that far exceeds the nation.
- When analyzed in relation to the overall small size of its establishment base, continues to be strongly innovative.
- Solar power is forecast to grow at the fastest pace of any renewable energy technology during this decade, with sizeable growth predicted in thin film solar cell market in which Ohio is a world leader.

### **Agbiosciences (new)**

- The agbiosciences industry opportunity area is a sizable with nearly 89,000 jobs in Ohio and has been a consistent job generator over the past decade in Ohio with an employment growth rate of three percent over the decade.
- Active in intellectual property generation from patents awarded and applied for across both industry and universities in Ohio, with a sizable number of emerging companies receiving pre-seed and seed funding.
- Wide range of market niches with strong growth potential, such as novel health products and agricultural chemicals.

### **Unconventional Oil and Gas, including shale operations (new)**

- The unconventional oil and gas industry has become a fast growing job generator for Ohio, driven primarily by the fracking operations along the eastern portion of the state related to the Marcellus shale development. Still this industry growth opportunity area is of just moderate size in Ohio, employing more than 10,000 people, and is only half as concentrated as that of the nation.
- Limited innovation and no risk capital or emerging companies found in Ohio.
- Market for extraction as well as related equipment forecast to have sustained growth and suggests a strong level of deployment of proven technologies generating continued job growth in Ohio.



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## **Details of Updated Assessment of Growth Opportunity Areas for the Next 3-5 Years**

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# ADVANCED MATERIALS

## What Is It?

Advanced materials are next generation or unconventional materials that outperform conventional materials or provide unique characteristics allowing them to play a large role in product development or product performance. Advanced materials cover a broad spectrum ranging from specific polymer materials, ceramics, composites, carbon fiber, nanoscale materials (e.g., nanotubes or nanoparticles), aerogels, and unique metals and alloys. Often a particular factor in the development of advanced materials is the integration of various material types into new functional materials ranging from carbon fiber composites, to metallic glasses, to nanoparticle-enhanced polymers. These advanced materials are then used as inputs to the plastics product industry as well as to other manufacturers for producing their products.

The development of these advanced materials is primarily driven by the need for greater functionality, greater durability (including in harsh/high temperature or biologic environments), greater strength and elasticity. Increasingly, advanced materials are being developed with enhanced conductive properties allowing for a wide variety of unique applications. These market applications include biomedical, aerospace, transportation, and advanced energy.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

The advanced materials industry growth opportunity area builds off the historic strength of Ohio in polymer and rubber chemistry as well as a strong legacy in various metals manufacturing. Numerous global leaders across a wide range of the advanced materials industry call Ohio home, including Goodyear, PolyOne, Lubrizol, Sherwin Williams, Owens Corning, and Graftech. Though employment in the Ohio industry has declined by more than 30 percent since 2001 to its current level of nearly 42,000 employees, it is still one of Ohio's premier technology industries, being more than twice as concentrated in Ohio as elsewhere in the U.S.<sup>3</sup> While this employment decline is faster than the industry at the national level, part of this decline may also be explained by increasing productivity. Using data from the U.S. Census' Annual Survey of Manufacturers, it is estimated that Ohio's advanced materials industry's productivity is currently 4 percent higher than the U.S. and growing by a faster average annual rate—11 percent for Ohio compared to 7 percent for the U.S. This productivity advantage and increase are important indicators that Ohio remains globally competitive, even in the face of job loss.

This concentration and strength has led to significant corporate and academic research capacities in the state, with R&D pushing the envelope in advanced materials development. This high level of innovation is reflected in the substantial numbers of new patents and applications, the number of new emerging companies, and significant new research investments. The continued innovative nature of Ohio's advanced materials industry is also reflected through Ohio being chosen as the home for the National Additive Manufacturing Innovation Institute (NAMII), a national additive manufacturing center of innovation excellence headquartered in Youngstown. This builds upon other nationally recognized advanced materials research centers focused on polymers, composites, and nanomaterials throughout the state.

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<sup>3</sup> It is important to note that this employment figure does not include substantial Ohio employment in the plastics products industry that is supplied by the advanced materials industry.

## ADVANCED MATERIALS: Recent Economic Performance

### Industry Employment Metrics

Advanced Materials	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	982	41,600	2.28	-26.7%	-6.1%	-31.2%
Ohio Job Performance Relative to U.S.				0.8%	-10.5%	-6.8%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Plastic, Rubber &amp; Resin Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 2.0%	<ul style="list-style-type: none"> <li>Downstream demand from manufacturing and construction</li> <li>Price of input materials</li> <li>Increased R&amp;D</li> <li>Investments in bioplastic technology</li> </ul>
<b>Paint Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 1.9%	<ul style="list-style-type: none"> <li>Downstream demand from manufacturing</li> <li>Price of crude and resins</li> <li>Improving plant efficiency and productivity</li> <li>Increased acquisitions</li> </ul>
<b>Adhesive Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 2.0%	<ul style="list-style-type: none"> <li>Aircraft and auto manufacturing demand</li> <li>Increased use of composite materials</li> <li>Industry consolidation</li> <li>Decreased resin price volatility</li> </ul>
<b>Metal Plating &amp; Treating</b> 2013–2018 Expected Annual Revenue Growth: 2.6%	<ul style="list-style-type: none"> <li>Increased demand from metal stamping and forging firms, and steel manufacturers</li> <li>Stronger competition from international competitors</li> <li>Minimal raw material price volatility</li> </ul>
<b>Plastics &amp; Rubber Machinery Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 7.6%	<ul style="list-style-type: none"> <li>Strong international demand and recovering domestic demand</li> <li>Improved construction and auto manufacturing</li> <li>Greater use of easily recyclable materials</li> </ul>

Source: IBISWorld

#### Industry Niches

Advanced Polymers –  
*Specialized*

Ceramics/Composites –  
*Specialized*

Specialty Metals & Alloys –  
*Specialized*

#### Leading Companies

Lubrizol; Owens-Corning;  
PolyOne; Promerus;  
Sherwin-Williams;  
Entrotech; Proctor &  
Gamble; Goodyear;  
Graftech, Momentive  
Performance Materials,  
RPM International

#### Emerging Companies

Bioformix; ECOSIL  
Technologies; General  
Nano; Renegade Materials

## ADVANCED MATERIALS: Recent Innovation Performance

### Patent Activity

110	331
<b>Number of recent patents issued</b>	<b>Number of recent patent applications</b>
<ul style="list-style-type: none"> <li>■ Industry: 98</li> <li>■ Universities: 12</li> </ul>	<ul style="list-style-type: none"> <li>■ Industry: 290</li> <li>■ Universities: 41</li> </ul>

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>■ Companies: 44</li> <li>■ Phase I &amp; II Awards: 139</li> <li>■ Total Funding: \$49.7 million</li> <li>■ Key Agencies: DoD, DOE, NSF</li> </ul>	<ul style="list-style-type: none"> <li>■ Companies: 50</li> </ul>	<ul style="list-style-type: none"> <li>■ Companies: 5</li> <li>■ Deals: 10</li> <li>■ Investment: \$36.2 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Synthetic resins or natural rubbers	106
Stock material or miscellaneous articles	62
Solid anti-friction devices, materials, lubricant or separate compositions for moving solid surfaces, and miscellaneous mineral oil compositions	54
Coating processes	32
Compositions	17
Liquid crystal cells, elements and systems	11
Compositions: coating or plastic	10
Adhesive bonding and miscellaneous chemical manufacture	10
Fabric (woven, knitted, or nonwoven textile or cloth, etc.)	10

#### *Significant New Infrastructure and Research Investments*

- **The National Additive Manufacturing Innovation Institute (NAMII)**  
\$30 million grant from Department of Defense
- **University of Dayton Research Institute Quick-Reaction Evaluation of Materials and Processes Program**  
\$45 million Air Force research contract

## ADVANCED MATERIALS: Market Outlook and Drivers

### Key Market Outlook

- Over the past 20 years the global market for high-performance polymers has grown from \$1 billion to \$7 billion in 2013 for a CAGR of 10 percent.<sup>4</sup>
- Conductive polymers market is expected to grow at a compound annual growth rate (CAGR) of 11 percent through 2017.<sup>5</sup>
- U.S. demand for high-temperature plastics is forecast to reach \$3.1 billion in 2017, a CAGR of 5.8% from \$2.4 billion in 2012. Advances will be propelled by the ongoing adoption of high-temperature plastics in place of more conventional materials in an expanding array of applications.<sup>6</sup>
- Bioplastics demand in the U.S. reached 220 million pounds in 2011 with a value of \$305 million. Demand is forecast to reach 550 million pounds by 2016 with a value of \$680 million.<sup>7</sup>
- Composite market is forecast to grow at a CAGR of 7 percent through 2017 to reach a materials market value of \$29.9 billion and an end products market valued at \$85 billion.<sup>8</sup>
- Global consumption of nanocomposites to increase at a CAGR of 19 percent, increasing from 138,389 metric tons and a market value of \$920 million in 2011 to 333,043 metric tons and \$2.4 billion by 2016.<sup>9</sup>
- The market for carbon nanotubes reached \$239 million in 2012 with a projected five year CAGR of 22.4 percent, reaching \$527 million by 2016.<sup>10</sup> A more optimistic forecast estimates the global carbon nanotubes market to be worth approximately \$2.7 billion by 2015.<sup>11</sup>
- The U.S. market for advanced ceramics is forecast to grow by 6 percent annually to \$14.2 billion in 2015.<sup>12</sup>
- 3D printing (additive manufacturing) is expected to gain a growing foothold in the direct manufacturing of highly complex, low-volume and highly customizable parts – possibly generating \$100 billion to \$200 billion by 2025 in economic impact.<sup>13</sup>

#### Key Market and Technology Drivers

- Multifunctional Materials
- Continued Emergence of Additive Manufacturing
- Light Weight and Harsh Environment Applications
- Sustainability, Biobased, and Recyclable Products

<sup>4</sup> Principia Partners, *High Performance Polymers*, 2014

<sup>5</sup> Global Industry Analysts, *Conductive Polymers – A US Report*, 2012

<sup>6</sup> Freedonia, *Freedonia Focus on High-Temperature Plastics: United States*, 2013.

<sup>7</sup> Freedonia, *Bioplastics: United States*, 2012

<sup>8</sup> Lucintel LLC, *Growth Opportunities in Global Composites Industry*, 2012

<sup>9</sup> BCC Research, *Nanocomposites, Nanoparticles, Nanoclays, and Nanotubes*, 2012.

<sup>10</sup> Lucintel LLC, *Growth Opportunities in Global Composites Industry*, 2012

<sup>11</sup> Nanoposts.com, *The Global Market for Carbon nanotubes: A Realistic Market Assessment – 2<sup>nd</sup> Edition*, 2010.

<sup>12</sup> Freedonia, *Freedonia Focus on Advanced Ceramics*, 2010.

<sup>13</sup> McKinsey & Company, *Disruptive technologies: Advances that will transform life, business, and the global economy*, 2013.

# AERO-PROPULSION POWER MANAGEMENT

## What Is It?

At its simplest, propulsion systems are machines that produce power required to push or pull a vehicle into motion and enable the vehicle to accelerate, decelerate, and maneuver while already in motion. For jet aircraft, turbine engines provide the propulsion required to operate reliably for extended periods. Propulsion requirements differ depending on the use requirements of the aircraft. For commercial aircraft, propulsion systems are designed to allow them to transport people and cargo from one point to another. However, the operating environments for commercial aircraft require designs and operations that adhere to strict sound volume requirements and the market realities of commercial aviation require these engines to operate extremely efficiently and safely, and with minimum costs and maximum reliability. For military aircraft propulsion systems, while they have to approach some of these same operating constraints, the added requirements of flexibility, obtainable speed (i.e., supersonic speeds), and quick maneuverability unique to defense-related needs add additional design and operational requirements.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

Ohio's leadership role in the advancement of aero-propulsion technologies dates back to the beginning of powered flight. Its leadership position continues with numerous facilities located throughout Ohio leading the future of aero-propulsion technologies, such as GE Aviation Systems' R&D and manufacturing operations in southwest Ohio (which are currently undergoing a \$200 million expansion and modernization effort), and the Air Force Research Laboratory at Wright-Patterson Air Force base, the preeminent federal laboratory for aerospace systems. Looking to the future, Ohio is also home to NASA's principal power and propulsion research operation at the NASA Glenn Research Center, where scientist and engineers are developing futuristic deep space power and propulsion systems.

Industry employment in Ohio, though dominated by GE Aviation Systems, includes major operations of leading aero-propulsion and power management suppliers, such as Eaton, Parker-Hannifin, and Honeywell. Accounting for more than 19,000 Ohio workers, not including federal employees, the industry has grown over the last decade, though its post-recession performance is slightly lagging the overall U.S. industry. However, productivity within Ohio's firms continues to grow since the recession and currently (2011 data) exceeds the U.S. average by more than \$76,000 per year per worker. This productivity advantage is an important indicator that Ohio remains globally competitive.

While total aircraft production is declining with flat revenue growth forecast, largely reflecting federal defense spending constraints, suppliers supporting commercial aviation are likely to see stronger demand in the near future as demand for new commercial aircraft and requirements to update existing fleets grow.

