Part 4: An Industrial Energy Efficiency Roadmap for Ohio Manufacturers: Potential, Barriers and Opportunities - *Full Version*

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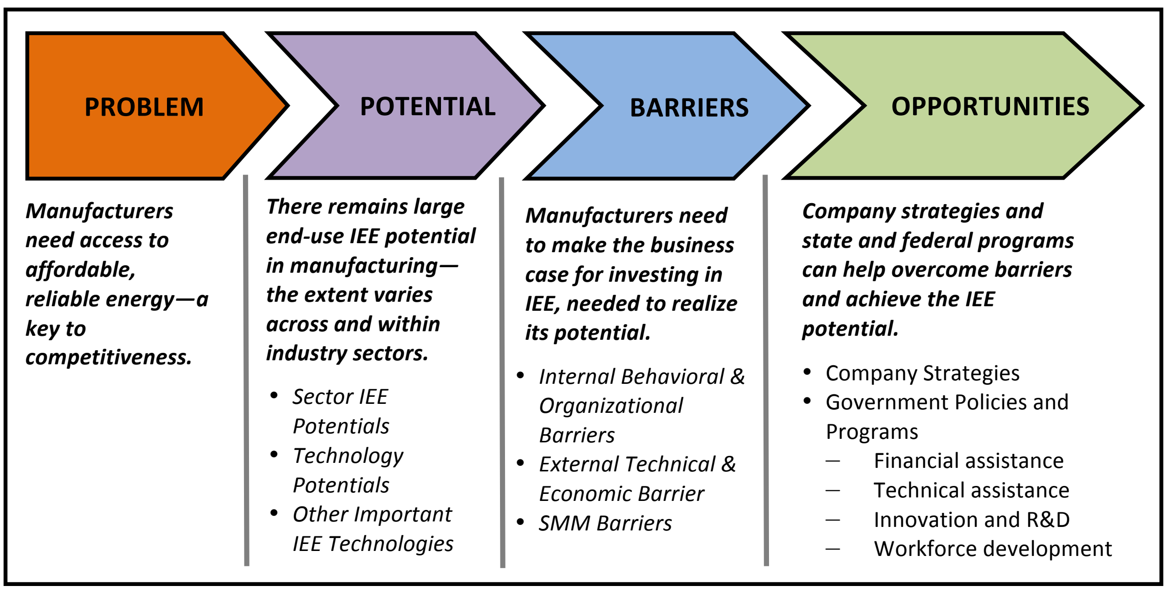
<u>**Executive Summary**</u>

Ohio manufacturers are increasingly concerned about the availability and cost of energy, and the implications for manufacturing competitiveness. The Ohio Manufacturers' Association (OMA) maintains that "ensured access to reliable affordable energy . . . must be key to Ohio's comprehensive energy plan. Without it, the state's short- and long-term ability to grow its economy and create jobs will be threatened."[1] The greatest potential for addressing this challenge is to increase *industrial energy efficiency* (IEE) throughout Ohio's manufacturing sector.

As illustrated in the IEE "roadmap" in Figure 1, to proactively pursue IEE, Ohio's manufacturers must identify the potential for making cost-effective IEE gains, assess barriers to realizing this potential, and adopt business strategies and take advantage of public sector opportunities to overcome these barriers.

Figure 1. Industrial Energy Efficiency Roadmap for Ohio Manufacturing



The potential, barriers and opportunities for making IEE gains vary greatly across manufacturing industries. The greatest differences are between energy-intensive trade-exposed (EITE) industries and non-energy-intensive (non-EI) industries, and between large and small-and-mid-sized manufacturers (SMMs).

- EITE manufacturing industries use much more energy, and in different ways, than non-EI industries. Both use fuels and electricity for heat and power, but the former consumes more energy for specific processes and feedstock. Because the latter's energy costs are a much smaller share of their overall production costs, investing in IEE is a somewhat lower priority than in EITE industries.

- Ohio's manufacturing sector is very heterogeneous. Major EITE industries include iron and steel, primary aluminum, petroleum refining, paper and paperboard, plastic materials and resins, organic and inorganic chemicals, cement, lime and iron foundries; large non-EI industries include auto manufacturing, aerospace, fabricated metal products and machinery.
- Small firms account for 89% of Ohio's 16,000 manufacturing establishments, mid-sized plants (100-499 employees) for 9% and large facilities (over 500 employees) for 1%. Large plants account for one-third of all jobs in manufacturing—SMMs about two-thirds.[2]
- Ohio SMMs require different considerations in assessing and making IEE improvements. They typically lack resources and personnel needed to overcome IEE barriers and realize their IEE potential.

IEE Potential

American manufacturers lag in their IEE achievements compared to many foreign competitors. They have reason to worry about the implications of competing with nations, such as China, that already benefit from other competitive advantages (e.g., low-cost labor, subsidies, lax regulations), including becoming more energy-efficient. Nevertheless, there is substantial potential for making IEE improvements in most U.S. manufacturing industries—and in Ohio.

