# Developing an Asset Inventory for Ohio's Energy Efficiency Sector

## Statewide Report of Findings
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Advanced Energy Economy
OHIO INSTITUTE
AEEOhioInstitute.org

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## INTRODUCTION

This document presents an asset inventory for Ohio's energy efficiency technology sector. The inventory was developed under the leadership of Advanced Energy Economy Ohio Institute (AEE Ohio Institute), a not-for-profit educational organization that promotes greater public understanding of advanced energy and its economic potential for Ohio. The Institute is dedicated to informing the energy policy debate with well-researched, fact-based data on the advanced energy economy in Ohio and by providing a public forum where state and local leaders can address Ohio's energy challenges for the future. This effort is AEE Ohio Institute's first statewide initiative to catalog an energy sector's strengths, assess the assets available to accelerate development of emerging technologies or commercialization of existing technologies, and inform efforts to grow Ohio's industrial base, physical and intellectual capital, revenues, and jobs. Additional financial support for this effort was provided by Edison Welding Institute and NorTech.

The purpose of an asset inventory is to identify the sector's business, physical, intellectual, and human capital — and educate key stakeholders about the assets on which the sector can best focus its efforts to grow. The development of this asset inventory followed the first three steps of the *InSeven by NorTech®* process, devised by a technology-based economic development organization in Northeast Ohio, to bring major stakeholders together to articulate a sector's seven-year goals and plan for achieving them[1]. The asset inventory is fact-based and intellectually rigorous, reflecting a consensus of key sector participants and stakeholders. Inventory findings can be used to finish the remaining steps and create an energy efficiency roadmap for the state or any of its regions.

To create a statewide asset inventory for energy efficiency technologies, AEE Ohio Institute formed an energy efficiency roadmapping team to build in-depth insight into Ohio's current energy efficiency assets and capabilities as well as the sector's potential. To build an active consensus, the team collaborated closely with a Working Group of energy efficiency sector participants and regional experts (see Exhibit 1), principally industry players but also researchers, economic development entities, and government participants. This Working Group contributed substantively to the analysis of the current state of the sector; if this roadmapping process or any other collaborative activities were to continue, they could also be asked to play a central role in validating findings on market opportunities and competitiveness, and in articulating a vision and action plan. The Working Group provided guidance to the roadmapping team, validated materials as they were developed, and shared sources of data and insight. Materials were also extensively vetted with subject matter experts (see Exhibit 2), whose input was incorporated into the final asset inventory.

[1] More information about NorTech's *InSeven* process can be found in the Appendix of this document.

Exhibit 1. **Regional Experts and Working Group Members**

| Name and Title | Organization |
| --- | --- |
| **Kimberly Gibson (Lead)**, AEE Ohio Institute Advisory Board Member and Director, EWI Advanced Energy Manufacturing Center | Advanced Energy Economy Ohio Institute and Edison Welding Institute |
| **David Beck**, President and CEO | Center for Innovative Food Technology |
| **Clarke Berdan II**, R&D Leader | Owens Corning |
| **Steve Bossart**, Lead Energy Analyst, Project Management Center | USDOE National Energy Technology Lab |
| **Larry Boyd**, Director | Industrial Technologies Program, Energy Industries of Ohio |
| **John Butkowski**, Sr. Product Engineer<br>**Ryan Chittester**, Engineer | RW Beckett/Beckett Energy Systems |
| **Steve Caminati,** Vice President, Public Affairs | Advanced Energy Economy Ohio Institute |
| **Steve Craig**, President | UniControl Inc. |
| **Lucas Dixon**, Project Manager | Plug Smart |
| **Mark Duffy,** LFL Global Systems Manager<br>**Joseph Howley,** Industry Relations Manager | GE Lighting |
| **Jeremy Faust**, Community Relations Manager | Greater Cincinnati Energy Alliance |
| **Robert Gilbert,** Technical Director, Center for Energy Education | Sinclair Community College |
| **John Glazer,** Director | TechGROWTH |
| **Jonathan Histed**, Sr. Marketing Manager | Novar/Honeywell |
| **David Karpinski**, Vice President and Director, Energy Enterprise | NorTech |
| **Robin Kinney**, Energy Committee Chair | Rural Action |
| **Faith Knutsen**, Associate Director of Operations | TechGROWTH |
| **Douglas Lafever**, Sr. Account Executive | AMERESCO |
| **Neill Lane**, President and CEO | Stirling Ultracold |
| **Leib Lurie,** CEO and Co-Founder | Dropoly |
| **Dave Mayewski**, Sales Development Leader | Rockwell Automation |
| **Steve Melink**, President | Melink Corporation |
| **Chris Meyer**, Past Director, Energy Programs | Dayton Development Coalition |
| **E. Michelle Mickens**, Director | Toledo Community Development Corporation |
| **Joyce Mihalik**, Vice President, Energy Services<br>**Jon Ratner,** Vice President, Sustainability | Forest City Enterprises |
| **Scott Miller,** Director of Energy and Environmental Programs | Ohio University Voinovich School |
| **Michelle Murcia,** President and Interim Executive Director | Advanced Energy Economy Ohio Institute |
| **Dwight Musgrave**, Owner | Thermal Visions, Inc. |
| **Jeff Myers**, Founder and Inventor | Terracal Systems |
| **Karl Parker**, President and CEO | Parker Enterprises Family of Businesses |
| **Linda Rasor,** Sr. Energy Consultant, Energy Enterprise | NorTech |
| **Frank Scardena**, Director of Venture Development | TechColumbus |
| **Kara Shell**, Project Engineer | Replex Plastics |
| **Dr. Yilmaz Sozer,** Assistant Professor | University of Akron |
| **Chad Smith**, Deputy Chief | Ohio Department of Development |
| **Ashley Sparks**, Sr. Project Coordinator, Energy Enterprise | NorTech |
| **Nicole Stika,** Sr. Manager, Education Programs | Council of Smaller Enterprises |
| **Taylor Stuckert**, Co-Director | Energize Clinton County |
| **Nadja Turek**, Director of Sustainability Services | Woolpert |
| **Gary Walzer,** Principal | GAW Associates |
| **Ed Zdankiewicz,** Business Development Manager | EchoGen Power Systems |
| **Hongping Zhao,** Assistant Professor | Case Western Reserve University |

Exhibit 2. **Subject Matter Experts**

| Name and Title | Organization | Area of Expertise |
|---|---|---|
| **Larry Boyd**, Director | Industrial Technologies Program, Energy Industries of Ohio | Industrial Technologies |
| **John Butkowski**, Sr. Product Engineer<br>**Ryan Chittester**, Engineer | Beckett Energy Systems | Burner Systems |
| **Bill Campbell**, Sr. Product Manager<br>**Tom Pfendler**, Product Marketing Manager | Emerson Liebert | Data Center Power Systems |
| **Peter Dickinson**, Chief Technology Officer | BuildingIQ | Building Control Systems |
| **Paul Fleming**, Owner | Fleming Consulting | Pumps |
| **Dean Gamble**, Building Energy Efficiency Policy Analyst | U.S. Environmental Protection Agency | Residential Building Envelope |
| **Jonathan Histed**, Senior Marketing Manager | Novar/Honeywell | Building Control Systems |
| **Patrick Hughes**, Director | Building Technology Research and Integration Center, ORNL | Building Envelope |
| **Steve Madera**, VP & GM of Global Precision Cooling | Emerson Liebert | Data Center Cooling Systems |
| **Dorene Maniccia**, Director, Policy and Industry Affairs | WattStopper | Lighting Control Systems |
| **Dave Mayewski**, Sales Development Leader | Rockwell Automation | Energy Management Systems/ Advanced Process Control |
| **Jim Moore**, Principal | TA Engineering | Boiler and Steam Systems |
| **Les Nelson**, Director | IAPMO Solar Heating and Cooling Programs | Solar Thermal Water Heating |
| **Sri Rahm**, Sr. Lighting Specialist | GE Lighting | Lamp Technologies |
| **John Seryak**, Principal and Lead Engineer<br>**Franc Sever**, Engineer | Go Sustainable Energy | Industrial Technologies |
| **Dr. Yilmaz Sozer**, Assistant Professor | University of Akron | Motors |
| **Douglas Trimbach**, Lighting Engineer | Lighting Optimizers, USA & Energy Optimizers, USA | Lighting |
| **Bill Tschudi,** Program Manager | Lawrence Berkeley National Laboratory | Data Centers |
| **Victor Zavala**, Assistant Computational Mathematician | Argonne National Laboratory | Building Control Algorithms |

Drawing upon research, industry expertise, and Working Group feedback, the general scope of the inventory was defined to include building- and industrial process-related energy efficiency products and services, as well as certain major appliances. The scope does not include: transportation; alternative fuels; power generation (except combined heat and power); grid technologies (except demand response and site-level technologies that communicate through the grid); or materials and sensors (unless they have a specific energy efficiency purpose within an in-scope system). Each of these exclusions is large enough to merit its own roadmapping effort, and in some cases those efforts have already been completed for all or part of the state.