## AERO-PROPULSION POWER MANAGEMENT: Recent Economic Performance

### Industry Employment Metrics

Aero-Propulsion Power Management	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	164	19,028	1.44	7.1%	-3.7%	3.2%
Ohio Job Performance Relative to U.S.				10.9%	-0.8%	9.7%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Aircraft, Engine &amp; Parts Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 1.8%	<ul style="list-style-type: none"> <li>• Demand from China and India</li> <li>• Current military contracts locked-in</li> <li>• Future Govt. contracts could face cuts/lower margins</li> <li>• More investment in R&amp;D</li> <li>• Low wage increases</li> </ul>
<b>Navigational Instrument Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 2.7%	<ul style="list-style-type: none"> <li>• R&amp;D funding in new areas to drive growth</li> <li>• Growing competition</li> <li>• Falling number of establishments and employees</li> <li>• Mature industry</li> </ul>
<b>Other General Purpose Machinery Manufacturing (incl. fluid power and hydraulics)</b> 2013–2018 Expected Annual Revenue Growth: 2.0%	<ul style="list-style-type: none"> <li>• Marginal industry consolidation</li> <li>• Moderate domestic demand</li> <li>• Rising import penetration</li> <li>• Improving aircraft demand</li> </ul>

Source: IBISWorld

#### Industry Niches

Aircraft Engine and Parts – *Specialized*

Fluid Power Cylinder and Actuator – *Specialized*

#### Leading Companies

GE Aviation Systems; PCC Airfoils; Orbital Research; Parker-Hannifin; Honeywell; TransDigm; Eaton Aerospace; Meyer Tool; SIFCO

#### Emerging Companies

GoHypersonic

## AERO-PROPULSION POWER MANAGEMENT: Recent Innovation Performance

### Patent Activity



**Number of recent patents issued**

- Industry: 9
- Universities: 1

**Number of recent patent applications**

- Industry: 2
- Universities: 0

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 17</li> <li>▪ Phase I &amp; II Awards: 52</li> <li>▪ Total Funding: \$19.8 million</li> <li>▪ Key Agencies: DoD, NASA</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 2</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 1</li> <li>▪ Deals: 1</li> <li>▪ Investment: \$0.13 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Metal founding	3
Aeronautics	3

#### *Significant New Infrastructure and Research Investments*

- **GE Aviation EPISCenter**  
\$51 million research center teaming with UDRI to develop new electrical power systems for future aircraft.
- **Continued multi-year DoD R&D task order/contracts for UDRI**  
Potentially more than \$200 million over the next 5-7 years for developing advanced power and thermal management technologies, materials, structures, and other defense-aerospace-related components

## AERO-PROPULSION POWER MANAGEMENT: Market Outlook and Drivers

### Key Market Outlook

- The aircraft, engine and parts manufacturing industry features civil and military segments. The civil segment is sensitive to downstream demand for global scheduled and nonscheduled air transport. On the back of renewed demand from commercial airlines, industry revenue is expected to increase over the five years to 2013 at an annualized rate of 2.1%. In 2013 alone, revenue is projected to increase 2.1% to total \$186.3 billion.<sup>14</sup>
- Growth in commercial aircraft manufacturer's revenues is expected to reach record levels in 2013, based on increased production rates and the introduction of the next generation aircraft. Backlogs are expected to continue growing, with airlines continuing to update their fleets with new fuel-efficient aircraft in order to stay competitive.<sup>15</sup>
  - Suppliers to aircraft original equipment manufacturers (OEMs) are likely to be challenged to keep pace with production requirements and are expected to invest in skills development, tooling, and manufacturing capacity.
- The global commercial aircraft gas turbine engine market will reach a value of \$24.6 billion in 2013 is expected to record positive growth over the next decade, as engine manufacturers seek to up their production rates to meet the demand from airlines for new aircraft by providing engines which improve flight performance, fuel efficiency, and meet noise and environmental regulations.<sup>16</sup>
- Turbine product demand for use in aircraft applications is forecast to increase 4.9% per year from \$9.9 billion in 2011 to \$12.5 billion in 2016.<sup>17</sup>
  - Continuing recovery from the 2007-2009 recession, rising levels of air travel activity, and strong increases in the air cargo industry will contribute to segment advances.
- Total value of the military fixed wing aircraft market reached \$73.3 billion in 2012 and is forecast to decline to approximately \$65.7 billion by 2017.<sup>18</sup>

#### Key Market and Technology Drivers

- Increasing fuel efficiency and weight reduction
- Noise reduction
- Thermal management

<sup>14</sup> IBISWorld, *Aircraft, Engine & Parts Manufacturing in the U.S.*, 2013.

<sup>15</sup> Deloitte, *2013 Global Aerospace and Defense Industry Outlook*, 2013.

<sup>16</sup> Visiongain, *Global Commercial Aircraft Gas Turbine Engine Market, 2013-2023*.

<sup>17</sup> Freedonia, *Focus Reports on Turbines: United States*, March 2013.

<sup>18</sup> Frost & Sullivan, *Global Military Fixed-wing Aircraft*, 2013.

# FUEL CELLS and ENERGY STORAGE

## What Is It?

Energy storage is a term used to describe various types of technologies that convert electricity into a form that can be used at a later time. Common energy storage technologies include battery storage, flywheel storage, superconducting magnetic energy storage, compressed air energy storage, pumped hydropower, and supercapacitors. Often discussed along with batteries are fuel cells, since both use electrochemical reactions to provide electricity. In the case of a battery, it stores electricity within chemical reactants—usually metal compounds like lithium, zinc or manganese—and once that stored electricity is used up must be recharged or discarded. Fuel cells also uses electrochemical reactions to generate electricity, but the reactants for fuel cells – hydrogen, methanol, and natural gas, among others – are supplied from outside the fuel cell and generate electricity as long as they are in supply.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

Ohio is home to many of the leading battery and fuel cell companies, including Energizer Battery, LG Fuel Cell Systems (formerly Rolls Royce), and Crown Battery Manufacturing. Still, this is a smaller and not yet specialized industry sector in Ohio, with just over 2,000 jobs. Furthermore, there appears to be troubling signs recently for Ohio's fuel cells and energy storage industry sector. Ohio's experience post recession shows an industry that is in decline while the nation's fuel cell industry is beginning to recover. Ohio's fuel cell and energy storage sector declined by 3.5 percent over the economic recovery years of 2009 to 2012, while it grew nationally by 2.6 percent. So, Ohio's ability to gain or even simply maintain market share is uncertain.

The reason for optimism is the strong growth potential of fuel cells and energy storage. Both batteries and fuel cells are potential sources for power needed by automobiles and other vehicles through the use of electric or hybrid vehicle technologies. Another critical use of fuel cells, batteries, and other energy storage devices is energy management. Having the ability to store and generate upon demand high levels of electricity is particularly important for energy management systems' ability to integrate many renewable, though intermittent, sources of electricity such as from wind and solar.

Ohio remains active in industry-driven innovation activities that can tap into these potential market growth opportunities. Despite its small industry base of under 30 business establishments, there were 33 industry awarded and applied for patents since 2010 and 17 pre-seed and seed backed emerging companies since 2006 in Ohio, suggesting the high level of industry innovation activity found in the state.

McKinsey Global Institute in its 2013 report on *Disruptive Technologies* cites energy storage as one of 12 key potentially economically disruptive technologies through 2025. At a low end, McKinsey notes a potential economic impact of \$90 billion, with \$40 billion from grid storage, \$25 billion from bringing reliable electricity to underserved markets, and \$20 billion from electric and hybrid vehicles. They predict a significant opportunity will be found in electric and hybrid vehicles with accelerated improvements in battery technology. *Fortune* magazine noted in September 2013 that fuel cell technology using hydrogen is also now seen by global automakers as more price-competitive, reliable and offers greater driving distances than in the past

## FUEL CELLS and ENERGY STORAGE: Recent Economic Performance

### Industry Employment Metrics

Fuel Cells & Energy Storage	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	28	2,076	0.80	10.0%	-3.5%	6.1%
Ohio Job Performance Relative to U.S.				46.2%	-6.9%	40.2%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Battery Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 4.5%	<ul style="list-style-type: none"> <li>Rebounding U.S. economy boosting downstream demand</li> <li>Increased consumer electronics and automotive mfg demand</li> <li>Push towards battery powered vehicles</li> <li>Faltering demand for alkaline batteries</li> <li>Volatile raw material prices</li> <li>Vertical integration squeezing smaller establishments</li> </ul>
<b>Electrical Equipment Manufacturing (incl. fuel cells)</b> 2013–2018 Expected Annual Revenue Growth: 3.3%	<ul style="list-style-type: none"> <li>Production in low-cost countries</li> <li>Falling employment and establishments</li> <li>Helpful govt. regulation (FERC)</li> <li>Global warming concerns improving investment in renewables</li> <li>Equipment replacement and expansion in energy sector</li> <li>Slow growth in value added by industry</li> </ul>
<b>Circuit Board &amp; Electronic Component Manufacturing (incl. capacitors)</b> 2013–2018 Expected Annual Revenue Growth: 0.8%	<ul style="list-style-type: none"> <li>Production to continue movement to low-cost countries</li> <li>Rising import costs</li> <li>Industry is in decline phase</li> <li>Rapid technological change – causes volatile demand</li> </ul>

Source: IBISWorld

#### Industry Niches

Storage Battery – *Current Opportunity (specialized and growing)*

Electronic Capacitors – *Emerging Strength*

#### Leading Companies

LG Fuel Cell Systems (fmr. Rolls Royce); Energizer Battery; Battelle; Liebert Corp.; Crown Battery Manufacturing; Faraday Technology; NexTech Materials

#### Emerging Companies

Blue Spark Technologies

## FUEL CELLS and ENERGY STORAGE: Recent Innovation Performance

### Patent Activity



**Number of recent patents issued\***

- Industry: 4
- Universities: 1

**Number of recent patent applications**

- Industry: 29
- Universities: 7

\*One patent issued jointly to an Ohio firm and university

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 12</li> <li>▪ Phase I &amp; II Awards: 34</li> <li>▪ Total Funding: \$9.6 million</li> <li>▪ Key Agencies: DoD, DOE, NSF</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 17</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 1</li> <li>▪ Deals: 2</li> <li>▪ Investment: \$3.0 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Chemistry: electrical current producing apparatus, product, and process	12
Electricity: battery or capacitor charging or discharging	6
Batteries: thermoelectric and photoelectric	5
Electrolysis: processes, compositions, and methods of preparing the compositions	4
Electricity: electrical systems and devices	3
Chemistry: electrical and wave energy	3

#### *Significant New Infrastructure and Research Investments*

- **LG's purchase of majority share of Rolls Royce Fuel Cell Group**

As part of the acquisition, LG was expecting to immediately added value with people, capability, and funding in to the business.

## FUEL CELLS and ENERGY STORAGE: Market Outlook and Drivers

### Key Market Outlook

- U.S. battery market is poised for an annual growth of more than 4.5 percent from 2013 through 2018, growing from \$11.7 billion market in 2013 to nearly \$14.6 billion in 2018.<sup>19</sup>
- Primary batteries are expected to remain the leading type of portable power supply in use in 2016 with expected demand of \$5.0 billion.<sup>20</sup>
- Revenue from the global thin film battery (TFB) market reached \$51.8 million in 2012 to and is projected to reach \$647.6 million in 2018, with a compound average annual growth rate of 49.3 percent.<sup>21</sup>
  - This substantial growth rate is driven by the use of TFBs in emerging sensor, RFID, and medical/consumer applications.
- The world market for rechargeable batteries – which are used in a range of applications, including automotive, communications, medical, laptops, and emergency power – is expected to reach \$21.4 billion by 2017.<sup>22</sup>
- An optimistic projection of the growth in the fuel cell market anticipates the market to grow at a CAGR of over 40 percent to reach \$4.2 billion in 2017 and reach a market value of \$14.1 billion by 2022.<sup>23</sup>
- The global fuel cell industry topped the \$1 billion mark in revenue from the sale of fuel cell systems in 2012, growing from \$847.5 million in 2011 to \$1.3 billion in 2012.<sup>24</sup>
  - Annual revenue from stationary fuel cells will grow from \$1.7 billion in 2013 to \$9 billion in 2022.<sup>25</sup>
- The global residential, commercial, and military fuel cell market is expected to reach nearly \$1.7 billion in 2017 after increasing at a five-year CAGR of 24.2%.<sup>26</sup>

#### Key Market and Technology Drivers

- Distributed generation
- Fuel processing and power conditioning requirements
- Application specific battery and fuel cell type development

<sup>19</sup> IBISWorld, Battery manufacturing in the U.S., 2013

<sup>20</sup> Freedonia, *Focus Reports on Batteries: United States*, October 2012.

<sup>21</sup> BCC Research, *Global Markets and Technologies for Thin-Film Batteries*, 2013

<sup>22</sup> Global Industry Analysts, *Rechargeable Batteries*, 2012

<sup>23</sup> SBI Energy, *Fuel Cell Technologies Worldwide*, 2013.