- The amount of IEE gains depends on the type and size of manufacturer. McKinsey & Company estimates that as much as 61% of energy savings potential resides within the EITE sector, and about 31% within the non-EI sector in the United States.[3] SMMs also have large unrealized efficiency gains.
- An American Council for an Energy-Efficient Economy report identified a diverse set of efficiency measures for Ohio's industries that could yield an overall efficiency resource opportunity for electricity of 21-26%.[4]
- A wide range of technologies are currently available for enabling cost-effective, short-, medium- and long-term IEE gains:
    - *Cross-cutting, energy support systems* widely used by manufacturers, such as motor-driven systems, steam systems and buildings (HVAC, lighting, building shells), represent about one-third of efficiency opportunities in U.S. plants.[5]
    - *Combined heat and power (CHP)* and *waste heat recovery* systems are especially promising sources of energy gains. Recycled Energy Development estimates that installing CHP in some of Ohio's largest manufacturing facilities could generate 850-2,000 MW of electricity, and captured waste heat at integrated steel mills, an additional 50-200 MW.[6]
    - *Process-specific measures* include improvements of existing equipment, processes, and practices, and the retrofitting or replacement of old equipment.
    - *Emerging technologies* are advanced production technologies that may not yet be technically and commercially available, but hold the promise of substantial energy gains in the future.

IEE Barriers

Manufacturers must make the "business case" for making IEE investments that will draw upon scarce capital resources. This requires addressing *internal company behavioral and organizational barriers* and *external economic and technical barriers* that prevent firms from making IEE investments, despite the potential gains.

- Internal behavioral and organizational barriers within companies include *lack of information* about IEE options and benefits, *elevated "hurdle rates," rapid payback requirements*, *capital budget allocation constraints* and *lack of expertise*.
- External technical and economic barriers include *capital availability*—the largest single concern of managers—and the *availability of new technologies, processes and products*.

IEE Opportunities

Many opportunities are available to Ohio's manufacturers to make IEE improvements including business strategies and state and federal programs.

- Business strategies include developing *plant and line-level energy management plans and systems, workforce training,* and *involving both engineering and front-line workers* in the design and implementation of these plans.
- State and federal programs include *financial assistance* (grants, loans, tax credits), *technical assistance*, *technology innovation and R&D*, and *workforce development*.
- Although these programs have been effective, they are not sufficient. New approaches, programs and legislation that could greatly strengthen Ohio's opportunities to make substantial IEE gains must be explored, researched and evaluated, especially as state and federal resources diminish.

Other Opportunities

Ohio is emerging as an important hub of clean energy manufacturing, and could pursue other clean energy opportunities to stimulate growth in statewide. Forward-looking Ohio manufacturers are already engaged in producing products, materials, parts, and components used in "green" buildings, advanced fuel vehicles, and "green" infrastructure and transportation system. In short, given its tremendous manufacturing strengths and capacities, with supporting policies, Ohio is poised to become a leading national center for multiple clean energy manufacturing clusters, supplying a wide-range of materials, parts and end-use products for local, domestic and international clean energy markets.

Introduction

High Road Strategies, LLC of Arlington, VA has been contracted by the Ohio University Voinovich School to identify and update existing research on opportunities on the state of energy and manufacturing in Ohio. This work is part of a project that the Voinovich School has undertaken with The Ohio Manufacturers' Association (OMA).[7] The project's goal is to generate a dialogue among OMA members and other stakeholders to articulate a path forward for Ohio manufacturers to take advantage of new and emerging opportunities in advanced energy manufacturing.

As a step towards this goal, this report summarizes the findings of a review of the most recent research studies, analyses, and data on industrial energy-efficiency (IEE) potential, barriers, and opportunities. Based on this analysis, it outlines an IEE "roadmap" for Ohio's manufacturers aimed at helping them identify potential cost-effective IEE gains and assess barriers that limit their ability to fully realize this potential. It also identifies and evaluates opportunities in both the private and public sectors for overcoming these barriers, enabling Ohio's manufacturing sector to move down a high IEE, low-carbon path in the coming years. It is well understood that this also could greatly contribute to Ohio's industrial competitiveness, promote economic growth, and create many new jobs.