This intensive asset inventory process, which covered the entire state, spanned five months and fostered multiple collaborative relationships. It has rallied a range of sector participants to support and accelerate the growth of the energy efficiency sector in Ohio over the next seven years.

This document is organized into four sections:

- **The Energy Efficiency Technology Sector and its Segments**: The energy efficiency technologies to be included in this sector are structured (or segmented) into a hierarchy of technology systems, sub-systems, components, and raw materials. The 48 technology segments identified are organized into 13 categories covering industrial process technologies, building technologies, and certain major appliances. Technologies and their value chains are also grouped into core technologies, enabling equipment and services, and supporting components or services, based on their value and role in the sector.
- **The Asset Inventory – Ohio's Strengths in Energy Efficiency Technologies**: For each of the core technology segments and enabling service types, the inventory of business and intellectual assets includes an assessment of concentration, stage of development, and position in the supply chain. There is a unique story to tell about each of Ohio's six regions and its individual strengths, as well as the statewide synergies that emerge.
- **Ohio's Opportunities and Potential Next Steps in Energy Efficiency Technologies:** Asset inventory findings can be used in a variety of ways at the state, regional, and company level. This section describes examples of potential next steps in the areas of policy, supply chain, technology and market development.
- **Appendix - NorTech's Roadmapping Methodology**: For additional context, the Appendix contains process information about the two phases of effort and seven steps involved in building a complete sector roadmap.

Each of these elements is discussed in the following pages.

**THE ENERGY EFFICIENCY TECHNOLOGY SECTOR AND ITS PRODUCT/TECHNOLOGY SEGMENTS**

Defining and organizing the specific technology systems associated with energy efficiency was a significant and challenging task. "Energy efficiency" is a very broad objective supported by a variety of technologies, services, and behavioral practices. It is typically incrementally improved along a spectrum from least efficient to most efficient, often in balance with other objectives, such as performance and cost-effectiveness, which may or may not correspond directly with energy efficiency. Rarely is there a clear threshold for a given technology's ideal, obtainable energy efficiency because it is difficult to control for product application. Third-party standards and certifications such as LEED[2], ASHRAE[3], or FEMP[4] designation are helpful in characterizing efficiency, but frequently require updates and do not cover all relevant technologies. Further complicating the issue are the constantly shifting conventional solutions (such as legal minimums for appliance performance or standard practice for industrial applications) that the team chose to exclude from the definition of "energy efficient."

For these reasons, a significant amount of effort was devoted to clarifying the operational definition of "energy efficiency" that would appropriately frame the remaining roadmapping efforts. This operational definition provided four criteria used to determine which solutions would be considered "energy efficient" for the purposes of this asset inventory:

1. Product-level efficiency should be a primary factor in the technology's purchase, as opposed to a side benefit of products that would be purchased by convention anyway.
2. If nationally recognized, third-party efficiency standards or certifications are available for a given technology system, the technology must achieve the appropriate rating.
3. If no appropriate third-party designation exists, the technology must include specific components or sub-systems that contribute to system efficiency, as identified by subject matter experts.
4. Energy efficiency must be driven by advances in technology – which are most likely to provide the greatest opportunities for economic impact and growth – rather than behavioral efficiency improvements. For this reason, the asset inventory only quantifies certain services (explained below).

The roadmapping team conducted a broad review of the energy efficiency sector and then carefully vetted the results with subject matter experts and Working Group members to identify the relevant technology systems and services, ultimately grouping them into thirteen (13) general categories:

1. **Steam Generation** comprises the boiler system and steam distribution system used in either an industrial process or building application. "Efficient" systems were identified by ENERGY STAR or FEMP designation when possible (i.e., for packaged systems) or by components such as burner controls and insulation when such designations would not be applicable.
2. **Heat Recovery** includes technologies that capture and repurpose waste heat energy, again in an industrial process or building application, either for steam/power generation (e.g., packaged combined heat and power systems) or for other process use (e.g., indirect fired absorption chillers, heat recovery desiccant dehumidifiers). The heat recovery and reuse function qualifies these technologies as "efficient;" no third-party designations or certifications were identified.

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[2] Leadership in Energy and Environmental Design
[3] American Society of Heating, Refrigerating and Air-Conditioning Engineers
[4] Federal Energy Management Program

3. **Process Heating** is specific to industrial process applications, and includes a range of fuel-based and electric-based process heating systems. Again, components such as controls, insulation and certain aspects of heat transfer sub-systems or material handling were identified as markers of "efficient" process heating technology.
4. **Compressed Air** includes both air compressors and compressed air distribution systems for industrial use. "Efficient" systems are identified by the presence of advanced motor technology or certain controls, as well as certain components within the distribution system.
5. **Advanced Motors, Pumps, and Fans** includes NEMA Premium motors, and pumps and fans categorized as efficient by their motors and certain additional, often friction-reducing, components. Although motors are identified here in their own system, they are also a cross-cutting sub-system in several of the other categories in this hierarchy.
6. **Industrial Cooling** comprises a compressor system, the associated industrial chiller/heat pump system, and the cooling tower system involved in industrial cooling processes. Efficient systems are identified by the presence of sub-systems such as advanced motors, fans, pumps and controls.
7. **Data Center** technologies were included based on the Department of Energy's emphasis on their potential energy savings opportunities. Data center power systems and liquid cooling systems were identified as the currently available technologies with an efficiency play, based on a range of critical components.
8. **Advanced HVAC** is a building technology category including furnaces, central air conditioners, air- and water-source heat pumps (including geothermal systems) and the air handling and distribution system. When applicable, the residential, commercial, and/or packaged versions of these systems are expected to have ENERGY STAR designation. For the air handling and distribution system, efficiency was assessed based on dampers, insulation and other equipment.
9. **Building Envelope** includes cool and green roof systems, insulation (which was then expanded to include refractory for non-building use), building phase change materials, exterior window and door systems, smart glass, and daylight systems. Some of these, such as exterior windows, doors and cool roof technologies, have long-standing ENERGY STAR designations, but their efficiency thresholds were adjusted to reflect more stringent anticipated updates based on third party raters such as the National Fenestration Rating Council and the Cool Roof Rating Council. The others were identified as efficient based on certain components. All thermal insulation was considered an efficiency play.
10. **Advanced Lighting** includes solid state (LED and OLED), linear fluorescent, compact fluorescent, metal halide, and low or high pressure sodium lighting systems. They were then further categorized into solid state and non-solid state technologies, based on supply chain differences. Some of these lamps for particular applications have ENERGY STAR and FEMP designations available, but most were identified as efficient based on the presence of certain components, ballast advances, etc.
11. **Water Heating Appliances** include solar thermal, high-efficiency gas storage, electric, gas condensing, whole-home tankless, and micro-CHP water heater systems. When applicable, ENERGY STAR designations are used; otherwise, components are identified to designate a particular water heater as efficient.
12. **Additional Major Appliances** include refrigerators and freezers, dehumidifiers, and clothes dryers. These were selected on the basis of residential appliances' direct energy use (based on DOE data) and therefore exclude dishwashers and clothes washers, whose primary energy efficiency play is in conservation of water that is heated outside the device. Commercial counterparts to these residential appliances are also included.

13. **Advanced Controls** comprise energy management systems for buildings, advanced process controls for industrial applications, and demand response systems that create efficiencies across multiple sites (and particularly among power generation assets). All of these systems are considered “efficient” as long as energy efficiency is part of their publicly communicated purpose.