<sup>24</sup> Navigant Research, *Fuel Cells Annual Report 2013*, 2013.

<sup>25</sup> Navigant Research, *Stationary Fuel Cells*, 2013.

<sup>26</sup> BCC Research, *Fuel Cells for Residential, Commercial and Military Power*, 2012.

# MEDICAL TECHNOLOGY

## What Is It?

Medical technology encompasses a wide range of health-care products used to diagnose, monitor, or treat diseases or conditions that affect humans. These innovative technologies include imaging, surgical instruments and equipment, implant devices, and regenerative medicine. Together, these innovative technologies are improving, largely through innovative medical instruments and devices, the quality of health care delivered and patient outcomes through earlier diagnosis, less invasive treatment options, and reductions in hospital stays and rehabilitation times. Advances in medical technology are often based on a “systems” approach in which a range of innovative technologies are integrated to provide more functional medical products.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

The medical technology industry represents an emerging industry strength in Ohio. Ohio is already specialized in surgical appliances involving such products as orthopedic devices, prosthetic appliances, surgical dressings, and surgical sutures, with employment of over 5,000 workers across more than 130 business establishments. Broad job gains in Ohio have been made since 2009 across many other medical technology-related industries beyond this traditional strength in surgical appliances, including job gains in electromedical devices, medical instruments, and analytical laboratory instruments.

Medical technology is also a considerable innovation strength found in Ohio. This innovation strength is found across both industry and academia. Since 2010, Ohio industry has generated over 900 patent awards and applications in medical technology, while academia is also converting its research activities into new patented technologies, with 136 patent awards and applications. For both industry and academia in Ohio, medical technology recorded the highest number of patents of all opportunity areas. As important, 35 innovative medical technology companies received later stage venture capital funding, demonstrating a strong ecosystem of innovation in Ohio.

The market opportunities for medical technology remain strong as aging populations in the U.S. and abroad, along with growing middle class among developing nations, keep demand high. New technologies for minimally invasive surgery, improved use of robotics, increased integration of biologics and regenerative medicine into medical devices, and remote monitoring from medical devices are keeping the pace of new commercialization strong.

Ohio Third Frontier has been an active contributor to the innovation and growth of medical technology in Ohio. More than 140 companies in Ohio have received OTF pre-seed and seed investments. Plus, major OTF investments with universities, such as the Global Cardiovascular Innovation Institute, continue to generate economic returns and advance a stronger focus on commercialization and translational research among Ohio’s strong academic medical centers.

## MEDICAL TECHNOLOGY: Recent Economic Performance

### Industry Employment Metrics

Medical Technology	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	1,655	24,688	0.80	11.3%	2.6%	14.2%
Ohio Job Performance Relative to U.S.				-5.4%	-1.0%	-6.7%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Medical Equipment &amp; Supply Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 3.9%	<ul style="list-style-type: none"> <li>• Aging U.S. population</li> <li>• Reduced hospital capital equipment spending</li> <li>• Soft elective surgery demand</li> <li>• Strong innovation and product development prospectus</li> <li>• Demand from emerging markets</li> <li>• Hospitals narrowing product vendor lists</li> </ul>
<b>Electromedical Device Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 7.0%	<ul style="list-style-type: none"> <li>• Changing U.S. demographics benefit industry</li> <li>• Healthcare Reform (ACA)</li> <li>• Excise tax on device mfgs.</li> <li>• Rising regulatory scrutiny (FDA)</li> <li>• Increasing R&amp;D, production, and product launches being moved overseas</li> <li>• Stringent reimbursement</li> <li>• Industry is in growing phase</li> </ul>
<b>Medical Supplies Wholesaling</b> 2013–2018 Expected Annual Revenue Growth: 4.8%	<ul style="list-style-type: none"> <li>• Increasing number of Americans over 65</li> <li>• Changing consumer demands</li> <li>• Aggressive competition</li> <li>• Heightened govt. regulations</li> <li>• Product lines to multiply increasing warehousing costs</li> <li>• Innovation rate to increase</li> <li>• Competitive bidding process</li> </ul>

Source: IBISWorld

#### Industry Niches

Surgical Appliances –  
*Current Strength*

Surgical and Medical Instruments –  
*Emerging Strength*

Medical Equipment Distribution –  
*Emerging Strength (nearly specialized)*

#### Leading Companies

Ethicon Endo-Surgery, Invacare, Devicor Medical Products, STERIS, Athersys, Cardinal Health, Mettler-Toledo, Philips Medical Systems, Hitachi Medical Systems, Zimmer Surgical

#### Emerging Companies

ViewRay; X-spine; Cleveland Heart; AxioMed Spine Corporation

## MEDICAL TECHNOLOGY: Recent Innovation Performance

### Patent Activity



- |  |   |
|--|---|
| <b>Number of recent patents issued</b> | <b>Number of recent patent applications</b> |
| ▪ Industry: 143                        | ▪ Industry: 617                             |
| ▪ Universities: 28                     | ▪ Universities: 108                         |

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 25</li> <li>▪ Phase I &amp; II Awards: 67</li> <li>▪ Total Funding: \$20.0 million</li> <li>▪ Key Agencies: DoD, NASA</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 140</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 35</li> <li>▪ Deals: 85</li> <li>▪ Investment: \$250.3 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Surgery: surgical instruments and devices	192
Elongated-member-driving apparatus	130
Surgery: diagnostic/therapy testing, techniques, or devices	105
Chemistry: molecular biology and microbiology	77
Surgery: blood/fluid-related devices	44
Drug, bio-affecting and body treating compositions	41
Prosthesis (i.e., artificial body members), parts, aids, accessories	34
Combinatorial chemistry technology: method, library, apparatus	30
Surgery: light, thermal, and electrical application	20
Chemical apparatus/process disinfecting, deodorizing, or sterilizing	14
Radiant energy	14
Image analysis	11
Beds	11
Surgery: splint, brace, or bandage	11

#### Significant New Infrastructure and Research Investments

- **Cleveland Heart Inc., Receives \$30 Million Investment for Development of Artificial Heart**  
Investment from Power Heart Consortium, a Korean private-equity group.
- **Continuation of CWRU Clinical and Translational Science Award (CTSA) for \$64.6 million**  
The grant from the National Institutes of Health (NIH) aims to accelerate the process of making medical discoveries and then taking them to patients.

## MEDICAL TECHNOLOGY: Market Outlook and Drivers

### Key Market Outlook

- The surgical instruments and equipment industry in the U.S. is expected to grow at an average annual rate of 3.9 percent through 2018 to a market value of just under \$111 billion.<sup>27</sup>
  - A key growth segment in surgical instruments is minimally invasive surgical devices and instruments, with a CAGR of 7.9 percent through 2016.<sup>28</sup>
- The medical imaging market is expected to see steady growth throughout the next five years at a CAGR of 5 percent. Global revenues in this market are expected to increase to \$34.1 billion by 2017.<sup>29</sup>
  - Most of the new growth in this market over the next five years will come from fusion technology that combine two or more imaging technologies into one machine offering more precise readings and lower radiation exposure.
- Due to the specialization of implantable devices this niche is best viewed through its key application markets.
  - Cardiovascular implant global market valued at an estimated \$85 billion but is set to see substantially slower growth with a CAGR of 2.8 percent through 2015.<sup>30</sup>
  - Orthopedic implant global market valued at \$28 billion and a CAGR of 2.7 percent through 2015.<sup>31</sup>
  - The growing field of neuromodulation implant devices currently has a global value of \$3 billion and is forecast annual growth rate of 16 percent through 2015.<sup>32, 33</sup>
- The global regenerative medicine market is expected to exceed \$35 billion by 2019.<sup>34</sup>

#### Key Market and Technology Drivers

- Instrument miniaturization
- Increasing hybridization of imaging technology
- Disposable instruments and equipment
- New materials enabling new applications and product development
- Hybrid technologies that incorporate pharmaceutical products and surgical equipment
- Improved image acquisition, modeling, and quantification technologies

<sup>27</sup> IBISWorld, Medical Instrument & Supply Manufacturing, 2013

<sup>28</sup> BBC Research, *The Market for Minimally Invasive Medical Devices*, 2011

<sup>29</sup> BCC Research, *Global Markets for Medical Imaging Reagents and Analysis Equipment*, 2013

<sup>30</sup> BCC Research, *Cardiovascular Devices: Technologies and Global Markets*, 2009

<sup>31</sup> BCC Research, *Advanced Orthopedic Technologies, Implants and Regenerative Products*, 2011

<sup>32</sup> Visiongain, *Neuromodulation Devices: World Market Prospects 2011-2021*, 2011

<sup>33</sup> TechNavio, *Global Neuromodulation Market 2011-2015*, 2012

<sup>34</sup> TriMark Publications, *Regenerative Medicine Markets*, 2013

# SENSING and AUTOMATION SYSTEMS

## What Is It?

Industrial automation technologies increase productivity and often improve quality and safety by reducing the need for human labor in the production of goods and services. These automation technologies accomplish these production tasks through the use of sensors, relays, and integrated control systems. Automation technologies range from advanced electronic and hydraulic/fluid power systems to digital controls. Sensors, which receive and respond to external signals or stimuli, are critical to the process of automation. Automation sensors not only sense, monitor, and control physical characteristics (e.g., is the part there?, is it the right one?, is it oriented the right way?), but also process characteristics (e.g., are the manufacturing tolerances correct?, is the production batch complete?). Combined, sensing and automation technologies comprise a “nervous system” for manufacturing plants and improve process efficiency.

Additionally, industrial and commercial sensors are becoming more integrated into the entire operation of a facility, not simply the production operations. Sensors and the control systems are developed to manage building envelopes (e.g., temperature, lighting, occupancy, safety, and security) as well as the ability to track the parts and products into and out of modern manufacturing operation through technologies such as RFID tags.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

The Ohio competitive focus in this industry growth opportunity area is broad and complex, reflecting the wide variety of applications for automation technologies. Within this diverse sector, the state is home to global leading companies such as Diebold (ATMs, kiosks, and voting machines), Nordson (automated dispensing systems), and Eaton (broad industrial automation technologies). Additionally, firms such as Mettler-Toledo have product lines related to industrial and analytic automation, and other major firms in this sector such as Rockwell Automation have important Ohio operations. Given this breadth, the sensing and automation systems industry also has strong complementary ties to other key Ohio sectors such as power management and situational awareness.

Even with employment declining by nearly a third over the last decade or so, it still employs nearly 18,000 workers and is an industry specialization for Ohio being 56 percent more concentrated in Ohio than in the overall U.S. There is a substantial level of innovation occurring within the major firms, with some smaller niche firms also developing new innovative sensor-based technologies. Total industry patents awarded and applied for reach over 400 since 2010 – making it one of the most active areas of intellectual property generation in Ohio – while 31 emerging companies have received pre-seed and seed funding since 2006.

While overall growth prospects are moderate, there are specific high growth niches for Ohio to pursue. These include microelectromechanical systems (MEMS), machine vision, and advanced sensors.

## SENSING and AUTOMATION SYSTEMS: Recent Economic Performance

### Industry Employment Metrics

Sensing & Automation Systems	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	417	17,959	1.56	-22.4%	-10.3%	-30.4%
Ohio Job Performance Relative to U.S.				2.2%	-13.5%	-8.2%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Electrical Equipment Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 3.7%	<ul style="list-style-type: none"> <li>Increased import penetration</li> <li>Strong export growth</li> <li>Power infrastructure expected to increase</li> <li>Building construction on upward trend</li> </ul>
<b>Instrument Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 2.7%	<ul style="list-style-type: none"> <li>R&amp;D funding in new areas to drive growth</li> <li>Increased demand from energy, health, and biotech firms</li> <li>Growing competition</li> <li>Falling number of establishments and employees</li> <li>Mature industry</li> </ul>
<b>Other General Purpose Machinery Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 3.3%	<ul style="list-style-type: none"> <li>Marginal industry consolidation</li> <li>Moderate domestic demand</li> <li>Rising import penetration</li> <li>Improving aircraft demand</li> </ul>

Source: IBISWorld

#### Industry Niches

Relay and Industrial Control – *Specialized*  
 Fluid Power Hose and Valve Fittings – *Specialized*  
 Fluid Power Cylinder and Actuator – *Specialized*

#### Leading Companies

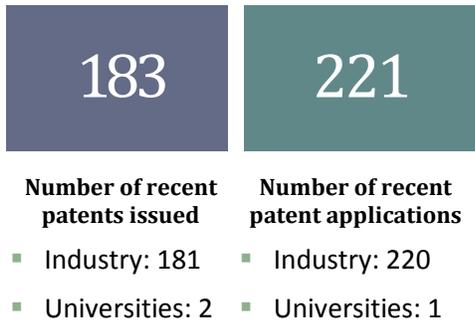
Eaton Corporation;  
 Rockwell Automation;  
 Diebold; Nordson;  
 Mettler-Toledo; Thermo-O-Disc (Emerson Electric);  
 ABB Automation