An Industrial Efficiency Roadmap for Ohio

In 2006, Hamilton, Ohio-based SMART Papers closed its more than 100-year old pulp and paper mill in Park Falls, Wisconsin, a town of only 2,800, laying off 300 well-paid, skilled workers. High-energy costs and international competition were the primary reasons for this decision. Two years later, the mill reopened as Flambeau River Papers under new ownership, with the help of state and private funding, hiring back most of the original workers. The new plant has been touted as the first U.S. fossil-fuel free integrated pulp and paper mill, and in 2008 it received a $30 million federal grant from the U.S. Department of Energy (DOE) to create a biorefinery for renewable sulfur-free diesel fuel.[8]

The Flambeau River Papers story exemplifies both the challenges and opportunities confronting manufacturers, not only in Wisconsin and Ohio, but also across the nation. America's manufacturing sector has suffered serious erosion over the last decade, a trend worsened by the recent recession and financial crisis—showing only slight signs of improvement in the past year-and-a-half. A net of over 57,000 manufacturing establishments and 6 million manufacturing jobs have been lost since 1998. Underlying these trends has been a steady decline in U.S. competitiveness in the global markets, reflected by America's persistently massive trade deficits in goods—over $800 billion in 2008—and rising import penetration into U.S. markets in numerous manufacturing industries.[9]

Most major industrial states, including Ohio, have experienced similar trends. Ohio ranks third in the nation, behind only California and Texas, in manufacturing output—$84.1 billion, or 5.1 percent of the U.S. total in 2008—and number of manufacturing jobs—614,500, or 5.3 percent of U.S. total in 2009. Its manufacturing sector has seen decline and erosion comparable to that of the nation as a whole. By 2008, it already lost nearly one-quarter of its manufacturing workforce since 2000—about a quarter of a million jobs disappeared—and another 11 percent relative to 2001 levels, or 110,000 jobs, in 2009, due to the recession. Ohio also lost a net of 2,300 manufacturing establishments between 2001 and 2008, a 12 percent loss, and an additional 500 in 2009.[10]

Although the recessions of the past decade—especially the Great Recession of 2007-2009—have exacted a significant toll, the long-term secular decline in economic performance indicators (jobs, number of establishments, value-added, trade deficits, import penetration) evidenced by both the U.S. and Ohio manufacturing sectors, can be attributed to other factors, notably technology-driven productivity gains and most importantly, the loss of markets to low-cost international competitors (especially China, India, Brazil and other emerging economies). This is no less true for Ohio than for the nation as a whole, which has seen numerous, large-scale plant closures and shifts of production plants offshore, with corresponding job losses.

From Climate to Energy Policy. In this context, it was not surprising that climate change legislation introduced in the 111th Congress—including the *American Clean Energy and Security Act of 2009* (H.R. 2454; a.k.a. the "Waxman-Markey" bill) passed by the U.S. House of Representatives in 2009—raised concerns among some business and political leaders. In particular, such policies were perceived as potentially putting Ohio manufacturers at a competitive disadvantage, threatening a further loss of jobs. Ohio manufacturers that are both highly energy-intensive—and therefore generate substantial greenhouse gas (GHG) emissions—and sensitive to international competition, are especially susceptible to costs imposed on the use of fossil-fuels that many foreign competitors would not be subject to.

Measures to mitigate these costs for "energy-intensive trade-exposed" ("EITE")[11] industries, at least for the short-term, therefore were strongly supported, especially by business and labor groups, and even by some environmental organizations concerned about "carbon leakage." The only long-term way to limit these costs though, would be for manufacturers to invest in technologies and adopt practices that would greatly reduce companies' energy use. That is, they would need to make investments in industrial energy efficiency to offset the added costs resulting from GHG emissions mitigation policies.

In the current political environment, however, passage of climate change legislation has become very unlikely, though there remains controversy over U.S. Environmental Protection Agency (EPA) regulations aimed at reducing GHG emissions produced by large electricity generators and some industrial facilities (such as cement). The focus of the policy debate within the business community and among policy makers subsequently has shifted to concerns about the supply and costs of energy.

On the supply side, while some have called for more domestic production of fossil fuel energy resources (oil, coal, natural gas), many states, including Ohio, have actually witnessed the growth of renewable energy generation (wind, solar, biomass, hydro), aided by state and federal programs (e.g., Ohio's SB 221), over the past few years, despite the recession. For example, the American Recovery and Reinvestment Act of 2009 (*ARRA*) bolstered and enhanced many state clean energy programs that supported both the development of new renewable generation and other clean energy resources, as well as the growth of clean energy manufacturing activities, creating thousands of new jobs. This was evidenced in states such as Michigan and California, as well as Ohio.[12]

While many state governorships and legislatures have turned more conservative as result of the 2010 elections, there remains support for promoting clean energy production and manufacturing opportunities—to meet states' energy demand and to support the growth of new manufacturing activity and jobs. For example, the Kasich administration in Ohio has offered assistance of $15.8 million to Spanish-based Isofoton, a leading solar energy technology company, which chose Napoleon, Ohio as home for its North American manufacturing facility. The state funds, administered by the Ohio Department of Development (ODOD) would leverage Isofoton's pledged $16.4 million investment in Ohio. As ODOD director James A. Leftwich, observed, "Making Ohio the base for Isofoton's first U.S. footprint, strengthens our state's manufacturing supply chain, and creates jobs statewide."[13]

Equally important is an elevated interest in strategies, programs and policies, involving the both the private and public sectors, that reduce energy demand, especially through improvements in energy efficiency, for buildings, transportation, manufacturing, and other industrial activities. There is a growing recognition that initiatives that result in energy savings and more efficient use of energy can yield substantial economic gains, over and above any reductions in carbon footprints.