Exhibit 3. **The Energy Efficiency Technology Sector: Technology Categories and Segments**

**Steam Generation**
- S01: Boiler System
- S02: Steam Distribution System

**Heat Recovery**
- S03: Heat Recovery System
- S04: Indirect Fired Absorption Chiller System
- S05: Heat Recovery Desiccant Dehumidifier System
- S06: Combined Heat And Power System (Packaged)

**Process Heating**
- S07: Fuel-Based Process Heating System
- S08: Electric-Based Process Heating System

**Compressed Air**
- S09: Air Compressor System
- S10: Compressed Air Distribution

**Advanced Motors, Pumps, Fans**
- S11: Advanced Motor System
- S12: Advanced Pumping System
- S13: Advanced Fan System

**Industrial Cooling**
- S14: Compressor System (Industrial Chiller/Heat Pump)
- S15: Chiller/Heat Pump System
- S16: Cooling Tower System

**Data Center**
- S17: Data Center Power System
- S18: Data Center Liquid Cooling System

**Advanced HVAC**
- S19: Furnace System
- S20: Central Air Conditioner System
- S21: Air-Source Heat Pump System
- S22: Water-Source Heat Pump System (incl. Geothermal)
- S23: Air Handling and Distribution System

**Building Envelope**
- S24: Cool Roof System
- S25: Green Roof System
- S26: Insulation and Refractory System
- S27: Building Phase Change Material System
- S28: Exterior Window System
- S29: “Smart Glass” Window System
- S30: Exterior Door System
- S31: Daylight System

**Advanced Lighting**
- S32: LED Lighting System
- S33: Linear Fluorescent Lighting System
- S34: Compact Fluorescent Lighting System
- S35: Metal Halide Lighting System
- S36: Low/High Pressure Sodium Lighting System

**Water Heating Appliances**
- S37: Solar Thermal Water Heating System
- S38: High Efficiency Gas Storage Water Heater System
- S39: Electric Water Heater System
- S40: Gas Condensing Water Heater System
- S41: Whole-Home Tankless Water Heater System
- S42: Micro-CHP Water Heater System

**Additional Major Appliances**
- S43: Refrigerator/Freezer System
- S44: Dehumidifier System
- S45: Clothes Dryer System

**Advanced Controls**
- S46: Energy Management System
- S47: Advanced Process Controls Systems
- S48: Demand Response System

Taken together, the 48 technology segments shown in Exhibit 3 define the energy efficiency technology sector. The sub-systems, components, and raw materials that make up these segments are also characterized as core, enabling, and supporting (see Exhibit 4,) based on their importance or role in improving the energy efficiency of a system, the value they add to the segment, and their position in the value chain. In general, core sub-systems, components, or raw materials have the strongest potential to create economic value and generate jobs for the state, because their sales generate higher economic value and offer greater potential for suppliers to capture that value in the form of profits. Enabling equipment or services, though not physically part of the technology segments described above, provide important know-how and are essential to commercialization. These include the engineers and integrators who will evaluate energy efficiency needs and select specific technologies to meet those needs. Supporting elements or activities, though they may be necessary to the operation of energy efficiency systems, are less important to sector growth; they are typically selected on the basis of cost or a supplier’s proximity to its customer, and they tend to follow the industry’s growth rather than lead it. The asset inventory quantifies all core and enabling assets.

Exhibit 4. **Energy Efficiency Technology Systems and Sub-systems Categorized by Value**

**Specialized Energy Efficiency Technologies**

**ENERGY STAR Packaged Boiler System**
**Insulation Materials**

**CORE**

- Product that influences buying decision, *OR*
- Contributes to majority of system value

**Specialized Equipment and Services**

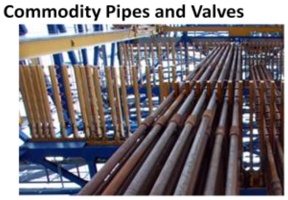
**Energy Audit Services**
**System Design Services**

**ENABLING**

- Sector-specific service that influences buying decision, *OR*
- Specialized equipment *outside* of the system

**Non-Specialized Products and Services**

**Non-Differentiating Operations and Maintenance or Installation Services**
**Commodity Pipes and Valves**



**SUPPORTING**

- Commodity products and services that are required for the system to function/ function efficiently, but are not Core or Enabling

**Energy Efficiency Services**

From the beginning, the project team and Working Group recognized the particular importance and anticipated a predominance of services in the energy efficiency sector. The greatest energy efficiency benefits are realized when a building or industrial process is approached holistically as a system to be optimized. Efficiency improvements include technology upgrades as well as behavioral changes, while commissioning, operations and maintenance all play a role in maintaining any efficiency benefit in the long term. It was therefore important to categorize services appropriately in this asset inventory, and begin assessing opportunities to leverage or grow them as part of the outcome.

For the purposes of this effort, the following services were categorized as enabling and were therefore quantified and categorized as part of the asset inventory:

- Comprehensive energy service companies (ESCOs)
- Building optimization (Architecture & Engineering services)
- Industrial process optimization (Architecture & Engineering services)
- Specialized financing services (excluding banks)
- Energy efficiency certifications/standards
- Energy audits
- Specialized, third-party operations and maintenance
- System-specific design/specification
- System-specific equipment

All of these enabling services play a role in technology specification or sale, and therefore are in a position to influence sector growth. On the other hand, services influencing behavioral changes, training, and education, or taking place after technology sales (such as contracting, operations and maintenance, or measurement and verification) were all classified as supporting because they are anticipated to follow, rather than lead, sector growth.

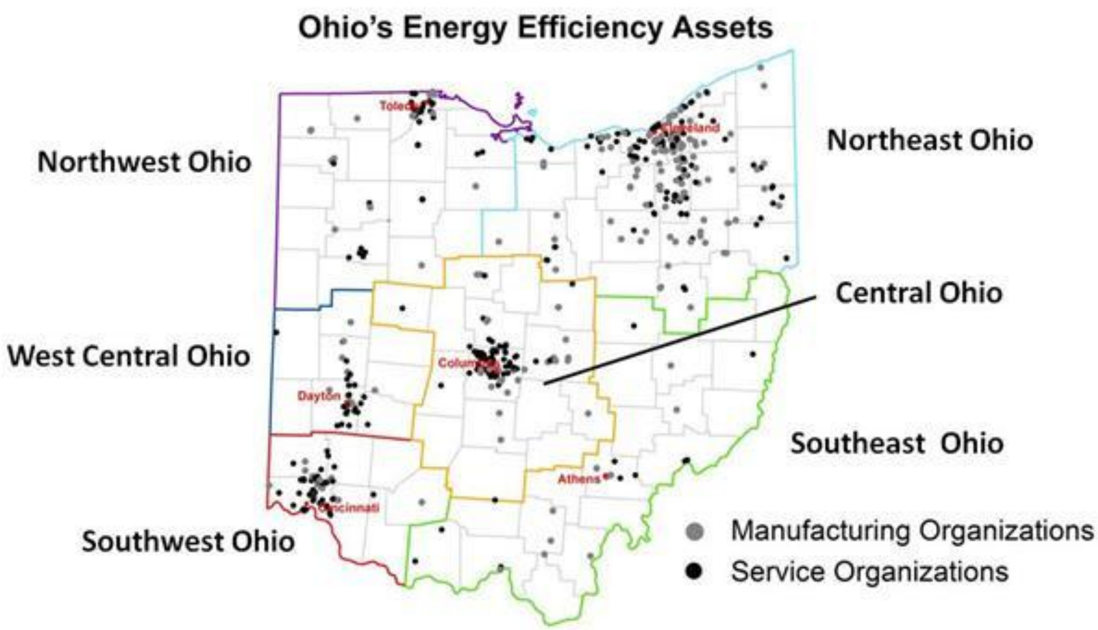
## THE ASSET INVENTORY:  OHIO'S STRENGTHS IN ENERGY EFFICIENCY TECHNOLOGIES AND SERVICES

Ohio has substantial assets in "core" energy efficiency technologies and "enabling" services and equipment.  These assets include more than:[5]

- 400 unique organizations that participate actively in energy efficiency research, pilot testing, and commercial activity
- $2.1 billion in revenue and funding
- 9,600 full-time-equivalent workers

These assets are distributed across Ohio's six regions roughly according to the state's major population centers, as mapped in Exhibit 5.

Exhibit 5.  **Regional Distribution of Ohio's Energy Efficiency Assets**




Six unique stories unfold when the assets are considered by region and analyzed according to:

- The number of organizations and their revenue/funding and jobs
- Stage of development (R&D, pilot, commercial)
- Stage in the value chain (raw materials, components, sub-systems, systems, and end users)

These regional stories are detailed on the following pages.  Each story includes a figure showing the technology segments and essential service categories with the greatest concentration in regional employment and revenue.  The figures also include Mekko charts, which show the proportion of each segment's organizations or employment involved in varying stages of development or value chain activity.  They can be read as two dimensional pie charts, in which the horizontal and vertical axes each represent 100%.