#### Emerging Companies

Integrated Sensors;  
 LineStream Technologies

## SENSING and AUTOMATION SYSTEMS: Recent Innovation Performance

### Patent Activity



### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 7</li> <li>▪ Phase I &amp; II Awards: 22</li> <li>▪ Total Funding: \$6.1 million</li> <li>▪ Key Agencies: DoD, NASA</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 31</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 2</li> <li>▪ Deals: 3</li> <li>▪ Investment: \$6.0 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Registers	132
Data processing: generic control systems or specific applications	51
Communications: electrical	22
Electricity: electrical systems and devices	14
Coating processes	10
Measuring and testing	10
Data processing: measuring, calibrating, or testing	9
Fluid handling	8
Data processing: database/file management, data structures, document processing	7
Electrical computers/digital processing systems: multi-computer data transferring or processor synchronization	7
Electrical computers/digital processing systems: support	6
Computer graphics processing, operator interface processing, and selective visual display systems	6
Image analysis	6
Optics: measuring and testing	6

## SENSING and AUTOMATION SYSTEMS: Market Outlook and Drivers

### Key Market Outlook

- The global market for sensors was valued at \$68.2 billion in 2012. The global sensors market is forecast to grow at a CAGR of 7.9 percent through 2019 to reach \$116.1 billion.<sup>35</sup>
  - The biggest growth opportunities in the sensor market are expected to come from the medical industry (9.0 percent) and consumer electronics (8.9 percent) where technology improvements in areas such as MEMS and optoelectronics will support the strong forecasted global growth rates.
- The global market for MEMS is projected to experience robust growth through 2018, doubling from its 2012 value of \$11 billion to \$22.5 billion in 2018.<sup>36</sup>
  - The bulk of the global MEMS revenue is expected to come from the microsensor market, which is projected to growth at a CAGR of 15.5 percent through 2016.<sup>37</sup>
- U.S. demand for all control technologies is forecast to reach \$30.7 billion in 2017, representing annual growth of 2.8% from \$26.7 billion in 2012.<sup>38</sup>
  - The U.S. market for industrial controls is forecast to total \$13.8 billion in 2017, up a CAGR of 2.2 percent from \$12.4 billion in 2012.
  - U.S. demand for process controls is forecast to climb 3.8 percent per annum to \$13.0 billion in 2017, making it the fastest growing segment.
- Machine vision (MV) technology enables automated capture and analysis of visual information. The global market for MV systems will experience substantial growth through 2019, with revenues increasing from \$13.5 billion in 2012 to \$23.5 billion at a CAGR of 9 percent.<sup>39</sup>

#### *Key Market and Technology Drivers*

- Technological advances improving efficiency and reliability
- Continued Miniaturization of technologies
- Reduction of energy consumption

<sup>35</sup> BCC Research, *Global Markets and Technologies for Sensors*, 2013

<sup>36</sup> Yole Development, *Status of the MEMS Industry*, 2013

<sup>37</sup> BCC Research, *MEMS: Biosensors and Nanosensors*, 2011

<sup>38</sup> Freedonia, *Focus Reports on Control Technologies: United States*, November 2013.

<sup>39</sup> BCC Research, *Global Markets for Machine Vision Technologies*, 2013

# SITUATIONAL AWARENESS and SURVEILLANCE SYSTEMS

## **What Is It?**

Situational awareness and surveillance systems encompass a comprehensive set of technologies that allow users to perceive information about their environment with respect to time and space and anticipate how those environmental factors may affect circumstances in the near future. Building upon technology advances in sensor and sensor systems and applications of Big Data for the continued use of information for decision making, enhanced situational awareness and surveillance systems has broad market opportunities for use in aviation, defense, and law enforcement.

## **Why Is It A Targeted Growth Opportunity Area For Ohio?**

Today, situational awareness and surveillance systems industries in Ohio are fast growing, though still only a small base of industry activity in Ohio with just under 6,000 jobs. But the market opportunities are substantial – and more importantly, represent new “blue ocean” markets in which there is ample opportunity for Ohio to not only realize significant economic growth but global leadership since no market leaders have been established.

One example of how opportunities in situational awareness and surveillance systems can open new market space for Ohio to be a global leader is in the commercial application of unmanned aerial systems. This builds upon the capabilities being advanced by the Air Force Research Labs at Wright Patterson and Ohio’s growing industry of search, detection and navigation guidance systems and instruments industry. Unmanned aerial systems (UAS) operate aircraft without a flight crew on-board, either by remote control or autonomously, and are being used extensively by the military for surveillance and attack missions. The commercial applications of UAS can also be quite extensive, from transportation, homeland security, and law enforcement surveillance to performing geophysical surveys for oil, gas, and mineral exploration to hunting hurricanes, among other uses. UAS are highly advanced inter-disciplinary technology systems calling for advances in automation and control, remote sensing, sensing data management systems, power and propulsion, and aircraft materials and design. Today, there is no market for commercial UAS, but by 2018 it is expected to be a multi-billion market place.

What also stands out for Ohio in situational awareness and surveillance systems is that it is already highly competitive and innovative, despite its small size. This industry is growing in Ohio even as it declines nationally, and despite its small size, it generated 45 industry patent awards and applications since 2010 and 18 emerging companies receiving later-stage, seed and pre-seed funding.

## SITUATIONAL AWARENESS and SURVEILLANCE SYSTEMS: Recent Economic Performance

### Industry Employment Metrics

Situational Awareness & Surveillance Systems	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	354	5,872	0.55	12.9%	4.3%	17.7%
Ohio Job Performance Relative to U.S.				9.7%	7.4%	17.8%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Instrument Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 2.7%	<ul style="list-style-type: none"> <li>R&amp;D funding in new areas to drive growth</li> <li>Increased demand from energy, health, and biotech firms</li> <li>Growing competition</li> <li>Falling number of establishments and employees</li> <li>Mature industry</li> </ul>
<b>Unmanned Aerial Vehicles (federal market)</b> 2013–2018 Expected Annual Revenue Growth: 3.8%	<ul style="list-style-type: none"> <li>Federal funding for defense</li> <li>Federal funding for homeland security</li> <li>Price of semiconductor and electronic components</li> <li>Research and development expenditures</li> </ul>
<b>Aircraft, Engine &amp; Parts Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 1.8%	<ul style="list-style-type: none"> <li>Demand from China and India</li> <li>Current military contracts locked-in</li> <li>Future Govt. contracts could face cuts/lower margins</li> <li>More investment in R&amp;D</li> <li>Low wage increases</li> </ul>

Source: IBISWorld

#### Industry Niches

Search, Detection and Navigation Instruments – *Emerging Strength, with especially strong job growth*

#### Leading Companies

YSI; Woolpert Inc.; Battelle; GIRD Systems; Inc.; METSS Corporation; L-3 Communications

#### Emerging Companies

The O'Gara Group; Persistent Surveillance Systems

## SITUATIONAL AWARENESS and SURVEILLANCE SYSTEMS: Recent Innovation Performance

### Patent Activity



- |   |  |
|---|--|
| <p><b>Number of recent patents issued</b></p> <ul style="list-style-type: none"> <li>▪ Industry: 12</li> <li>▪ Universities: 5</li> </ul> | <p><b>Number of recent patent applications</b></p> <ul style="list-style-type: none"> <li>▪ Industry: 33</li> <li>▪ Universities: 5</li> </ul> |
|---|--|

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 34</li> <li>▪ Phase I &amp; II Awards: 103</li> <li>▪ Total Funding: \$28.8 million</li> <li>▪ Key Agencies: DoD, USDA</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 17</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 1</li> <li>▪ Deals: 3</li> <li>▪ Investment: \$10.6 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Communications: electrical	6
Telecommunications	6
Data processing: financial, business practice, management, or cost/price determination	6
Image analysis	5
Communications: directive radio wave systems and devices (e.g., radar, radio navigation)	3
Measuring and testing	3
Electricity: measuring and testing	3
Television	3
Data processing: vehicles, navigation, and relative location	3

*Significant New Infrastructure and Research Investments*

- **Woolpert partners on a \$1.5 billion contract related to aeronautical surveying, airspace obstruction mapping and geographic information systems services**

Woolpert could realize up to \$100 million from the Federal Aviation Administration contract

## SITUATIONAL AWARENESS and SURVEILLANCE SYSTEMS: Market Outlook and Drivers

### Key Market Outlook

- The global market for remote sensing products is expected to reach \$7.6 in 2013. This market is further expected to grow to \$8.1 billion in 2014 and \$12.1 billion in 2019, a compound annual growth rate (CAGR) of 8.2 percent over the five-year period from 2014 to 2019.<sup>40</sup>
  - Airborne platforms as a segment are expected to reach \$3.0 billion by the end of 2013. This segment is expected to grow to \$4.7 billion in 2019, a CAGR of 7.3 percent.
- The global market for surveillance equipment is expected to grow at a CAGR of 9.4 percent to reach \$127.6 billion in 2017.<sup>41</sup>
- The commercial market for UAS is estimated to reach \$2.8 billion by 2018, according to WinterGreen Research.<sup>42</sup> This includes small unit surveillance, urban monitoring, force protection, and aerial mapping as the projected core uses for commercial unmanned aerial systems. Commercial UAS are designed to offer interchangeable payloads: Meteorological, air samplings, IR monitoring and emergency are the most common uses for helicopter UAS. Harbor & border control, area & event security, search & rescue, out-reach Surveillance, and damage assessment are applications for the technology.
- According to Frost & Sullivan, the potential market for law enforcement UASs is about \$459.1 million even if only 25 percent of U.S. police force participates.<sup>43</sup>
- The global market for ECBN hazard monitoring, decontamination and personal protective equipment was valued at \$148.3 billion in 2012 and is expected to increase to \$193.7 billion in 2014 and then to \$387.9 billion in 2019, a CAGR of 14.9% over the five-year period from 2014 to 2019.<sup>44</sup>

#### Key Market and Technology Drivers

- Ability to respond quickly to events
- Increasing efficiency and effectiveness of operations
- Providing uniform operating environment for decision makers, analysts, and operators
- Collaboration and communication across multiple organizations
- Border security

<sup>40</sup> BCC Research, *Remote Sensing Technologies and Global Markets*, 2013

<sup>41</sup> BCC Research, *Surveillance and Security Equipment: Technologies and Global Markets*, 2013.

<sup>42</sup> WinterGreen Research, *Commercial Unmanned Aerial Systems: Market Shares, Strategies and Forecasts, Worldwide, 2012–2018*, Product 247707, July 26, 2012.

<sup>43</sup> Frost & Sullivan, *Non-military Use of Unmanned Aerial Systems in the United States*, 2012.

<sup>44</sup> BCC Research, *Surveillance and Monitoring of Explosive, Chemical, Biological and Nuclear Hazards*, 2013.

# SOFTWARE APPLICATIONS for BUSINESS and HEALTHCARE

## What Is It?

Software applications enable organizations to reduce costs and increase productivity, achieve greater profitability, and improve efficiency. Business software has become ubiquitous among industries and is constantly advancing with new technologies and growing generation of data applied to business operations. Within the broad markets of software applications for business, the opportunity in Health IT stands out. It offers the potential to dramatically revolutionize healthcare delivery as electronic health records become a platform for improving health care decisions by health providers as well as advancing more patient-centered health information technology applications.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

Industries related to software applications have been a consistent job generator for the past decade in Ohio even over the recession years. These industries stand as one of Ohio's most innovative sectors, with a strong presence in both patent activity as well as emerging companies. While not yet a specialized industry sector, it is quite sizable, at over 67,000 jobs in 2012, and can generate large numbers of new jobs. The Ohio Third Frontier is already an important asset for the growth of the state's software applications-related industries. Through the extensive network of entrepreneurial signature programs and pre-seed/seed funds, the Ohio Third Frontier is fostering the growth of emerging software companies.

The overall market prospects for software applications are particularly strong going forward. A new era of Big Data is unfolding in which new technologies are being advanced to improve how organizations manage the unprecedented amount of digital information being generated from digitizing of records, on-line transactions, social networking, and Internet searches to better serve their customers and provide insights into the development of new products. A wide range of advanced skills in data analytics and visualization, data base management and high performance computing, human-computer interactions, and cybersecurity to protect and ensure the integrity of information will be needed to meet market needs.

Ohio is particularly well-positioned, through its world-renowned academic medical centers, to be a leader in the emerging new era of connected health. McKinsey & Company explains that "connected health" will be driven by technologies of big data, social media, and mobility that will feature data-based transparency of medical outcomes, personalized care focused on diagnosing and monitoring an individual's underlying biology and consumer-directed care.<sup>45</sup> Academic medical centers are leaders in advancing many of these new applications given their close connections to advanced medical technologies and health outcomes research.

Looking forward over the next 3 to 5 years, an important driver for advancing software applications will be pursuing open innovation approaches that link major industry leaders in Ohio, particularly in health care, with the growing base of innovative software companies. The Ohio Third Frontier is well positioned to spur these efforts forward.

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<sup>45</sup> Sam Marwaha et al, *Biopharma in the Coming Era of 'Connected Health,'* McKinsey on Business Technology, Number 26, Spring 2012.