Ohio's Energy Profile. Ohio's generation mix could have significant implications for the state, which is one of the nation's largest consumers of energy. Most of its energy consumption consists of fossil-fuel energy sources (coal, natural gas, petroleum products) used to supply heat and power and generate electricity. For example, in 2008, Ohio was the nation's sixth largest energy consuming state overall, the third largest consumer of coal, the seventh largest consumer of natural gas, and eighth in petroleum consumption.[14]

In addition, Ohio's industrial sector was the fourth largest industrial end-use consumer in the nation in 2008. Correspondingly, it also is the largest energy consuming sector overall, and of fossil fuels in particular, within the state.[15] The industrial sector accounts for 37 percent of all electricity consumed in the state—about 85 percent of which is generated by burning coal and 11 percent by nuclear power.[16] It consumes about one-fifth of the petroleum used by Ohio's economy (three-quarters goes to transportation fuels), eight percent of the state's coal (most of the remainder, over 90 percent, goes to electric power), and over one-third of natural gas and renewable energy resources.

Within the industrial sector, manufacturing is by far the largest consumer of energy, and of fossil fuels in particular—the other sub-sectors, which include agriculture, construction, and mining, for example, consume only between 4-5 percent of all electricity generated in the state.[17] Manufacturers use energy sources to generate heat, mechanical power, and electricity. Many also use energy sources (such as petroleum, natural gas, coal and coke) as a raw material in production processes or other non-fuel purposes, otherwise known as *feedstock*.[18]

Manufacturers' Energy Problem. Given Ohio manufacturers' reliance on fossil fuel energy sources, organizations such as the Ohio Manufacturers' Association (OMA), have grown increasingly concerned about the availability and cost of energy, and the implications for manufacturing competitiveness. Historically, manufacturers treated energy largely as a fixed cost. This view has shifted due to several events, including the oil shocks of the 1970s, new air quality regulations in the 1990s, electricity deregulation in the 1990s and the problems that subsequently emerged (i.e., the electricity crisis in California) in wholesale electric power markets in the early 2000s.[19]

Concerns about the growing dependency on foreign energy (especially oil) sources—and increased competition for energy supplies, particularly from the rapidly growing emerging economies—have added a geopolitical dimension to the energy policy debate. Today, manufacturers face a far greater level of uncertainty regarding the supply of energy than ever before—such as high price volatility in energy markets resulting from severe weather, economic crises, and international political events.[20]

In recent years, efforts to curb GHG emissions added to the uncertainties regarding energy costs. As a result, business leaders began to call for greater clarity and certainty in government energy policies, at both the state and federal levels. For example, OMA argues that "[f]or manufacturers, ensured access to reliable, affordable energy—whatever its source—must be key to Ohio's comprehensive energy plan. Without it, the state's short- and long-term ability to grow its economy and create jobs will be threatened."[21] OMA therefore calls for Ohio lawmakers to place energy "at the top of their list of priorities" in addressing "the underlying pressures that make it difficult to manufacture in Ohio."[22]

OMA also recognizes that one of the most cost-effective approaches, with the greatest potential for addressing this challenge, is to increase *industrial energy efficiency* (IEE) throughout the manufacturing base. However, it further notes that even though many manufacturers "acknowledge that efficiency has many benefits, including reduced consumption that results in lower generation costs and a smaller carbon footprint," they face a number of barriers and difficulties in implementing efficiency measures within their plants.[23]

An IEE Roadmap. A purpose of this report is to provide Ohio manufacturers with a deeper understanding of the IEE challenge, and especially, the opportunities available to them for making significant energy savings in their facilities. The structure of the report is schematically represented in Figure 1 as a "roadmap." After defining the energy and IEE *problem* confronting manufacturers, the report discusses the *potential* for making energy efficiency gains in existing and future manufacturing facilities, the *barriers* that have made it difficult to achieve this potential, and the *opportunities* in both the public and private sectors for overcoming these barriers. These steps are briefly summarized below:

- **The IEE Problem—**Manufacturers need to understand how they can cost-effectively achieve energy efficiency gains in their facilities and production processes. By cutting their energy consumption they can lower their production costs and reduce carbon emissions. Yet, despite these and other benefits from reducing energy use and improving their operational efficiency, many manufacturers have not adopted IEE practices nor invested in IEE technologies.
- **The IEE Potential**—The literature contains considerable evidence that in most manufacturing industries there is substantial potential for achieving IEE gains, though this potential (and barriers, see below) can vary substantially across and within sectors.

Figure 1. Industrial Energy Efficiency Roadmap for Ohio Manufacturing

PROBLEM

Manufacturers need access to affordable, reliable energy—a key to competitiveness.