[5] All estimates as of 2011

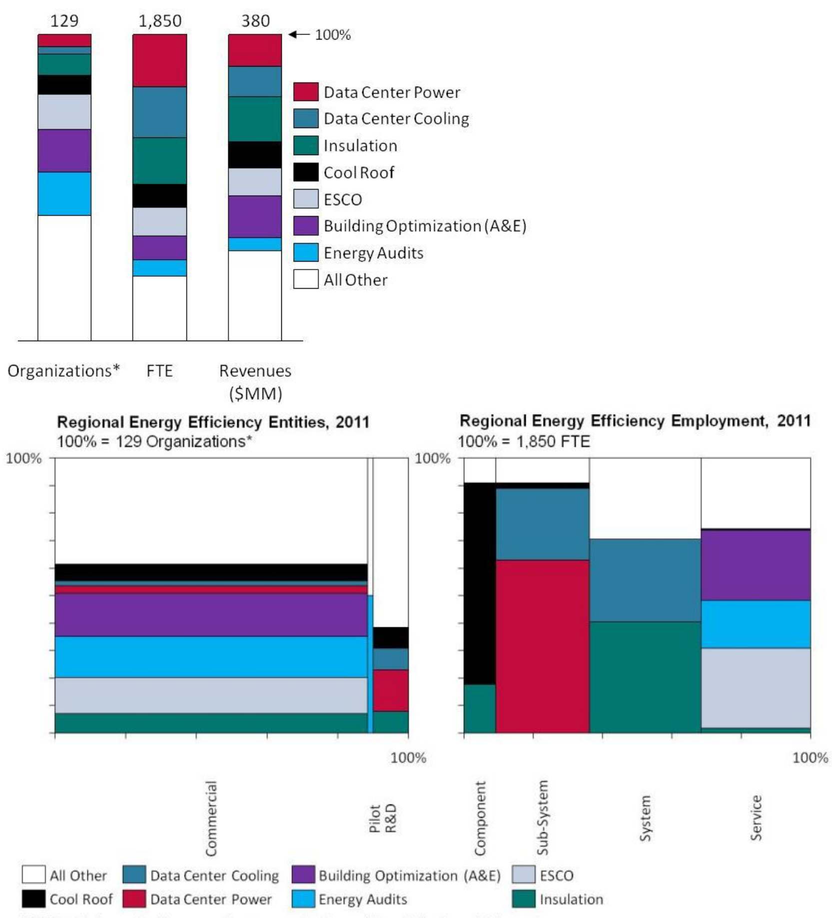
***Central Ohio is an innovative R&D and engineering hub, with concentration in data center technologies, insulation, and cool roof products.*** Several market leaders with regional presence dominate the data center and building materials manufacturing: Emerson Electric and Cisco Systems in data center technologies, Owens Corning in insulation, and Owens Corning, PPG Industries, and AkzoNobel in cool roof products. Owens Corning and Emerson each have major R&D centers in the region, complemented by diverse development activity at Battelle Memorial Institute, Edison Welding Institute, PolymerOhio, and The Ohio State University. Unique engineering assets, such as Go Sustainable Energy, Plug Smart, JadeTrack, Thermal Visions, and Terracal Systems, also drive innovation in energy efficient products and services. Their offerings range from holistic building and industrial process optimization, to pilot-stage energy auditing software, to vacuum-insulated panels for major appliances and alternatives to traditional geothermal technology.

The region's assets include:

- 92 unique[6] organizations
- 1,850 full-time equivalent workers
- $380 million in revenue and funding

Exhibit 6 depicts these assets by segment, commercialization horizon, and value chain.

Exhibit 6. **Central Ohio's Energy Efficiency Assets**




[6] This statistic refers to the number of distinct organizations in the region, whereas the slightly larger organization count in the diagrams considers the same organizations with activity in multiple different systems as multiple assets.

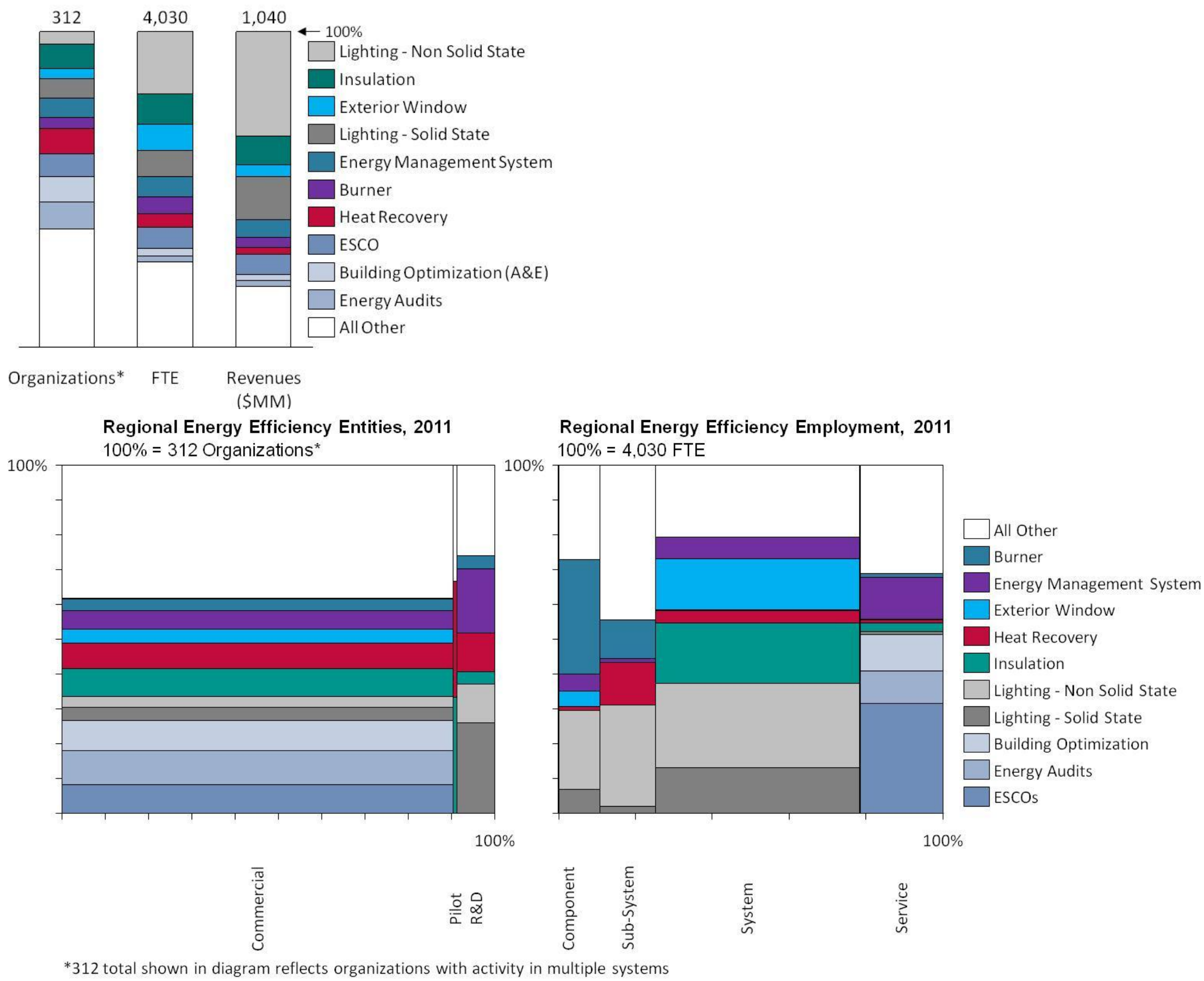
***Northeast Ohio has sizeable and diverse assets in lighting, insulation, exterior windows, and several other efficiency segments.*** Energy efficient lighting activity represents the largest concentration of headcount and revenue, and is anchored by GE Lighting, with more than 30 other assets representing solid state and non-solid state technologies across the commercialization horizon and value chain. A variety of lighting, insulation, and exterior window assets reflect a known regional strength in materials development and manufacturing. Though not reflected in the most concentrated segments, assets like R.W. Beckett, Echogen Power Systems, Novar, and Rockwell Automation integrate important systems for building and industrial process efficiency, often emphasizing controls. The Northeast Ohio Working Group plans to further explore all of the segments shown in Exhibit 7.

The region's assets include:

- 220 unique[7] organizations
- 4,030 full-time equivalent workers
- $1.04 billion in revenue and funding

Exhibit 7 categorizes these assets by segment, commercialization horizon, and value chain.