## SOFTWARE APPLICATIONS for BUSINESS and HEALTHCARE: Recent Economic Performance

### Industry Employment Metrics

Software Applications	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012*	Total Change, 2001–2012*
Ohio Specific Performance	7,679	67,204	0.75	11.9%	1.3%*	13.3%*
Ohio Job Performance Relative to U.S.				9.1%	-12.8%*	-4.0%*

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

\*Note: These post recession and total change figures reflect a significant reclassification of one large Ohio establishment from a software-related NAICS code in 2011 to a corporate/regional management office NAICS code in 2012. Due to disclosure issues it is impossible to remove the employment of this firm from the 2001-2011 data.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Software Publishing</b> 2013–2018 Expected Annual Revenue Growth: 3.7%	<ul style="list-style-type: none"> <li>Improving tech and falling hardware costs</li> <li>Hospitals going to digital medical records</li> <li>Industry move to software delivery via cloud computing</li> <li>Greater proliferation of open-source software</li> <li>Move to subscription-based business model</li> </ul>
<b>Data Processing &amp; Hosting Services</b> 2013–2018 Expected Annual Revenue Growth: 3.0%	<ul style="list-style-type: none"> <li>Continued outsourcing of IT needs</li> <li>Expense of providing IT services</li> <li>Investments in products that streamline/improve operations</li> <li>Increased use of systems by financial industry</li> <li>Industry drive towards cloud computing</li> <li>Hard drive supply disruptions increasing costs</li> </ul>
<b>Internet Publishing and Broadcasting</b> 2013–2018 Expected Annual Revenue Growth: 17.3%	<ul style="list-style-type: none"> <li>Advertisers shift towards online and mobile resources</li> <li>Medium-sized firms expected to struggle</li> <li>Low barriers of entry to industry</li> <li>Greater use of geolocation in ads</li> </ul>
<b>IT Consulting</b> 2013–2018 Expected Annual Revenue Growth: 2.9%	<ul style="list-style-type: none"> <li>Innovation needed for better growth</li> <li>Declining public-sector demand</li> <li>Increasing price competition</li> <li>M&amp;A activity expected to accelerate</li> <li>Low barriers of entry to industry</li> </ul>

Source: IBISWorld

#### Industry Niches

Other Computer Related Services – *Specialized*

#### Leading Companies

LexisNexis; Convergys; CardinalCommerce; TOA Technologies; Apteryx; Reynolds and Reynolds; Hyland; Cincom Systems

#### Emerging Companies

ThinkVine Corporation; COMS Interactive

## SOFTWARE APPLICATIONS for BUSINESS and HEALTHCARE: Recent Innovation Performance

### Patent Activity



- |  |   |
|--|---|
| <b>Number of recent patents issued</b> | <b>Number of recent patent applications</b> |
| ▪ Industry: 63                         | ▪ Industry: 178                             |
| ▪ Universities: 1                      | ▪ Universities: 7                           |

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 19</li> <li>▪ Phase I &amp; II Awards: 42</li> <li>▪ Total Funding: \$12.2 million</li> <li>▪ Key Agencies: DoD</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 296</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 58</li> <li>▪ Deals: 87</li> <li>▪ Investment: \$261.9 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Data processing: financial, business practice, management, or cost/price determination	67
Data processing: database and file management, data structures, or document processing	25
Data processing: vehicles, navigation, and relative location	21
Data processing: measuring, calibrating, or testing	20
Data processing: presentation processing of document	19
Electrical computers/digital processing systems: multi-computer data transferring or processor synchronization	13
Data processing: generic control systems or specific applications	13
Telephonic communications	6
Data processing: structural design, modeling, simulation, and emulation	6

#### *Significant New Infrastructure and Research Investments*

- **Ohio Health Information Partnership, the Hilliard-based nonprofit that manages the new statewide health information exchange called CliniSync, goes live in 2013.**

Thirty-seven hospitals are now live on the network, and more than 1,200 physicians have signed up for services with 700 already receiving results and reports directly from their local hospitals.

## SOFTWARE APPLICATIONS for BUSINESS and HEALTHCARE: Market Outlook and Drivers

### Key Market Outlook

- The North American business software market is anticipated to grow at a CAGR of 7.7 percent through 2015 to reach \$165 billion.<sup>46</sup>
- The global market for customer relationship management (CRM) software reached \$18.1 billion in 2012 and is expected to reach \$20.8 billion by the end of 2013. At a CAGR of 15.1 percent, the CRM market is forecast to reach \$36.5 billion by 2017.<sup>47</sup>
- Globally, the market for enterprise cloud-based services will grow from \$18.3 billion in 2012 to \$31.9 billion in 2017 with year-on-year growth rates pegged at 17 percent over the next five-years.<sup>48</sup>
- Biomedical and health care-related IT will experience significant growth across all niches in the next several years, with the overall market increasing from \$15.9 billion in 2012 to \$22.6 billion in 2017 at a CAGR of 7.2 percent.<sup>49</sup>
- Software applications accounted for over 73 percent of the health IT market in 2012 and is expected to continue to have roughly the same market share through 2017. This will result in software applications increasing from its value of \$8.2 billion in 2012 to \$18.8 billion in 2017 for a CAGR of 18 percent. Most of this growth will continue to come from the electronic health records subsector—already the largest subsector at more than \$6.5 billion in 2012—which is expected to a CAGR of 20 percent.<sup>50</sup>
- Big Data applications for storing, processing and analyzing large and complex data is expected to realize a 58 percent CAGR from 2012-2017.<sup>51</sup>
- The global market for big data analytics is expected to grow at an astounding 55 percent year-over-year growth rate increasing its market value from \$1.5 billion in 2012 to just under \$14 billion in 2017.<sup>52</sup>

### Key Market and Technology Drivers

- Growth of software-as-a-service and on-demand applications enabled by cloud computing
- Increased enterprise mobility and emphasis on open platforms
- Expanding amounts of data and the need for software to process and analyze it
- Technological advancements such as electronic medical records, picture-archiving and communications systems, data management systems, and personal health records
- Growing demand of computerized physician order entry for reduced errors and instant access to medical information
- Growth of “accountable care organizations”
- Reducing healthcare costs—especially with impetus of federal funding for health information exchanges
- Electronic devices measuring and recording vitals and other medical information

<sup>46</sup> Datamonitor, *Global Market Trends 2010: Business Software Forecasts*, 2011.

<sup>47</sup> Gartner Inc, *Market Share Analysis: Customer Relationship Management Software, Worldwide*, 2012.

<sup>48</sup> Analysys Mason, *Enterprise cloud services: worldwide forecast 2012-2017*, 2013.

<sup>49</sup> MarketsandMarkets, *North American Healthcare IT Market, By Application, Delivery Mode & Component—Forecasts to 2017*, 2013.

<sup>50</sup> BCC Research, *Healthcare Information Technology*, 2013.

<sup>51</sup> Wikibon, *Big Data Vendor Revenue and Market Forecast 2012-2017*, 2012.

<sup>52</sup> MarketsandMarkets, *Hadoop & Big Data Market-Trends, Geographical Analysis & Worldwide Market Forecasts (2012 – 2017)*, 2012.

# SOLAR PHOTOVOLTAICS and SOLAR ENERGY

## What Is It?

Solar power harnesses the energy of the sun and converts it to electricity or heat. Although photovoltaic (PV) technology, which converts solar energy into electricity using cells or modules, has existed for more than 50 years, it has taken decades to turn the technology into commercialized products, and, as a result, become an industry. Innovations in solar technology are enabling a wide spectrum of uses from concentrated solar power plants and building-integrated PV to powering electronic devices. Increasing social and political concern for environmental sustainability combined with the need for secure energy supplies has stimulated demand for alternative energy resources, including solar.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

Albeit small, with only ten establishments and slightly over 1,500 employees, the solar photovoltaics and solar energy industry is undoubtedly a current strength of Ohio encompassing an industry sector that is nearly five times as concentrated as the nation and growing at an unprecedented rate of more than 550 percent over the decade. Building upon Ohio's legacy of glass and plastics manufacturing, Ohio has been able to far outpace the national growth rates thereby increasing its overall market share.

Ohio is best known for the presence of First Solar, one of the largest U.S. solar power manufacturers. However, as a result of its unique comparative advantage, Ohio has been able to attract other significant solar photovoltaic efforts, such as Isofoton's new \$31 million plant as well as the Napoleon Solar Project, among the largest solar installations in Ohio that was completed in 2012 by BNB Renewable Energy Holdings.

What also stands out for Ohio in solar photovoltaics and solar energy is that it is highly innovative, despite its small size. It generated 112 industry patent awards and applications since 2010 and 24 investments were made in emerging companies. Three companies alone received \$10.8 million in post-seed/venture capital investments.

Ohio's unique opportunity in solar photovoltaics and solar energy bodes well for future economic growth when the market outlook for the industry sector is examined. Solar power is anticipated to grow at a faster pace than any other renewable energy technology during this decade. The market revenues in North America are expected to grow at a CAGR of 28.3 percent from 2010–2017 and reach \$17 billion. More specifically, the cadmium telluride (CdTe) solar cell market, of particular interest to Ohio whose leading thin-film firm First Solar currently holds 90 percent market share, is expected to increase from a \$2.8 billion market in 2009 to \$4.6 billion by 2015.

## SOLAR PHOTOVOLTAICS and SOLAR ENERGY: Recent Economic Performance

### Industry Employment Metrics

Solar Photovoltaics & Solar Energy	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	10	1,543	4.94	457.1%	13.0%	529.6%
Ohio Job Performance Relative to U.S.				493.0%	10.7%	564.1%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Solar Panel Mfg</b> 2013–2018 Expected Annual Revenue Growth: -15.6%	<ul style="list-style-type: none"> <li>• Tax credits for energy efficiency</li> <li>• Government assistance drives demand</li> <li>• Price of semiconductor and electronic components</li> <li>• Trade-weighted index</li> <li>• Electric power consumption</li> <li>• World price of natural gas</li> <li>• States expected to raise renewable portfolio standard (RPSs)</li> <li>• Technological advances in efficiency conversion</li> <li>• Markets flooded with cheap solar panels</li> <li>• Low energy commodity costs</li> </ul>

Source: IBISWorld

#### Industry Niches

Semiconductors and Related Devices – *Current Opportunity*

Heating Equipment – *Current Opportunity*

#### Leading Companies

First Solar; Xunlight; Ferro Corporation

#### Emerging Companies

Ecolibrium Solar; Nextronex

## SOLAR PHOTOVOLTAICS and SOLAR ENERGY: Recent Innovation Performance

### Patent Activity



- |   |  |
|---|--|
| <p><b>Number of recent patents issued</b></p> <ul style="list-style-type: none"> <li>▪ Industry: 22</li> <li>▪ Universities: 0</li> </ul> | <p><b>Number of recent patent applications</b></p> <ul style="list-style-type: none"> <li>▪ Industry: 90</li> <li>▪ Universities: 2</li> </ul> |
|---|--|

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 1</li> <li>▪ Phase I &amp; II Awards: 2</li> <li>▪ Total Funding: \$0.25 million</li> <li>▪ Key Agencies: DOE, NSF</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 20</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 3</li> <li>▪ Deals: 6</li> <li>▪ Investment: \$10.8 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Batteries: thermoelectric and photoelectric	53
Semiconductor device manufacturing: process	16
Stoves and furnaces	5
Electrical transmission or interconnection systems	4
Metal working	3
Static structures (e.g., buildings)	3
Coating processes	3
Electricity: measuring and testing	3

## SOLAR PHOTOVOLTAICS and SOLAR ENERGY: Market Outlook and Drivers

### Key Market Outlook

- Solar energy has become, and will continue to be, one of the fastest growing technologies in the global energy industry over the next few years.<sup>53</sup>
  - In terms of installations, the PV market is projected to have a CAGR of 30.5 percent to 2016. In terms of revenue, the global PV market generated \$85.16 billion in 2011, and the market is expected to grow at a 1.5 percent CAGR from 2011 to 2016. This growth in solar installations has not translated into greater revenue due to the continued decline in the average selling price of solar modules.
  - The utility-scale market is projected to grow at a compound annual growth rate (CAGR) of 60.6 percent from 2011 to 2016.
  - The concentrating solar power (CSP) segment of the market generated about \$2.83 billion in revenue with 1,685 MW installed by the end of 2011.
- Utility-scale photovoltaic (PV) plants and concentrating solar power (CSP) plants are expected to accelerate during the next decade in the United States due to the presence of high solar irradiance and the continuous pressure for the implementation of numerous renewable energy generation technologies.
- The cadmium telluride (CdTe) solar cell market is expected to increase from a \$2.8 billion market in 2009 to \$4.6 billion by 2015.<sup>54</sup>
- The market value of the building integrated photovoltaic (BIPV) industry is expected to grow from \$2.1 billion in 2012 to \$7.5 billion in 2015.<sup>55</sup>
  - Solar glass is expected to make up slightly more than half the market at \$4.2 billion, with wall integrated solar cells at \$830 million and solar tiles and shingles making up \$1.5 billion with various other solar technologies making up the remaining \$1 billion.<sup>56</sup>

### Key Market and Technology Drivers

- Continued improvements in conversion efficiency
- Development of new photovoltaic materials and applications
- Government incentives and mandates
- Cost competitiveness with conventional electricity generation methods
- Energy security and environmental sustainability

<sup>53</sup> Frost & Sullivan, *Analysis of the Global Solar Power Market*, 2013

<sup>54</sup> Solar&Energy, *CdTe Solar Cell Technology Trend and Market Forecast (2006-2015)*, 2011

<sup>55</sup> BCC Research, *Building-Integrated Photovoltaics (BIPV): Technologies and Global Markets*, 2011

<sup>56</sup> Nanomarkets, *Building-Integrated Photovoltaics Markets*, 2012

## What Is It?

The agbiosciences industry is comprised of companies and producers that are engaged in economic activity across the agriculture and associated bioscience value chain. This includes: the development of inputs for production (equipment, seeds, agricultural chemicals, etc.), primary production, downstream conversion of agricultural products into a wide variety of value-added food, feed, fiber, fuel and industrial bio-based products, and research and testing services to produce, enhance, secure, and sustain products.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

While historically an important industry sector for the State of Ohio, the agbiosciences continues to be not only a large and significant industry sector, but also one that has been a consistent job generator over the past decade in Ohio with an employment growth rate of three percent over the decade. While no longer a specialized industry sector, it is quite sizable – at nearly 89,000 jobs in 2012.