Key challenge: How can manufacturers achieve gains in *industrial energy efficiency* (IEE), lowering production costs and reducing their carbon footprints?

POTENTIAL

There remains large end-use IEE potential in manufacturing—the extent varies across and within industry sectors.

***Sector IEE Potentials*:**

- EITE sector—61%
- Non-EITE sector—39%

[McKinsey & Co.]

***Technology Potentials*:**

- Cross-cutting energy support systems (motors, buildings, steam systems)—33%
- Sector specific process steps—67%

[McKinsey & Co.]

Other Important IEE Technologies:

- Combined Heat and Power (CHP) and waste heat recovery systems

BARRIERS

Manufacturers need to make the business case for investing in IEE, needed to realize its potential.

***Internal Behavioral & Organizational Barriers*:**

- Lack of information and awareness
- Plant manager risk aversion
- High "hurdle rates" and rapid payback requirements
- High transaction costs
- Capital budget constraints
- Capital investment cycles (4-7 years or longer)
- Lack of technical expertise and trained workforce

External Technical & Economic Barriers:

- Capital availability
- New IEE technologies, processes & products

***SMM Barriers*:**

- More limited staff, time and financing
- Lack of information deters IEE decisions by SMM managers
- Greater difficulties in quantifying benefits
- SMMs pay more for and use energy less efficiently

OPPORTUNITIES

Company strategies and state and federal programs can help overcome barriers and achieve the IEE potential.

***Company Strategies*:**

- Energy management plans
- Energy auditing
- Plant and line-level performance goals and tracking
- Designated energy managers and personnel
- Workforce training and skill standards
- Targeted budget allocations

***Government Policies and Programs*:**

- Financial assistance (tax credits, grants, loan guarantees, utility public benefits funds and rebates)
  - ARRA State Energy Program (DOE, OAQDA) IEE grants
  - Ohio Energy Gateway Fund (ARRA, OBJSP)
  - OBJSP-Advanced Energy
  - Advanced Energy Fund (ODOD)
  - Manufacturers Energy Efficiency Program grants (ODOD)
  - Capital Access Program small business loans
  - Utility Rebate Program (PUCO, SB 221)—FirstEnergy, AEP, DP&L, AMP, Vectren
- Technical assistance:
  - Manufacturers Energy Efficiency Program services
  - DOE's IACs & Save Energy Now Program
  - EPA Energy STAR Partnership
  - Hollings MEP (NIST)
- Innovation and R&D:
  - DOE ITP
  - Ohio Third Frontier
- Workforce Development:
  - Ohio Investment in Training Grants
  - DOE ITP
  - DOL MSSC Green Production Module skill standards certification

LEGEND:

ARRA=American Recovery & Reinvestment Act of 2009
DOE=U.S. Department of Energy
DOL=U.S. Department of Labor
EITE=Energy-Intensive Trade-Exposed
EPA=Environmental Protection Agency
IACs=Industrial Assessment Centers
IEE=Industrial Energy Efficiency
ITP=Industrial Technology Program
MEP=Manufacturing Extension Partnership
MSSC=Manufacturing Skill Standards Council
NIST=National Institute of Standards & Technology
OAQDA=Ohio Air Quality Development Authority
OBJSP=Ohio Bipartisan Job Stimulus Plan
ODOD=Ohio Department of Development
PUCO=Public Utility Commission
SMM=Small and Medium-sized Manufacturers

- **IEE Barriers**—Despite the many benefits of IEE, a number of barriers and obstacles have typically caused manufacturers to under-invest in technologies and practices necessary to realize the IEE potential. Managers in manufacturing firms need to make a business case for making such investments. These barriers apply across the manufacturing sector, though they may vary in degree of importance for EITE and large non-energy-intensive ("non-EI") industries, and small- and medium-sized manufacturers ("SMMs"; defined as firms with gross annual sales below $100 million and fewer than 500 employees). They can take the form of *internal company behavioral and organizational barriers*, and *external economic and technical barriers*. Many SMMs, in addition, face special obstacles to making energy saving investments, related to their size, that larger firms might not have.
- **IEE Opportunities**—Both internal *company strategies* and *government programs and policies* are important for overcoming these barriers and enabling manufacturers to achieve their IEE potential.
  - *Company strategies* include initiatives and actions, involving plant managers and employees, which can help address and overcome many of the internal behavioral and organizational barriers to investing in IEE.
  - *Government policies and programs*—at both the federal and state level—can provide additional support to internal company strategies, as well as address external technical and economic barriers to investing in and implementing IEE measures: these include financial assistance, technical assistance, technology innovation and R&D programs, and workforce programs.