Exhibit 7. **Northeast Ohio's Energy Efficiency Assets**

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[7] This statistic refers to the number of distinct organizations in the region, whereas the slightly larger organization count in the diagrams considers the same organizations with activity in multiple different systems as multiple assets.

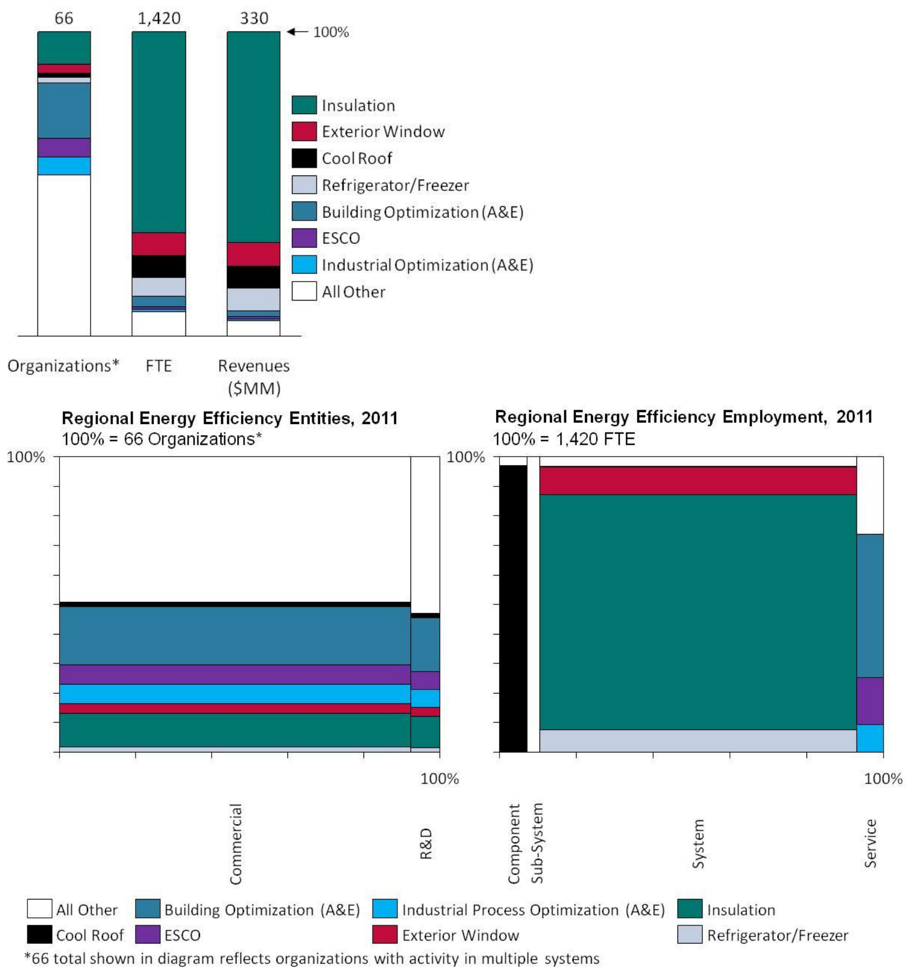
***Northwest Ohio's strengths in insulation, exterior windows, cool roof systems, and major appliances are rooted in its industrial heritage.*** Industry mainstays like Owens Corning, Johns Manville and Louisiana-Pacific, Whirlpool, and Great Lakes Window anchor the energy efficiency activity in these segments. By far, insulation dominates this activity; five organizations account for nearly 70 percent of employment and revenue. Reflecting the industrial emphasis, architecture and engineering firms in Northwest Ohio focus on industrial process optimization, system/controls integration, and industrial facility optimization, including specialized know-how at the Center for Innovative Food Technology in food processing and greenhouse efficiency. Separately, Smashray and Bowling Green State University's OLED research and development efforts complement substantial lighting activity in other parts of the state.

The region's assets include:

- 49 unique[8] organizations
- 1,420 full-time equivalent workers
- $330 million in revenue and funding

Exhibit 8 categorizes these assets by segment, commercialization horizon, and value chain.

Exhibit 8. **Northwest Ohio's Energy Efficiency Assets**




[8] This statistic refers to the number of distinct organizations in the region, whereas the slightly larger organization count in the diagrams considers the same organizations with activity in multiple different systems as multiple assets.

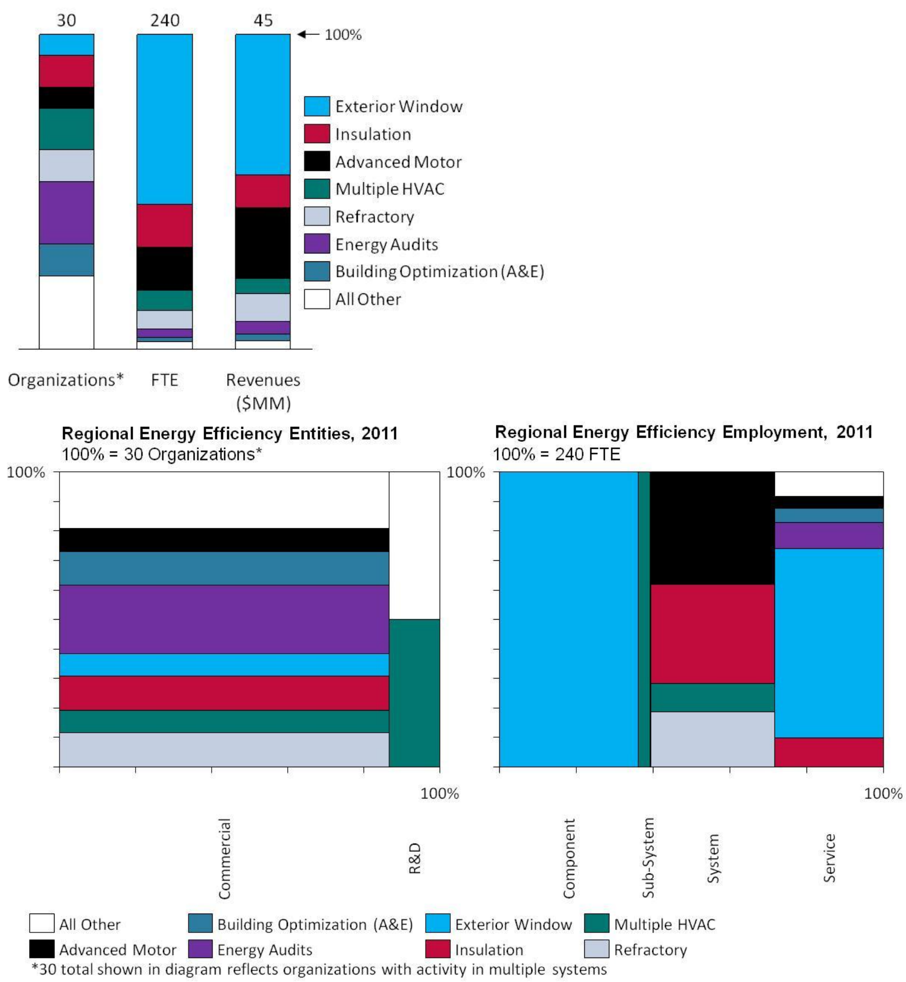
***Southeast Ohio is a hotbed of Stirling Engine and Stirling-based technology development amidst more traditional manufacturing.*** Employment and revenue are led by six mid-sized window and window component, insulation, and advanced motor manufacturers, including Edgetech I.G., International Converter, and Rockwell Automation. Though smaller in size, Global Cooling, Sunpower, and Ultimate Air house unique Stirling intellectual property and manufacturing that advance energy efficient HVAC and heat recovery systems with global impact. For example, this region is home to intellectual property supporting Micro Combined Heat and Power system use for home water heaters in Europe. Ohio University's Consortium for Energy, Economics, and Environment bolsters Stirling-related and other energy efficiency technology research and supply chain development.

The region's assets include:

- 20 unique[9] organizations
- 240 full-time equivalent workers
- $45 million in revenue and funding

Exhibit 9 categorizes these assets by segment, commercialization horizon, and value chain.

Exhibit 9. **Southeast Ohio's Energy Efficiency Assets**




[9] This statistic refers to the number of distinct organizations in the region, whereas the slightly larger organization count in the diagrams considers the same organizations with activity in multiple different systems as multiple assets.