Furthermore, certain subsectors within the agbiosciences are poised to expand significantly with the development of new products and markets in areas such as novel health, specialty crops, and biobased products. Using just biobased products as an example, it is estimated that there is a potential to replace up to two-thirds of petroleum-based chemicals with agricultural-based materials, representing 50,000 different products—a \$1 trillion global market.<sup>57</sup> Ohio Third Frontier investments in efforts such as the Ohio Bioproducts Innovation Center (OBIC) are helping to position the state's industrial sector to capture increased market share within this growing global market.

Another area of potential economic opportunity is agricultural chemicals, currently a specialized industry subsector in Ohio that has experienced growth since the recession. The market for global agricultural chemicals, which includes fertilizers and pesticides, approached \$120 billion in 2009 and is on a strong pace to reach \$196 billion by 2014 for a CAGR of 10.4 percent.<sup>58</sup> As U.S. farmers return to replenishing their fields with nutrients – following moderate-to-exceptional droughts– the U.S. market for fertilizers is expected to grow by a CAGR of 14.7 percent from 2009-2014 for a value of \$21 billion in 2014.<sup>59</sup>

Ohio is well positioned to generate further economic activity by expanding into new agbioscience markets as a result of its level of innovation, driven both by the fundamental scientific research and translational support mechanisms contained within the Ohio State University, which encompasses the State's land-grant Agricultural Experiment Stations and Extension activities, as well as its numerous innovative industrial leaders, including Scotts-Miracle-Gro, The Andersons, and J.M. Smucker Company. However, like many other states, the risk capital markets have not been as supportive of emerging agbioscience companies.

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<sup>57</sup> Jarrell, K.A., "Synthetic Biology and Sustainable Chemistry Revolution." *Industrial Biotechnology*. Winter 2009.

<sup>58</sup> BCC Research, *Global Markets for Agrochemicals*, 2010

<sup>59</sup> IBISWorld,

## AGBIOSCIENCES: Recent Economic Performance

### Industry Employment Metrics

Agbiosciences	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	3,251	88,599	0.91	-0.6%	3.5%	2.9%
Ohio Job Performance Relative to U.S.				1.8%	1.3%	3.1%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Fertilizer Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 3.1%	<ul style="list-style-type: none"> <li>• Returning demand from farmers</li> <li>• Higher prices for fertilizers</li> <li>• Significant influence from U.S. agriculture industry</li> <li>• Strong commodity prices</li> <li>• Government regulations on renewable fuel standards</li> <li>• Increase biofuel production</li> </ul>
<b>Organic Chemical Manufacturing (incl. Ethyl Alcohol)</b> 2013–2018 Expected Annual Revenue Growth: 4.5%	<ul style="list-style-type: none"> <li>• Demand from manufacturing</li> <li>• World price of oil</li> <li>• Continued biofuel mandates and incentives</li> <li>• Viable production volumes from cellulosic/non-“food” feedstocks</li> </ul>
<b>Farm Supplies Wholesaling (incl. seed development)</b> 2013–2018 Expected Annual Revenue Growth: 1.6%	<ul style="list-style-type: none"> <li>• Rising prices for feed and fertilizer</li> <li>• Products to be sourced direct from manufacturer</li> <li>• Demand for meat and dairy products</li> <li>• Biotechnology to increase seed prices, decrease use of fertilizers and pesticides</li> </ul>
<b>Synthetic Fiber Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 1.7%	<ul style="list-style-type: none"> <li>• Declining domestic demand</li> <li>• Companies to continue outsourcing</li> <li>• Increasing demand from auto sector</li> <li>• Industry to move to more niche products</li> <li>• Volatile input prices</li> </ul>

Source: IBISWorld

#### Industry Niches

Ag Chemicals – *Specialized (grew from 2009-2012)*

Biomass-Based Products (including biofuels) – *Emerging Opportunity*

Ag Research, Testing, & Services – *Emerging Opportunity*

#### Leading Companies

Scotts-Miracle-Gro, The Andersons, Bettcher Industries, Garick, Nestle Prepared Foods, The J.M. Smucker Company, Pierre Foods, Hyponex, Vita-Mix, John Morrell Company

#### Emerging Companies

Red Lion Bio-Energy Technologies, Verichem, Algaeventure Systems, Phycal

## AGBIOSCIENCES: Recent Innovation Performance

### Patent Activity



**Number of recent patents issued\***

- Industry: 25
- Universities: 1

**Number of recent patent applications**

- Industry: 76
- Universities: 12

\*One patent issued jointly to an Ohio firm and university

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 6</li> <li>▪ Phase I &amp; II Awards: 11</li> <li>▪ Total Funding: \$3.3 million</li> <li>▪ Key Agencies: NSF, USDA</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 46</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 2</li> <li>▪ Deals: 2</li> <li>▪ Investment: \$19.0 million</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Food or edible material: processes, compositions, and products	17
Chemistry: molecular biology and microbiology	12
Organic compounds	10
Foods and beverages: apparatus	7
Cutlery	6
Plant protecting and regulating compositions	6
Chemistry: fertilizers	4
Fuel and related compositions	4
Liquid purification or separation	4

## AGBIOSCIENCES:

### Market Outlook and Drivers

#### Key Market Outlook

- The global market for agricultural biotech (including transgenic seeds) is expected to reach \$24.8 billion by 2017, up from \$13.7 billion in 2011 for a CAGR of 11.4 percent with the U.S. market expected to account for approximately 75 percent of the global market.<sup>60</sup>
- The global seed treatment market reached \$3.1 billion in 2012 and is expected to grow to nearly \$4.8 billion by 2018, a compound annual growth rate (CAGR) of 8.3% for the period of 2013 to 2018.<sup>61</sup>
  - The North American seed treatment market is expected to reach \$1.5 billion in 2018.
- The North American biofuels market (44.5 percent of the global market) reached 66.8 billion in 2012. Growth is expected to continue, though at a slightly slower pace (CAGR of 8 percent) for the five-year period of 2012-2017 for a forecast market value of \$98.1 billion by 2017.<sup>62</sup>
- While biopower currently remains limited and often subsidy-dependent, tech breakthroughs and the expansion of international trade in biomass pellets are expected to lead to sustained growth with worldwide revenue from biomass power generation reaching \$11.5 billion annually by 2020.<sup>63</sup>
- Demand for natural polymers in the U.S. market is expected to reach \$4.6 billion by 2016. Growth is expected to be supported by consumer's desire for products from environmentally compatible products instead of petroleum-based resources.<sup>64</sup>
- The U.S. fertilizer sales reached \$26.0 billion in 2013 and are expected to grow to \$34.1 billion by 2018, a CAGR of 5.6%. U.S. demand for fertilizers will also increase from \$35.9 billion in 2013 to \$55.6 billion in 2018, with the difference being met through substantial imports.<sup>65</sup>

#### Key Market and Technology Drivers

- Consumer demand for sustainable products
- Perception of genetically modified goods
- Food security
- Advanced computational power for genomics research and testing
- Government incentives and regulations

<sup>60</sup> BCC Research, *Agricultural Biotechnology: Emerging Technologies and Global Markets*, 2012.

<sup>61</sup> BCC Research, *Seed Treatment: Technologies and Global Markets*, 2013.

<sup>62</sup> Datamonitor, *North America - Biofuel Consumption*, 2013.

<sup>63</sup> Navigant Research, *Market Data: Biomass Power Generation*, 2013.

<sup>64</sup> Freedonia, *Natural Polymers: United State*, 2012.

<sup>65</sup> IBISWorld, *Fertilizer Manufacturing in the U.S.*, 2013.

# UNCONVENTIONAL OIL and GAS

## What Is It?

Unconventional oil and gas resources are contained in formations that require advanced technologies and stimulation techniques to enable efficient extraction. The most common types of unconventional oil and gas are bituminous sands, tight gas, and shale gas. Primary industries in this sector are involved in the extraction and distribution/transportation of the oil or gas, as well as in oil and gas machinery manufacturing and drill site construction.

Though significantly more complex to extract than conventional oil and gas, continued innovation has brought prices down enough to make unconventional extraction an economically viable alternative. An increasing push for energy independence has generated significant demand and interest in the continued development of unconventional oil and gas wells.

## Why Is It A Targeted Growth Opportunity Area For Ohio?

The unconventional oil and gas industry has become a fast growing opportunity for Ohio, with job gains of 18 percent in the post-recession years of 2009-2012 driven primarily by the fracking operations along the eastern portion of the state related to the Marcellus shale development. Still this industry growth opportunity area is of just moderate size in Ohio, employing more than 10,000 people, and is only half as concentrated as that of the nation (LQ of 0.50).

The global market for unconventional natural gas extraction, which includes both vertically and horizontally drilled wells, was valued at \$61.6 billion in 2011 and could see its value reach \$91.3 billion by 2016 for a CAGR of 8.2 percent over the five-year period. The majority of the unconventional natural gas extraction happens in North America, which accounted for 89 percent of the market at a value of \$54.8 billion in 2011. Furthermore, driven by the shale gas boom in North America, the hydrofracture equipment industry saw global demand increase by 36.6 percent between 2009 and 2010 and a market value increase of 42.1 percent over the same time. Growth rates over the next five years, however, are expected to be more realistic and come in at a CAGR of 8.6 percent from 2011 to 2016 for a market value of \$21.4 billion in 2016.

While there might be deployment activities related to fracking operations in Ohio, there does not appear to be related innovation activities. Industry generated only 11 industry patent awards and applications since 2010 and there was no related academic activity during that time period. In addition, there were no risk capital investments made anywhere along the development continuum, pointing to the potential lack of emerging companies.

As a result, while the State of Ohio may deem the unconventional oil and gas industry to be a targeted industry of the future from a deployment standpoint, it is unclear what role the Ohio Third Frontier could make in an industry that is currently not being driven by innovation or commercialization activities within Ohio.

## UNCONVENTIONAL OIL and GAS: Recent Economic Performance

### Industry Employment Metrics

Unconventional Oil & Gas	2012 Metrics			Recent Jobs Performance		
	Establishments	Employment	Specialization	Change Through Recession, 2001–2009	Change Post Recession, 2009–2012	Total Change, 2001–2012
Ohio Specific Performance	508	10,304	0.50	-3.9%	17.6%	13.0%
Ohio Job Performance Relative to U.S.				-18.2%	1.6%	-19.6%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data from IMPLAN.