The development of this framework builds on the recently completed study, *Assuring Ohio's Competitiveness in a Carbon-Constrained World*, the product of collaboration between Ohio University and the Ohio State University ("OU-OSU report"). The project was funded by a grant awarded through the federal stimulus program, ARRA, and administered by the Ohio Department of Development (ODOD) in partnership with the Ohio Environmental Protection Agency (OEPA).[24] It especially draws on the findings of an analysis of the potential risks and opportunities for Ohio's manufacturing sector under climate and energy policies, produced by High Road Strategies, LLC of Arlington, VA, which is presented as Chapter Two in the OU-OSU report ("HRS/OU-OSU").[25]

In several places in the current report, findings of the HRS analysis in the OU-OSU report will be incorporated and expanded in the development of the IEE roadmap. In particular, the report will not only examine the IEE potential, barriers and opportunities for Ohio's EITE industries but also for non-EI manufacturers, and especially SMMs.

Industrial Energy Efficiency and Ohio Manufacturing

Industrial energy efficiency (IEE) refers to the amount of energy consumed in the production of a product. This includes the energy used for heat, mechanical power, and electricity used in production processes or in the operation of facilities (such as for heating, ventilation, air conditioning, heating and refrigeration) that house production activities. In some instances, it is used as feedstock in the making of products. A manufacturer can make IEE improvements in a number of ways, either by reducing the amount of energy needed in production processes, or the amount consumed by facilities, or more efficient use of energy feedstocks.

EITE and Non-EI manufacturers. Opportunities for making IEE gains, however, tend to vary greatly across the spectrum of manufacturing industries, reflecting wide variations in how energy is used in manufacturing activities. Generally, *EITE manufacturing industries* use substantially more energy, and in different ways, than *non-EI industries*. EITE manufacturers will usually consume fuels (such as natural gas, petroleum liquids) to provide process heat or purchased electricity for electricity-based processes, such as electrolysis, which non-EI manufacturers are not likely to require. EITE industries are also more likely to use energy feedstocks in their production (coke in iron and steelmaking, natural gas liquids or liquefied petroleum gas in petrochemical manufacturing).

As a result, EITE manufacturers historically have been much more concerned about maintaining access to a reliable supply of energy sources at low prices than non-EI firms. The former may have energy costs that amount to as much as 10 to 40 percent or more of their costs per unit of production. Some EITE industries' energy costs may in fact be greater than their labor costs, though in the large materials processing industries (iron and steel, aluminum, chemicals), material costs tend to be much larger than either labor or energy costs. In any event, in order to remain competitive, EITE industries, such as, say, iron and steel, have attempted to make steady gains in their IEE over the years, through investments in new equipment and technologies and energy-saving practices.

Non-EI industries' energy costs, on other hand, usually tend to be a much smaller share (under 5 percent or less, and perhaps much less) of overall production costs. As a result, these industries tend to make investing in IEE improvements a somewhat lower priority than EITE industries. Nevertheless, as the interviews Ohio manufacturers documented in Part 2 of this project suggest, many non-EI firms are interested, if not concerned, about energy costs as one factor in their overall cost structure that they try to control. In addition, even though total plant-wide energy use is relatively low, important production processes can be somewhat energy-intensive (e.g., machining, parts stamping, casting, paint drying shops in auto and other manufacturing plants).[26]

Energy-intensity levels. For example, the HRS/OU-OSU report estimated the energy intensity of selected industry sectors at the 6-digit NAICS level important to Ohio's economy, including both EITE and non-EI industries.[27] Comparing energy-intensity figures calculated as the ratio of the value of purchased energy fuels and electricity and total *production costs* (materials, payroll, and capital expenditures)—drawing on data from the Census Bureau's *Annual Survey of Manufactures* (ASM), *Statistics for Industry Groups and Industries*—the most energy-intensive industries not surprisingly show the highest ratios, almost all over 5 percent and most in double digits (2008)—e.g., primary aluminum (23 percent), cement (21 percent), lime (25 percent), paper mills (12 percent), and all other basic inorganic chemicals (13 percent), etc.

It is important to note that iron and steel mills and ferroalloy products and petroleum refineries, both show much smaller energy-intensive levels by this measure—7 percent and 2 percent, respectively, in 2008. However, feedstock energy sources (coal and coke, and crude oil, respectively) represent a large share of these industries' production costs, included as material costs in the ASM data, but not as purchased energy costs. Thus the energy-intensity numbers for these industries are misleading—if feedstock energy were factored in, the energy-intensity indicators would be much higher for both.[28]

On the other hand, for several other major industries in Ohio known to be non-EI, the energy-intensity levels are less than 5 percent, and many somewhat less—e.g., automobile manufacturing (0.5 percent), turbine and turbine generator set units (1 percent), industrial trucks tractors, trailers and stacker machinery (1 percent), coated and laminated paper manufacturing (3 percent), and breweries (4 percent). In contrast to the EITE industries, energy-intensity calculations based on purchased energy costs as share of value added, also are low for these industries, indicating that energy costs are somewhat smaller relative to labor and capital expenditures.