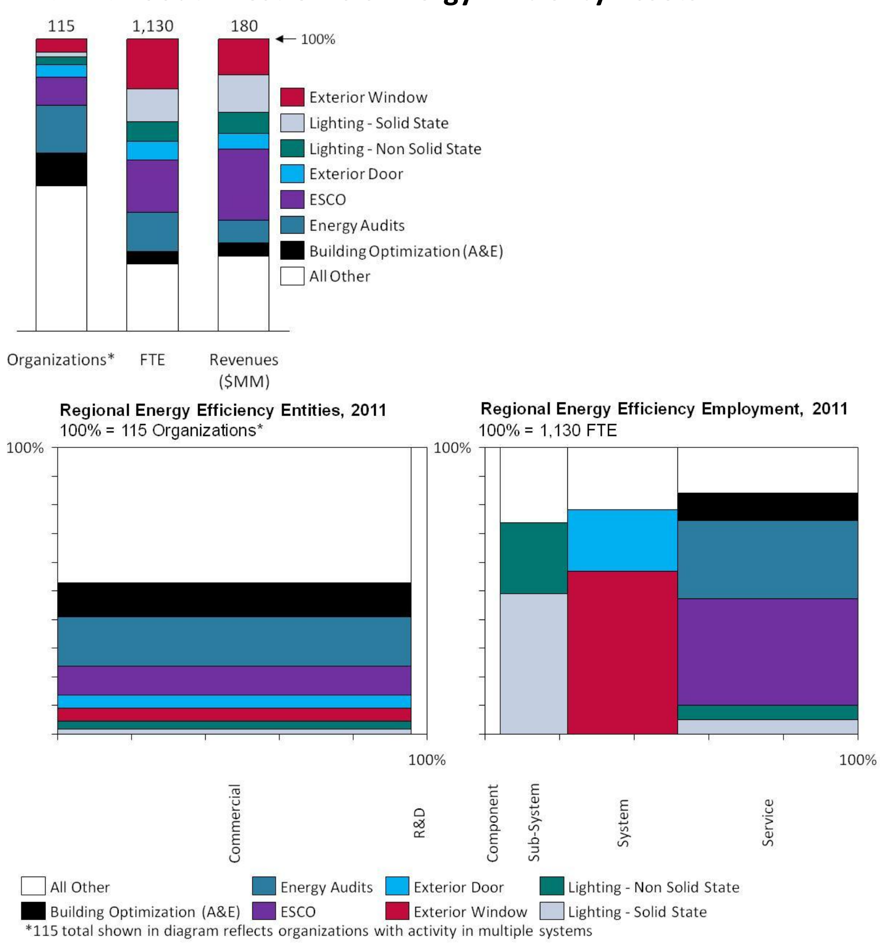
***Southwest Ohio has a distinctive concentration in building services, paired with substantial exterior window, door, and lighting manufacturing.*** Southwest Ohio's 40 percent concentration of energy efficiency revenue and employment in a variety of essential services, most of them building-related, is higher than any other Ohio region. In addition to quantified enabling services, unique supporting services add to the region's strength. Greater Cincinnati Energy Alliance develops a network of qualified contractors and helps to coordinate project financing to provide regional efficiency service. Melink offers exportable HVAC commissioning services to major national retail and restaurant chains. Most of the remaining 60 percent of regional assets are split between efficient window, door, and lighting manufacturing plants. Almost all regional assets are commercial, with limited R&D in building energy management (Cincinnati Technologies) and electrofluidic display technology (Gamma Dynamics) for smart building applications.

The region's assets include:

- 86 unique[10] organizations
- 1,130 full-time-equivalent workers
- $180 million in revenue and funding

Exhibit 10 categorizes these assets by segment, commercialization horizon, and value chain.

Exhibit 10. **Southwest Ohio's Energy Efficiency Assets**




[10] This statistic refers to the number of distinct organizations in the region, whereas the slightly larger organization count in the diagrams considers the same organizations with activity in multiple different systems as multiple assets.

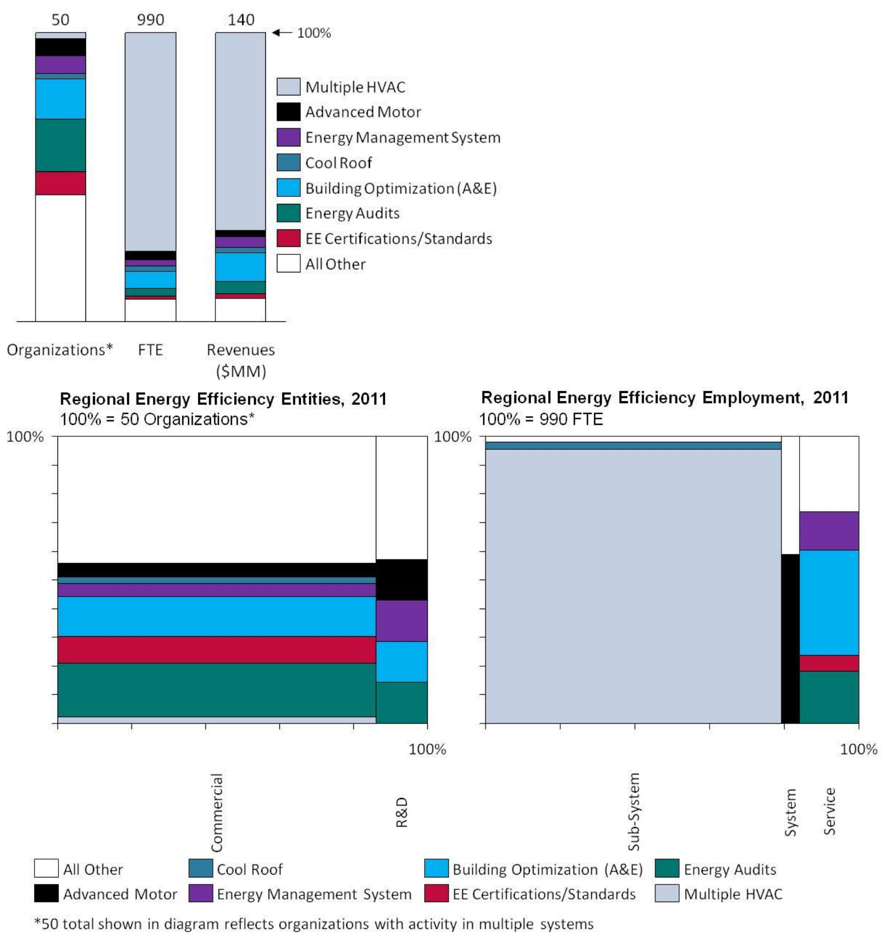
***West Central Ohio's emerging auditing tools complement its established strengths in building services and R&D capability.*** As in Southwest Ohio, building efficiency services play an important role in this region, with game-changing auditing tools under development by Woolpert, Dropoly, and the University of Dayton. Woolpert and the University of Dayton are collaborating on scalable auditing techniques to allow rapid assessments of institutional campuses or communities, while Dropoly software engages community members to improve collective residential efficiency. However, manufacturing still leads the concentration of energy efficiency activity, with Emerson Climate Technologies' single HVAC asset accounting for nearly 70 percent of employment and revenue in the region's efficiency sector. Three NEMA premium motor manufacturers (Globe Motors, Regal Beloit and SEW-EURODRIVE) comprise the next largest technology segment, including some R&D activity. The remaining activity is fragmented across segments, and is synergistic with other Ohio strengths.

The region's assets include:

- 37 unique[11] organizations
- 990 full-time-equivalent workers
- $140 million in revenue and funding

Exhibit 11 categorizes these assets by segment, commercialization horizon, and value chain.

Exhibit 11. **West Central Ohio's Energy Efficiency Assets**




[11] This statistic refers to the number of distinct organizations in the region, whereas the slightly larger organization count in the diagrams considers the same organizations with activity in multiple different systems as multiple assets.