### Outlook for Key Component Sectors

U.S. Industry Sectors	Key Factors
<b>Oil Drilling &amp; Gas Extraction</b> 2013–2018 Expected Annual Revenue Growth: 2.5%	<ul style="list-style-type: none"> <li>• Rising output of natural gas</li> <li>• Increasing coal and oil prices</li> <li>• Increased global growth – particularly emerging markets</li> <li>• Marcellus Shale and Bakken formation</li> <li>• Most new electrical plants to be natural gas fired</li> <li>• Environmental advantages over coal</li> <li>• Increasing use of biofuels</li> </ul>
<b>Oil &amp; Gas Pipeline Construction</b> 2013–2018 Expected Annual Revenue Growth: 2.2%	<ul style="list-style-type: none"> <li>• Rising commodity prices increasing machinery demand</li> <li>• Oil and gas exploration to increase</li> <li>• Potential for new Alaskan fields</li> <li>• More gas fired generation plants coming online</li> </ul>
<b>Mining, Oil &amp; Gas Machinery Manufacturing</b> 2013–2018 Expected Annual Revenue Growth: 1.9%	<ul style="list-style-type: none"> <li>• Increased domestic supply of natural gas</li> <li>• Steady expansion in production and consumption</li> <li>• Recovery in housing investment</li> <li>• Increased maintenance costs in Midwest and Northeast</li> <li>• Increased govt. scrutiny</li> <li>• More regulations and environmental concerns</li> <li>• Expansion of LNG infrastructure</li> </ul>

Source: IBISWorld

**Industry Niches**  
 Natural Gas Liquid Extraction – *Emerging Strength, with especially strong job growth*

**Leading Companies**  
 Momentive Specialty Chemicals

## UNCONVENTIONAL OIL and GAS: Recent Innovation Performance

### Patent Activity

4	7
<b>Number of recent patents issued</b>	<b>Number of recent patent applications</b>
<ul style="list-style-type: none"> <li>▪ Industry: 4</li> <li>▪ Universities: 0</li> </ul>	<ul style="list-style-type: none"> <li>▪ Industry: 7</li> <li>▪ Universities: 0</li> </ul>

### Innovation Investment

SBIR	OTF Pre-Seed or Seed-backed Companies	Post-Seed VC-backed Companies
<ul style="list-style-type: none"> <li>▪ Companies: 0</li> <li>▪ Phase I &amp; II Awards: --</li> <li>▪ Total Funding: --</li> <li>▪ Key Agencies: --</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 0</li> </ul>	<ul style="list-style-type: none"> <li>▪ Companies: 0</li> <li>▪ Deals: --</li> <li>▪ Investment: --</li> </ul>

### Patent Activity Detail: Key Patent Classes

USPTO Patent Class	Number of Patents and Applications
Wells	5
Earth boring, well treating, and oil field chemistry	4

## UNCONVENTIONAL OIL and GAS: Market Outlook

### Key Market Outlook

- The global market for unconventional natural gas extraction, which includes both vertically and horizontally drilled wells, was valued at \$61.6 billion in 2011 and could see its value reach \$91.3 billion by 2016 for a CAGR of 8.2 percent over the five-year period.<sup>66</sup>
  - The majority of the unconventional natural gas extraction happens in North America, which accounted for 89 percent of the market at a value of \$54.8 billion in 2011, as is expected to reach nearly \$64 billion by 2016, equivalent to a 2011 to 2016 CAGR of 3.1 percent.
- Driven by the shale gas and tight gas boom in North America, the hydrofracture equipment industry saw global demand increase by 36.6 percent between 2009 and 2010 and a market value increase of 42.1 percent over the same time. Growth rates over the next five years, however, are expected to be more realistic and come in at a CAGR of 8.6 percent from 2011 to 2016 for a market value of \$21.4 billion in 2016.<sup>67</sup>

#### *Key Market and Technology Drivers*

- Cost competitiveness with conventional extraction methods
- Government subsidies and regulations
- Energy security
- New environmentally sustainable chemicals
- Improved boring methods

<sup>66</sup> BCC Research, *Unconventional Natural Gas Extraction: Technologies and Global Markets*, 2012

<sup>67</sup> BCC Research, *Unconventional Natural Gas Extraction: Technologies and Global Markets*, 2012

## Appendix A: Assessment Criteria Ratings

### Industry Performance:

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**Industry Specialization:** Measures the level of concentration of an industry sector in Ohio relative to the nation. When the industry specialization is considerably higher than the nation it suggests Ohio has a competitive advantage in that industry sector that has resulted in a higher concentration. The specific calculation of industry specialization is the share of Ohio's private sector employment divided by the share of total industry employment in that industry sector for the nation – or what is termed a location quotient. A location quotient greater than 1.0 indicates a higher relative concentration, whereas a location quotient of less than 1.0 signifies a relative underrepresentation.

- Location quotient:**
- Top Tier: 2.0 or higher;
  - Upper Tier: 1.2-2.0;
  - Lower Tier: 0.75 to 1.2;
  - Lowest Tier: Less than 0.75
- 

**Job Growth:** A straightforward measure of whether an industry sector is gaining or losing jobs in Ohio from 2009 to 2012, a period of time that encompasses the ongoing economic recovery.

- Percentage growth in jobs from 2009-2012:**
- Top Tier: 2.0% growth or higher;
  - Upper Tier: 0% to 2% growth;
  - Lower Tier: -5% to 0%;;
  - Lowest Tier: Decline greater than 5%
- 

**Relative Job Growth to the Nation:** Measures whether the Ohio industry sector is gaining or losing jobs at a rate faster or slower than the nation. It is measured as the difference between the percentage change in employment for Ohio's industry sector minus the percentage in employment in that same industry sector for the nation over the period 2009 to 2012.

- Ohio's percentage change in jobs compared to the nation, 2009-2012:**
- Top Tier: 5.0 percentage points higher in Ohio;
  - Upper Tier: 0-5 percentage points higher in Ohio;
  - Lower Tier: 0 to -5 percentage points lower in Ohio;
  - Lowest Tier: 5 percentage points or more lower in Ohio

### *Innovation Activity:*

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**Presence of Patent Activity:** A higher number of patents generated by an industry sector in Ohio suggest a more significant focus on industry innovation activity.

**Patent awards and applications in Industry Sector:**

- Top Tier: 400 patents or more;
  - Upper Tier: 151-399;
  - Lower Tier: 25-150;
  - Minimal patent activity: Less than 25
- 

**Presence of Emerging Innovation Companies:** A higher number of companies in each Industry Sector receiving later stage, seed or pre-seed venture capital funding or SBIR funding from 2006 through September of 2013 suggests a more significant base of emerging high growth potential companies

**Number of Emerging Innovation companies:**

- Top Tier: 50 or more emerging innovation companies;
  - Upper Tier: 25-50;
  - Lower Tier: 10 to 24;
  - Minimal Activity: Less than 10
- 

### *Market Potential:*

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**Market Outlook in Overall Industry Sector:** Market outlook for industry sector revenue growth based on projections from IBIS World

**Projected growth in overall industry sector revenues:**

- Top Tier: 10% or higher;
  - Upper Tier: 5% to 9.9%;
  - Lower Tier: 0% to 4.9%;
  - Declining
- 

**Market Outlook in Identified Niches for Ohio:** Market outlook for specific markets in an industry sector that reflect opportunities for Ohio companies.

**Projected growth in identified niche market revenues:**

- Top Tier: 10% or higher;
- Upper Tier: 5% to 9.9%;
- Lower Tier: 0% to 4.9%;
- Declining

## Appendix B: Targeted Growth Opportunity Area - NAICS Specific Detail

### Industries in the Advanced Materials Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
-----	<b>Advanced Materials Total</b>	<b>982</b>	<b>41,600</b>	<b>2.28</b>	<b>-26.7%</b>	<b>-6.1%</b>	<b>-31.2%</b>	<b>-10.5%</b>
----	Advanced Polymers Total	479	25,132	2.37	-23.5%	-6.3%	-28.3%	-8.2%
325199	All other basic organic chemical mfg.	55	3,891	2.92	2.2%	1.6%	0.2%	-0.2%
325211	Plastics material and resin mfg.	77	4,113	1.91	17.1%	-1.4%	7.5%	-2.9%
325212	Synthetic rubber mfg.	30	1,127	2.64	-6.8%	-23.9%	-30.5%	-22.8%
325510	Paint and coating mfg.	83	5,406	3.57	-13.0%	3.7%	-13.0%	0.7%
325520	Adhesive mfg.	41	2,005	2.59	-10.4%	-1.2%	-13.4%	-5.7%
325991	Custom compounding of purchased resins	35	1,446	2.29	-22.7%	-27.8%	-48.5%	-33.2%
325998	Other misc. chemical product mfg.	87	2,340	1.70	-35.9%	-14.5%	-44.9%	-15.6%
326211	Tire mfg., except retreading	14	2,917	1.59	-62.8%	-10.3%	-67.6%	-9.5%
333220	Plastics and rubber industry machinery	57	1,887	3.43	-9.1%	-10.4%	-19.3%	-17.7%
----	Ceramics/Composites Total	34	1,994	3.44	-25.9%	7.2%	-20.6%	-1.7%
325182	Carbon black mfg.	2	121	1.83	-37.4%	91.3%	15.6%	91.4%
327125	Nonclay refractory mfg.	23	1,125	5.12	-28.2%	-2.7%	-30.8%	-9.3%
335991	Carbon and graphite product mfg.	9	747	2.54	-19.8%	16.7%	-10.3%	3.8%
----	Biomass-Based Products Total	12	423	0.39	18.0%	-9.8%	6.5%	-6.0%
325191	Gum and wood chemical mfg.	1	28	0.42	1969.6%	-57.4%	625.1%	-52.7%
325221	Cellulosic organic fiber mfg.	6	286	0.81	53.9%	-22.9%	17.8%	-18.1%
325222	Noncellulosic organic fiber mfg.	5	109	0.16	-79.1%	240.7%	-29.4%	243.8%
----	Specialty Metals & Alloys Total	457	14,052	2.34	-32.5%	-7.4%	-37.5%	-17.5%
331112	Ferroalloy and related product mfg.	6	864	7.57	-13.3%	13.5%	-0.1%	2.8%
331311	Alumina refining	2	292	3.59	-	2379.9%	-	2370.8%
331312	Primary aluminum production	6	980	2.75	-22.3%	-14.7%	-34.6%	-11.8%
331314	Secondary smelting & alloying of aluminum	8	339	1.63	2.1%	-12.6%	-25.3%	-29.4%
331419	Primary nonferrous metal, ex. Cu and Al	3	443	1.43	-34.4%	84.2%	91.4%	76.3%
331423	Secondary processing of copper	5	204	4.92	-94.9%	-29.3%	-96.7%	-32.5%
332117	Powder metallurgy part mfg.	7	77	0.24	-65.0%	-10.2%	-64.6%	-22.6%
332812	Metal coating & nonprecious engraving	175	4,474	2.10	0.5%	-12.7%	-18.2%	-24.4%
332813	Electroplating, anodizing, & coloring metal	245	6,379	2.61	-15.2%	-10.4%	-26.8%	-20.8%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Aero-Propulsion Power Management Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Aero-Propulsion Power Mgmt Total</b>	<b>164</b>	<b>19,028</b>	<b>1.44</b>	<b>7.1%</b>	<b>-3.7%</b>	<b>3.2%</b>	<b>-0.8%</b>
336412	Aircraft engine and engine parts mfg.	67	12,068	3.85	-0.8%	-3.3%	-4.0%	-0.6%
336413	Other aircraft parts and equipment	49	4,011	0.97	5.0%	-5.5%	-0.8%	-12.7%
333995	Fluid power cylinder and actuator mfg.	32	1,558	2.31	1.4%	-6.1%	-4.8%	-19.3%
334511	Search, detection, and navigation instruments	16	1,391	0.27	610.8%	0.9%	617.0%	12.0%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Fuel Cells and Energy Storage Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Fuel Cells and Energy Storage Total</b>	<b>28</b>	<b>2,076</b>	<b>0.80</b>	<b>10.0%</b>	<b>-3.5%</b>	<b>6.1%</b>	<b>-6.9%</b>
334414	Electronic capacitor manufacturing	2	75	0.33	2232.2%	336.2%	10072.7%	337.0%
334416	Electronic coils, transformers, & inductors	11	223	0.67	-12.0%	-39.2%	-46.5%	-37.2%
335311	Electric power & specialty transform. mfg.	11	810	0.82	39.7%	-0.4%	39.2%	-0.2%
335911	Storage battery manufacturing	4	961	1.71	-0.1%	0.6%	0.5%	-8.7%
335912	Primary battery manufacturing	1	7	0.01	-100.0%	-	1520.5%	-