Nevertheless, large non-EI facilities, such as a large auto manufacturing plants, may still be large consumers of energy. And as noted above, some operations within such facilities may be energy-intensive relative to most of the plants' other operations. The HRS/OU-OSU report, drawing on the emissions inventory developed for the OU-OSU project, showed that certain non-EI industries were nevertheless relatively large GHG-emitters—reflecting consumption of fossil fuels for heat, power and production processes, as well as users of purchased electricity. For example, automobile manufacturing ranked 15th (501 thousand metric tons of CO_2-equivalent emissions) out of over 140 industries in the emissions inventory database. The other non-EI industries mentioned above, and several others, all are in the top thirty emitting industries. Plant owners in these industries therefore would be sensitive to any volatility in energy prices, especially if associated with a climate policy. Consequently, they would have an incentive to make IEE improvements to get these costs down.

Establishment size variations. The potential, barriers and opportunities for IEE gains vary not only depending on the degree of energy-intensiveness of industries, but also on their scale of operations. Large EITE manufacturers have different potentials, constraints and opportunities available to them than non-EI industries, and small or medium-sized firms face a different IEE terrain than larger facilities, regardless of their energy-intensity. Table I provides a broad view of the 3-digit industry sectors in Ohio, showing their economic characteristics (shipments, value added, employment) and establishment sizes and numbers.[29] The industry sectors are ranked by the value of their shipments. The sectors in bold include major EITE industries, though not all industries in them are energy-intensive. In total, Ohio has over 16,000 manufacturing establishments, of which a little under 200, or 1 percent, are large facilities with 500 or more employees; 1,500 or 9 percent or are medium-sized plants (100-499 employees); and, 14,500 or 89 percent are small facilities, with under 100 employees, most of which employ less 20 workers.

Transportation equipment manufacturing is by far the largest industry in Ohio in terms of shipments, twice that of the next largest, primary metals. The former includes the state's large auto-related manufacturing cluster, as well as smaller but still important aerospace manufacturing facilities. Primary metals include the iron and steel and ferroalloys—the state's largest EITE industry and greatest GHG emitter—and the aluminum and non-ferrous metals manufacturing sectors, which also includes energy-intensive primary aluminum industry.

Transportation equipment manufacturing tops the state in the number of large facilities (500 or over employees), but is second to the fabricated metal products sector in the number of mid-sized manufacturers (100-499 employees). The latter, by far, leads the state in total number of number of small plants (less than 100 employees)—and in the number of plants with less than 20 employees (mostly machine shops). Chemicals, food, machinery, and plastics and rubber products also have relatively large numbers of large and/or medium-sized establishments.

Table I. Ohio Manufacturing Sectors: Establishments and Economic Characteristics

3-Digit NAICS	Manufacturing Industry	Number of Establishments* (sizes in number of employees)				Industry Economic Characteristics (2008)**		
		All	Large (500+)	Mid-sized (100-499)	Small <100	Value of shipments ($ billion)	Value added ($ billion)	Number of employees (1,000)
336	Transportation equipment	752	56	206	490	67.10	22.60	113.8
331	**Primary metals**	**438**	**18**	**91**	**329**	**32.35**	**10.26**	**45.2**
332	Fabricated metal products	3,993	20	246	3,727	31.45	16.40	119.2
325	**Chemicals**	**722**	**9**	**98**	**615**	**30.27**	**15.09**	**38.2**
311	**Food**	**913**	**20**	**109**	**784**	**25.21**	**11.07**	**51.9**
324	**Petroleum & coal products**	**162**	**2**	**8**	**152**	**23.22**	**2.02**	**4.9**
333	Machinery	1,893	15	165	1,713	20.03	9.91	76.3
326	Plastics & rubber products	1,041	14	190	837	17.09	7.25	70.6
335	Electrical eq., appliance, & comp.	335	9	56	270	9.96	4.82	31.0
334	Computer & electronic prod.	453	9	50	394	7.88	4.79	23.1
322	**Paper**	**333**	**2**	**74**	**257**	**7.78**	**3.34**	**21.8**
327	**Nonmetallic mineral prod.**	**788**	**5**	**51**	**732**	**5.79**	**3.20**	**24.3**
339	Miscellaneous	1,152	5	48	1,099	4.84	2.97	25.7
323	Printing & related support activities	1,412	5	60	1,347	4.61	2.78	28.8
337	Furniture & related products	730	5	16	709	3.70	1.99	20.8
312	Beverage & tobacco products	80	3	7	70	3.62	1.70	3.8
321	Wood product	666	1	17	648	2.35	1.05	14.3
314	Textile product mills	204	0	8	196	0.51	0.26	2.9
313	Textile mills	64	0	6	58	0.36	0.13	1.6
315	Apparel	74	0	4	70	0.26	0.14	1.3
316	Leather & allied product	28	1	2	25	0.16	0.08	1.3
	Total Ohio Manufacturing	**16,233**	**199**	**1,512**	**14,522**	**298.54**	**121.85**	**720.78**

** Census Bureau, Economic Census 2007 ** Census Bureau, ASM 2008.*

Table II provides a more disaggregated view (6-digit NAICS) of Ohio's main manufacturing industries. The table is based on the top 15 GHG-emitters in the state according to the emissions inventory developed through the OU-OSU-report. All but three of the industries—all in the bottom third of the table—meet the criteria of an EITE industry. Leading the group is iron and steel and ferroalloy products, with the largest value of shipments (at least, of those industries for which the value is disclosed) and employment. It also has the second largest number of large (on the list and also in the state), and medium-sized plants.