**Ohio's Statewide Synergies: Potential Areas of Critical Mass**

As important as the regional findings are the statewide synergies they reflect. Exhibits 12 and 13 summarize the statewide asset inventory, including the energy efficiency segments with the greatest revenue and headcount concentrations. Exhibit 12 summarizes the statewide distribution of prominent segments, indicating clear synergies in strength including:

- Building insulation systems
- Energy efficient lighting systems (both solid state and non-solid state)
- Technologies spanning multiple HVAC systems in the advanced HVAC category
- Exterior window systems
- Building services (including building optimization architects and engineers, energy service companies, and energy auditors)

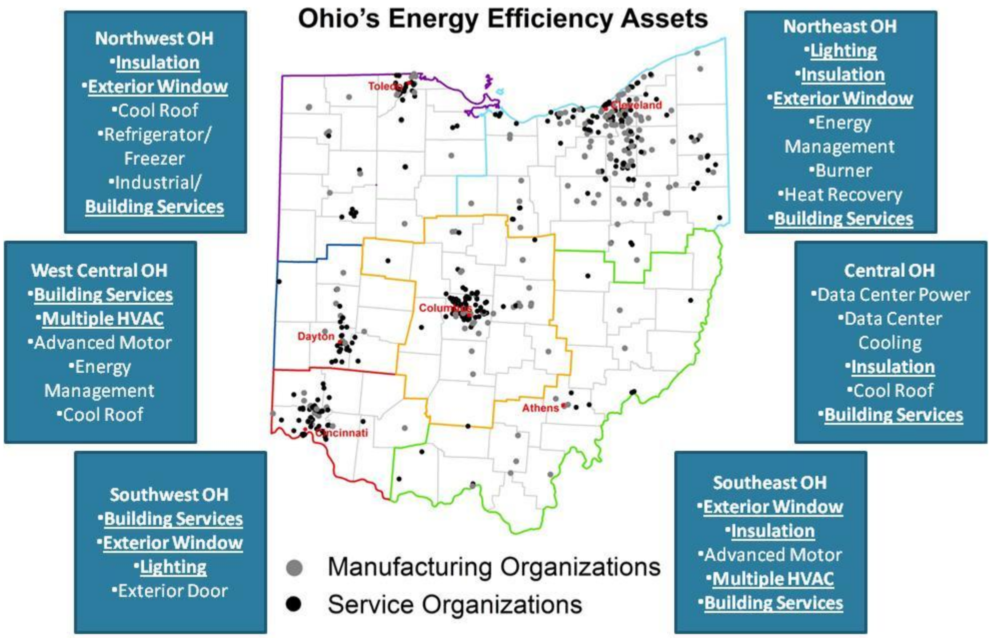
As shown in Exhibit 13, activity in these segments is predominantly commercial, with some research and development, across the value chain. Given their concentration and distribution in terms of commercialization horizon and value chain, these segments could be potential statewide areas of "critical mass," a distinction typically hypothesized by the Working Group based on asset inventory findings and tested against competitive U.S. regions and relevant market projections.

Exhibit 12 also includes technology areas to watch, or perhaps to advance regionally. Additional asset inventory analysis suggests the following segments with opportunities for statewide collaboration between less concentrated entities (in terms of revenue and headcount) that are unique or geographically dispersed:

- Building energy management systems
- Heat recovery systems inclusive of both heat recovery units and application technologies, particularly for combined heat and power systems
- Cool roof coatings and materials

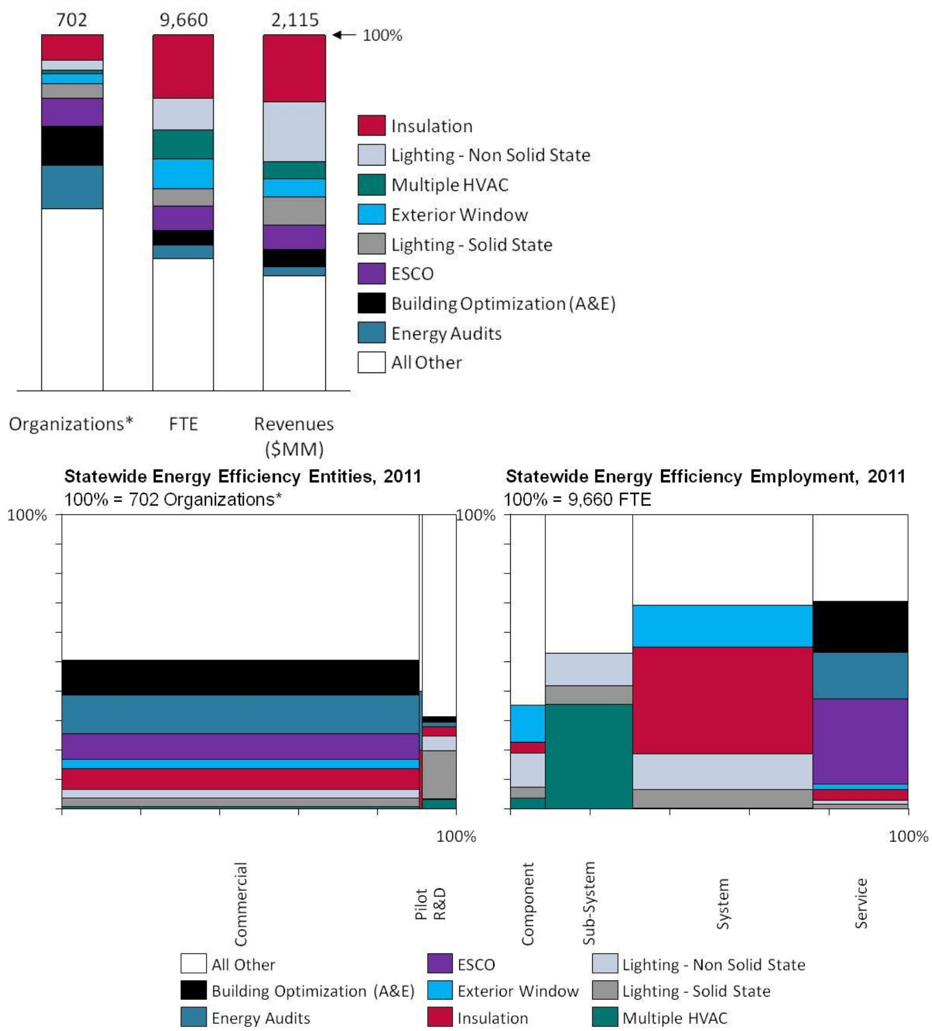
Finally, the enabling services emphasizing building optimization, including architects and engineers, ESCOs, and auditing firms, are in a position to leverage Ohio's technology strengths, and to capitalize on any energy efficiency market opportunity developed within the state of Ohio. According to one Working Group member, "Services are especially important for access to the existing building retrofit market. [Energy efficiency] technologies can stand alone in new construction, but enablers are important to go-to-market efforts with existing building customers." Given Ohio's existing, aged building stock across a range of markets, the state should be ripe with opportunity for facility optimization services that include retrofits. As discussed in the next section, the state can promote this opportunity by advancing policy objectives or demonstrating the bottom-line benefit of purchasing such services, as well as leveraging service assets for Ohio technology deployment. In the meantime, the asset inventory itself can assist Ohio manufacturing and service firms in identifying each other, and potentially forming partnerships or alliances.

Exhibit 12. **Statewide Synergies with Segment Distribution**




Note: Synergies, based on concentration in revenue and headcount, are identified in bold, underlined font

Exhibit 13. **Ohio Energy Efficiency Organizations, Employees, and Revenues by Technology Segment**




*702 total shown in diagram reflects organizations with activity in multiple systems

## MOVING FORWARD: OHIO'S OPPORTUNITY IN ENERGY EFFICIENCY TECHNOLOGY AND POTENTIAL NEXT STEPS

The asset inventory findings highlight the extent and concentration of energy efficiency activity and capability in Ohio and its regions. Opportunities to leverage these findings in growing Ohio's energy efficiency sector exist at the state, regional, and company level.

### State Level Policy Opportunities

At the state level, AEE Ohio Institute has a strong interest in using these findings to support policy discussion and advancement. Working Group members and regional experts agreed that advancing policy is an important element of growing the sector as a whole. They varied in their perspectives about whether to prioritize either federal or state policy changes, or pursue both simultaneously. One shared that "industry organizations tend to be really effective at addressing national policy, but not state policy, [so] more education is needed at the state policy level." Another suggested that given the national footprint of some of Ohio's largest technology assets, national policy initiatives might be most valuable to growing such organizations. A third agreed that national policy is a stronger motivator for manufacturing firms but that state policy has a greater influence on service businesses – and hence a coordinated national and state approach would be most effective.

In pursuing state or federal policy objectives, the asset inventory findings are a supporting resource. They concretely demonstrate Ohio's manufacturing base in energy efficient building technologies, as well as associated service providers. A Working Group member shared the perspective that some of the technologies in which Ohio is strong, such as lighting and HVAC technologies, are frequently considered for retrofit incentives, while others, such as building envelope products, may sometimes be "overlooked in terms of development resources or retrofit incentives… because it is harder to calculate [efficiency] improvement or return on investment." Statewide manufacturing strengths in several of these building technologies, and services for optimizing building efficiency, can support an energy efficiency retrofit opportunity in Ohio's existing residential, commercial, industrial and institutional buildings.