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Medical Technology Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Medical Technology</b>	<b>1,655</b>	<b>24,688</b>	<b>0.80</b>	<b>11.3%</b>	<b>2.6%</b>	<b>14.2%</b>	<b>-1.0%</b>
325413	In-vitro diagnostic substance mfg.	4	307	0.41	113.5%	-15.9%	79.5%	-14.5%
334510	Electromedical apparatus mfg.	25	748	0.33	-62.0%	7.8%	-59.0%	10.5%
334516	Analytical laboratory instrument mfg.	15	211	0.17	-72.2%	21.1%	-66.3%	17.7%
334517	Irradiation apparatus manufacturing	8	331	0.67	-3.6%	-12.7%	-15.8%	-10.0%
339112	Surgical and medical instrument mfg.	40	2,320	0.49	5.5%	11.8%	18.0%	7.2%
339113	Surgical appliance and supplies mfg.	132	5,184	1.34	-9.4%	5.6%	-4.3%	5.7%
339114	Dental equipment and supplies mfg.	7	326	0.51	-14.2%	43.4%	23.0%	36.6%
423450	Medical equipment merchant wholesalers	783	7,886	1.06	26.6%	2.7%	30.1%	0.7%
621511	Medical laboratories	450	5,318	0.81	48.4%	6.5%	57.9%	-4.7%
621512	Diagnostic imaging centers	191	2,057	0.77	68.6%	-20.2%	34.5%	-22.2%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Sensing and Automation Systems Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Sensing and Automation Systems Total</b>	<b>417</b>	<b>17,959</b>	<b>1.56</b>	<b>-22.4%</b>	<b>-10.3%</b>	<b>-30.4%</b>	<b>-13.5%</b>
332912	Fluid power valve and hose fitting mfg.	39	4,393	3.09	-24.2%	-3.6%	-27.0%	-19.5%
333913	Measuring and dispensing pump mfg.	3	123	1.08	-71.9%	-44.3%	-84.3%	-51.3%
334512	Automatic environmental control mfg.	26	1,106	1.58	-52.0%	-14.9%	-59.2%	-9.4%
334513	Industrial process variable instruments	100	2,794	1.19	-19.3%	8.4%	-12.6%	4.9%
334514	Totalizing fluid meters & counting devices	15	247	0.59	-55.5%	-24.7%	-66.5%	-21.3%
334515	Electricity and signal testing instruments	46	1,843	1.15	-20.5%	-2.1%	-22.1%	0.3%
335313	Switchgear & switchboard apparatus mfg.	46	1,151	0.96	-32.0%	-38.2%	-57.9%	-39.0%
335314	Relay and industrial control manufacturing	69	3,575	1.93	12.2%	-16.7%	-6.5%	-20.0%
333995	Fluid power cylinder and actuator mfg.	32	1,558	2.31	1.4%	-6.1%	-4.8%	-19.3%
334519	Other measuring & controlling device mfg.	41	1,169	0.97	-25.3%	-13.3%	-35.2%	-14.5%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Situational Awareness and Surveillance Systems Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Situational Awareness and Surveillance Systems Total</b>	<b>354</b>	<b>5,872</b>	<b>0.55</b>	<b>12.9%</b>	<b>4.3%</b>	<b>17.7%</b>	<b>7.4%</b>
334519	Other measuring & controlling device mfg.	41	1,169	0.97	-25.3%	-13.3%	-35.2%	-14.5%
334511	Search, detection, & navigation instruments	16	1,391	0.27	610.8%	0.9%	617.0%	12.0%
561621	Security systems services, except locksmiths	297	3,312	0.80	-2.8%	14.0%	10.8%	6.2%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Software Applications Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Software Applications Total</b>	<b>7,679</b>	<b>67,204</b>	<b>0.75</b>	<b>11.9%</b>	<b>1.3%</b>	<b>13.3%</b>	<b>-12.8%</b>
334611	Software reproducing	5	63	0.21	-14.4%	-68.3%	-72.9%	-42.6%
511210	Software publishers	530	5,602	0.50	27.5%	20.6%	53.7%	9.3%
518210	Data processing, hosting & related services	389	4,793	0.48	-19.7%	5.2%	-15.6%	1.9%
519130	Internet publishing and web search portals	288	4,528	0.94	9.0%	0.8%	9.9%	-48.9%
541511	Custom computer programming services	3,267	25,209	0.92	23.0%	-6.5%	15.1%	-20.5%
541512	Computer systems design services	2,830	20,377	0.68	27.2%	12.5%	43.1%	-6.3%
541513	Computer facilities management services	107	1,462	0.72	-38.7%	-4.4%	-41.4%	0.2%
541519	Other computer related services	263	5,170	1.22	-16.3%	-11.5%	-26.0%	-15.7%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Solar Photovoltaic and Solar Energy Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Solar Photovoltaics and Solar Energy Total</b>	<b>10</b>	<b>1,543</b>	<b>4.94</b>	<b>457.1%</b>	<b>13.0%</b>	<b>529.6%</b>	<b>10.7%</b>
333414	Heating equipment, ex. warm air furnaces	4	560	22.12	368.8%	18.5%	455.3%	18.6%
334413	Semiconductors and related device mfg.	6	983	3.42	519.0%	10.1%	581.7%	7.6%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

Note: Solar Photovoltaics was shared based on Ohio employment and establishment numbers via Hoovers.com for the Solar Cell and Solar Heating SIC codes as a share of the employment numbers for the NAICS codes via QCEW and enhanced with IMPLAN.

## Industries in the Agbiosciences Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
-----	<b>Agbiosciences Total</b>	<b>3,251</b>	<b>88,599</b>	<b>0.91</b>	<b>-0.6%</b>	<b>3.5%</b>	<b>2.9%</b>	<b>1.3%</b>
----	Ag Chemicals Total	46	2,224	1.55	-17.6%	11.0%	-8.5%	11.6%
325311	Nitrogenous fertilizer mfg.	25	1,568	5.34	-18.9%	13.1%	-8.3%	9.1%
325312	Phosphatic fertilizer mfg.	2	17	0.06	26652.6%	-94.7%	1312.4%	-89.5%
325314	Fertilizer, mixing only, mfg.	16	594	1.86	-58.4%	141.9%	0.7%	139.1%
325320	Pesticide & other ag. chemical mfg.	3	45	0.08	-63.1%	-6.3%	-65.4%	-3.7%
----	Ag Research, Testing, & Services Total	1,459	19,255	0.80	27.0%	3.5%	31.4%	0.0%
541380	Testing laboratories	54	479	0.90	-4.8%	-15.0%	-19.0%	-24.4%
541940	Veterinary services	1,077	11,728	0.97	23.4%	2.9%	27.0%	-1.0%
54171*	Physical, engineering & biological research	328	7,048	0.61	37.7%	5.9%	45.8%	3.2%
----	Agricultural Processing Total	120	2,589	0.50	-6.4%	-9.4%	-15.2%	-9.3%
311211	Flour milling	15	409	0.80	-12.8%	6.2%	-7.4%	4.1%
311221	Wet corn milling	1	260	0.54	-15.8%	88.4%	58.7%	35.5%
311222	Soybean processing	7	291	1.15	3.7%	-30.2%	-27.6%	13.0%
311225	Fats and oils refining and blending	6	225	0.94	6.7%	28.5%	37.1%	27.2%
311311	Sugarcane mills	0	14	0.12	-	-47.5%	-	-31.9%
311312	Cane sugar refining	1	22	0.22	-	-6.5%	-	14.3%
311313	Beet sugar mfg.	1	92	0.36	-29.7%	32.8%	-6.6%	23.0%
321113	Sawmills	87	1,225	0.41	-13.0%	-17.8%	-28.4%	-18.5%
322110	Pulp mills	2	50	0.22	87.0%	-62.4%	-29.7%	-66.7%
----	Inputs to Production Total	635	618	0.88	-14.7%	1.1%	-13.7%	-3.0%
333111	Farm machinery and equipment mfg.	18	18	0.49	-3.5%	17.2%	13.1%	1.2%
333210	Sawmill/woodworking machinery	12	12	0.92	-59.5%	-26.4%	-70.2%	-23.6%
333291	Paper industry machinery mfg.	10	10	0.85	-36.0%	-24.3%	-51.5%	-20.9%
333294	Food product machinery mfg.	30	31	2.87	-12.0%	0.9%	-11.2%	-3.9%
423820	Farm and garden equip. wholesalers	279	266	0.89	-8.8%	2.5%	-6.5%	1.8%
424910	Farm supplies wholesalers	286	281	0.79	-15.5%	-0.8%	-16.2%	-2.1%

## Industries in the Agbiosciences Sector - Continued

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
-----	<b>Agbiosciences Total</b>	<b>3,251</b>	<b>88,599</b>	<b>0.91</b>	<b>-0.6%</b>	<b>3.5%</b>	<b>2.9%</b>	<b>1.3%</b>
----	Food Products Total	990	54,196	1.00	-4.3%	4.3%	-0.2%	2.8%
	Food Products - Continued							
311230	Breakfast cereal mfg.	4	579	0.99	-50.5%	9.7%	-45.7%	3.5%
311320	Confectionery mfg. from cacao beans	6	19	0.07	50.5%	26.7%	90.6%	24.6%
311330	Confectionery mfg. from purchased chocolate	51	1,263	1.02	47.0%	-10.5%	31.6%	-9.9%
311340	Nonchocolate confectionery mfg.	21	760	1.10	-12.3%	12.5%	-1.4%	5.4%
311411	Frozen fruit and vegetable mfg.	2	454	0.38	254.9%	-14.1%	204.8%	-10.8%
311412	Frozen specialty food mfg.	22	5,637	2.55	-23.6%	12.8%	-13.9%	9.6%
311421	Fruit and vegetable canning	41	2,058	0.84	51.1%	-57.8%	-36.2%	-53.4%
311422	Specialty canning	6	3,837	9.19	-38.2%	251.6%	117.4%	263.7%
311511	Fluid milk mfg.	21	2,492	1.22	-14.4%	-6.7%	-20.2%	-3.2%
311512	Creamery butter mfg.	4	6	0.06	9683.5%	-94.4%	449.5%	-99.2%
311513	Cheese mfg.	14	1,008	0.61	-5.8%	18.7%	11.8%	11.8%
311514	Dry, condensed, and evaporated dairy products	10	2,648	4.55	-4.9%	0.5%	-4.4%	-3.9%
311520	Ice cream and frozen dessert mfg.	17	1,175	1.46	-14.9%	-6.2%	-20.2%	-6.7%
311611	Animal, except poultry, slaughtering	61	1,037	0.19	-36.7%	-12.0%	-44.3%	-9.1%
311612	Meat processed from carcasses	70	6,057	1.39	4.2%	12.0%	16.7%	11.5%
311613	Rendering/meat byproduct processing	8	183	0.58	-15.2%	-13.7%	-26.8%	-8.7%
311615	Poultry processing	13	3,179	0.37	13.2%	47.8%	67.2%	50.9%
311811	Retail bakeries	200	2,209	0.81	-41.7%	1.3%	-40.9%	-8.2%
311812	Commercial bakeries	168	5,282	1.04	-4.1%	-3.2%	-7.2%	-4.2%
311813	Frozen cakes and other pastries mfg.	6	520	1.17	20.9%	16.6%	40.9%	9.0%
311821	Cookie and cracker mfg.	25	3,422	2.66	30.7%	1.9%	33.2%	-2.1%
311822	Mixes/dough from purchased flour	16	796	1.39	66.8%	-29.5%	17.6%	-27.6%
311823	Dry pasta mfg.	7	257	0.94	47.1%	149.1%	266.5%	151.5%
311830	Tortilla mfg.	4	20	0.03	-27.8%	-48.7%	-63.0%	-51.7%
311911	Roasted nuts and peanut butter mfg.	9	756	1.44	-5.7%	62.6%	53.3%	53.4%
311919	Other snack food mfg.	22	2,665	1.88	3.1%	23.3%	27.1%	14.4%
311920	Coffee and tea manufacturing	11	94	0.14	-1.4%	-35.2%	-36.1%	-56.4%
311930	Flavoring syrup and concentrate mfg.	9	518	1.36	-8.0%	-6.2%	-13.7%	-8.2%

## Industries in the Agbiosciences Sector - Continued

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
-----	<b>Agbiosciences Total</b>	<b>3,251</b>	<b>88,599</b>	<b>0.91</b>	<b>-0.6%</b>	<b>3.5%</b>	<b>2.9%</b>	<b>1.3%</b>
----	Food Products Total	990	54,196	1.00	-4.3%	4.3%	-0.2%	2.8%
	Food Products - Continued							
311941	Mayonnaise, dressing, and sauce mfg.	12	931	1.77	-26.1%	0.1%	-26.0%	-6.7%
311942	Spice and extract mfg.	15	963	1.17	-37.9%	38.8%	-13.9%	31.3%
311991	Perishable prepared food mfg.	16	855	0.61	4.2%	-0.5%	3.8%	-4.6%
311999	All other miscellaneous food mfg.	19	485	0.46	-27.6%	-38.4%	-55.4%	-44.0%
312120	Breweries	21	1,438	1.25	33.0%	-9.4%	20.5%	-26.4%
312130	Wineries	51	496	0.28	112.6%	63.2%	246.9%	50.0%
312140	Distilleries	8	96	0.31	-7.7%	-46.1%	-50.3%	-57.4%
----	Biomass-based Products Total	18	566	0.38	-14.7%	3.5%	42.5%	4.9%
325193	Ethyl alcohol mfg.	6	143	0.36	-	83.3%	-	77.7%
325191	Gum and wood chemical mfg.	1	28	0.42	1969.6%	-57.4%	780.6%	-52.7%
325221	Cellulosic organic fiber mfg.	6	286	0.81	53.9%	-22.9%	18.7%	-18.1%
325222	Noncellulosic organic fiber mfg.	5	109	0.16	-79.1%	240.7%	-28.7%	243.8%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

## Industries in the Unconventional Oil and Gas Sector

NAICS Code	NAICS Description	Estab. 2012	Emp. 2012	2012 LQ	Percent Change			Competitive Share '09-'12
					2001-2009	2009-2012	2001-2012	
----	<b>Unconventional Oil &amp; Gas Total</b>	<b>508</b>	<b>10,304</b>	<b>0.50</b>	<b>-3.9%</b>	<b>17.6%</b>	<b>13.0%</b>	<b>1.6%</b>
211111	Crude petroleum and natural gas extraction	197	2,888	0.41	-0.3%	10.7%	10.3%	-6.4%
211112	Natural gas liquid extraction	13	191	0.75	350.3%	282.0%	1620.0%	264.1%
221210	Natural gas distribution	145	4,057	0.95	-6.9%	8.8%	1.2%	8.7%
237120	Oil and gas pipeline construction	106	2,492	0.51	4.5%	39.1%	45.4%	13.0%
333132	Oil and gas field machinery and equipment	10	355	0.12	-13.6%	69.9%	46.7%	40.4%
486210	Pipeline transportation of natural gas	37	321	0.30	-28.6%	-14.4%	-38.9%	-21.1%

Source: Battelle analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.