As another Working Group member noted, communicating these strengths and their potential local impact can help bridge the "educational gap in creating a compelling case for existing, mature manufacturers to invest resources into improving efficiency," which can complement policy improvements by providing a business case for technology deployment. Sharing case studies of energy efficiency technologies' impacts on the profitability of local businesses would help promote energy efficiency investment, even in absence of policy development or implementation.

### Regional Cluster Development Opportunities

As multiple Working Group members noted, it is difficult to fully determine which energy efficiency technologies have "critical mass" in Ohio without understanding comparable activity in other states or the market opportunity for the different technology areas. The purpose of an asset inventory, as part of the full cluster roadmapping process, is to begin identifying the most promising technologies for regional or statewide investment. According to *InSeven by NorTech®*, the asset inventory ideally would be followed by a market analysis and competitive assessment for areas of relative strength within the region, to determine if that strength is competitive outside of the region and relevant to projected market demand. Northeast Ohio already intends to pursue, as a region, an assessment such as this in order to devise a plan for growing its regional energy efficiency assets. Given the number and diversity of assets throughout Ohio, it may be beneficial for one or more of the other regions, or the even the state as a whole, to complete these steps as well. Doing so would allow the region(s) or state to clearly determine the most promising technology areas of focus, and build an action plan around promoting their growth. More information about additional steps of the cluster roadmapping process can be found in the Appendix.

**Company-Level Collaboration Opportunities**

Even in absence of immediate leadership for regional or statewide technology cluster development, individual companies can take advantage of asset inventory findings by collaborating with other organizations on:

- Advocacy activity at the state or federal level
- Referral or partnership strategies to facilitate supply chain development, access to capital, or market access
- Funding applications for technology development or commercialization
- Pilot or demonstration projects to develop case studies or document business cases for technology or service deployment

The quantified and categorized inventory of technology and service assets is a valuable resource for any of the organizations in Ohio's energy efficiency value chain. It offers a list of potential suppliers, customers and/or partners, as well as insight into their roles in energy efficiency technology, and the extent of that activity, in Ohio as a whole or one of the its six regions. AEE Ohio Institute can use this inventory as a starting point for engaging such organizations in policy development and other efforts to advance the energy efficiency industry.

**APPENDIX**

**THE *InSeven by NorTech®* ROADMAPPING METHODOLOGY:**
**LEVERAGING OHIO'S ENERGY EFFICIENCY ASSETS TO GENERATE JOBS**

NorTech's *InSeven* roadmapping process (shown in Exhibit 14) targets a technology sector, builds an extensive fact base through research and rigorous analysis, and brings together sector stakeholders — private companies, researchers, and policymakers — who draw on that fact base to define a vision for the sector and a roadmap for attaining the vision and accelerating growth in revenue and job creation. The resulting roadmap reflects a fact-based view of sector assets and opportunities, with active support of key stakeholders who will drive its successful implementation. In this effort, only the first phase was completed to yield an asset inventory describing the current state of the sector in Ohio.

Exhibit 14. ***InSeven by NorTech®* Roadmapping Methodology**[12]


Although only the first three steps were completed, the following describes how those steps fit into the larger seven-step methodology (shown in Exhibit 14), which could be completed in the future by the state as a whole, or one or more of its regions:

> **Step 1: Launch the Roadmapping Effort.** The roadmapping team defined the scope of the effort and held a kickoff meeting with the Working Group and other industry stakeholders to share information and agree on roles, responsibilities, and timelines.

[12] Please see *The Cluster Development Roadmapping Process* (NorTech, 2011) for more detailed information about the process that supports these key activities and deliverables.

**Step 2: Define and Segment the Energy Efficiency Technology Sector.** The roadmapping team identified the various segments and components of energy efficiency technology and related services, as well as their roles and relative contribution — core, enabling, or supporting — to each technology's economic value. The team then divided the sector into distinct technology segments, each associated with specific products, supply chains, and functions. This step defined in detail the technologies to be considered in sector roadmap and provided an organizing framework for the asset inventory that followed.

**Why Are Technology Segments Necessary?**

**Dividing the sector into technology segments affords a much more detailed picture of the state's assets than considering the sector as a whole.**

- The energy efficiency sector is extremely diverse, with both mature and emerging technologies. In most cases, meeting the energy efficiency needs of any one end-user will require integrating several technologies, and hence the designers of customized solutions are particularly important to the industry. To fully understand the diversity of the sector's technologies as well as its strengths and opportunities for growth, the roadmapping methodology breaks the sector into distinct technologies and clearly articulates the enabling role of the engineers and integrators who customize or combine them for the end user.
- Technology segmentation makes it possible to identify the sector participants that are best positioned to capture value from the market opportunity, and the supply chains that support those participants. These technology segments and supply chains can then be understood in detail and used as the basis for specific, measurable action. Viewing the sector as a whole would not have surfaced numerous technology-specific opportunities for the cluster.

**Step 3: Identify Priority Segments of Ohio's Energy Efficiency Sector.** Using the technology segments identified in Step 2 as a framework, the roadmapping team created a comprehensive inventory of the state's energy efficiency-related assets, highlighting the technology segments in which Ohio has the strongest capabilities and a potential critical mass of assets — businesses, intellectual property, supply chain infrastructure, etc. — as measured by the number of entities involved, Ohio-based revenues, and jobs. To increase the granularity of the results, these assets were further categorized by stage of development (research, pilot program, or commercial) and by the organization's position in the value chain. Stage of development is a significant indicator of a technology's potential to contribute economic value; commercial assets are most likely to create value within the 7-year time horizon of the roadmap and would therefore be more heavily weighted in setting segment priorities. Similar weight would be given to a company's position in the value chain. Businesses downstream in the value chain are closer to the customer and are often better positioned to capitalize on market demand. The roadmapping team can use this information to assess the region's critical mass in each of the segments and select the highest-potential technology segments. These segments would then become the priorities for the roadmap.

**Step 4: Estimate the Market Opportunity for Ohio's Energy Efficiency Technologies.** For each priority segment, the roadmapping team would build a broader fact base by assessing the market opportunity — in terms of both revenue and jobs — including the size of the addressable market, the portion of each segment available to Ohio companies, and an estimate of how much the state could likely capture within the roadmap's 7-year timeframe.

**Step 5: Build Insight into the Competition Ohio Faces in Energy Efficiency Technologies.** The roadmapping team would assess Ohio's competitive position relative to other U.S. regions with significant, comparable energy efficiency technology activity, based on government support, local demand, local research entities and companies focused on energy efficiency, availability and cost of labor, supply infrastructure in place, and energy costs. This analysis would provide perspective on Ohio's ability to compete for the talent, jobs, and brand recognition needed to promote growth in a mature industry. It would also provide insight into the global market share that Ohio could expect to capture.

**Step 6: Develop an Initial "To Be" State and "Game Plan" with the Working Group.** To create an energy efficiency technology roadmap for the entire sector, the roadmapping team and the Working Group would identify the region's strengths (e.g., concentrations of companies, customer relationships) and barriers to its success. They then would articulate the "To Be" state for Ohio's energy efficiency technology sector — a broad vision including goals for each of the priority segments. To create the other half of the sector roadmap, the "Game Plan," the team would highlight areas where segment visions are complementary, and identify synergies and potential efficiencies in the actions required, ensuring that sector initiatives would be timed and orchestrated appropriately across the state.

**Step 7: Syndicate Roadmap and Finalize to Reflect Stakeholder Feedback**. As in each previous step of the roadmapping process, the team would work with a broad range of sector participants to seek their input on the "To-Be" state and "Game Plan," and to vet their information and analysis as well as the resulting vision and roadmap.

## ABOUT BUSH CONSULTING GROUP

Bush Consulting Group conducts high impact strategy work for senior organizational leaders that leverages unique skills in detailed primary research and rigorous economic analysis. The firm's experience is that, as with corporate success in innovation, effective technology-based economic growth requires a focus on fundamental economic drivers and proficiency in technology commercialization. Building on this premise, Bush Consulting Group was a key contributor to the development of *InSeven by NorTech®*, nationally recognized as a best in class cluster development approach. As *InSeven's* sole licensee, the firm has completed numerous such efforts. Bush Consulting Group's consultants bring a strong commercial perspective and deep business and economic analysis skills to technology-based economic development, as well as the ability to grasp technical issues rapidly and facilitate development of complex, data driven, multi-stakeholder strategies.