Automobile manufacturing, which is a non-EI industry, probably has a value of shipments comparable to that of the iron and steel industry.[30] It has fewer establishments, but at least half are large or medium-sized facilities. The other two non-EI industries on the list—all other plastic products and other miscellaneous chemical products—are dominated by small manufacturing establishments. The former industry nevertheless also has the largest number of large establishments and medium-sized establishments on the list—and in the state.[31]

Table II. Top GHG-Emitting Ohio Industries (6-digit NAICS): Establishments and Economic Characteristics

Manufacturing Industry	NAICS	Tot Emis. Rank (Tot.)	No. of Estab.	No. Estab. 500+ Empl..	No. Estab. 100-499 Empl.	No. Estab. <100 Empl.	No. Empl. (1,000)	Value of Shipments ($ billion)	Value Added ($ billion)
Iron and Steel Mills & Ferroalloys	**33111**	*1*	53	8	20	25	16.5	14.6	9.6
Petroleum Refineries	**324110**	*2*	4	2	2	0	1.8	12.5	2.3
Lime	**327410**	*3*	9	0	1	8	0.4	D	D
Primary Aluminum	**331312**	*4*	5	1	1	3	1.3	D	0.1
Paper (except Newsprint) Mills	**322121**	*5*	10	2	5	3	3.3	1.3	0.7
Plastics Material and Resins	**325211**	*6*	83	0	16	67	5.1	D	1.3
Nitrogenous Fertilizer	**325311**	*7*	4	0	2	2	0.4	0.3	0.1
All Other Basic Inorganic Chemicals	**325188**	*8*	35	0	1	34	1.0	0.5	0.2
Cement	**327310**	*9*	11	0	1	10	0.3	0.2	0.1
All Other Basic Organic Chemicals	**325199**	*10*	43	0	9	34	2.9	D	D
All Other Plastic Products	326199	*11*	506	9	98	399	37.0	7.6	3.8
Iron Foundries	**331511**	*12*	40	2	9	29	5.0	1.2	0.5
Paperboard Mills	**322130**	*13*	12	0	3	9	1.0-2.5	D	D
Automobiles	336111	*14*	13	3	4	6	11.8	D	D
Other Misc. Chemical Products	325998	*15*	79	0	3	76	2.0	1.1	0.5
SUBTOTAL TOP 15 GHG-EMITTING INDUSTRIES:			*907*	*27*	*175*	*705*			
TOTAL OH MANUFACTURING:	**31-33**		**16,233**	**199**	**1,512**	**14,522**			

Sources: HRS/OU-OSU 2011; Census Bureau, 2007 Economic Census and ASM 2008.

In short, the structure of the industries in Ohio is very heterogeneous. It is worth noting though that, in aggregate, the EITE industries on the list appear to lean towards large and medium-sized establishments—the EITE industries account for 8 percent of the 199 large manufacturing establishments reported in Ohio in the 2007 economic census, but only 2 percent of small establishments. Nevertheless, the majority of the EITE industries on the list, including primary aluminum, plastics material and resins, cement, lime, iron foundries, paperboard, all other basic organic and inorganic chemicals, have a large number of small and medium-sized establishments, as well.[32]

SMMs. SMMs account for 99 percent of all manufacturing establishments in Ohio, while large facilities with over 500 employees account for 1 percent of the total number of establishments. This is very close to the pattern for the nation—that is, Ohio does not have a disproportionate number of small and medium-sized firms compared to the U.S. as a whole. In any case, despite their small numbers, large plants account for roughly one-third percent of all jobs in manufacturing, while SMMs account for about two-thirds.[33] As seen, Ohio's substantial

EITE sector has both a relatively large share of the state's large manufacturing establishments and numerous SMMs.

EITE SMMs and non-EI SMMS may differ along the same lines as their larger counterparts in terms of their IEE potentials, barriers and opportunities. The EITE SMMs' energy costs remain a somewhat greater concern than for non-EI SMMs, and therefore have more incentive to explore IEE opportunities. At the same time, there are areas where they have similar concerns, such as regarding access to affordable, reliable supplies of energy. SMMs usually cannot make the same kinds of large-scale, long-term purchase agreements with energy providers, such as electric utility companies, as large firms. They usually lack the staff, time, and resources needed to negotiate and manage such deals. And they may have other characteristics, constraints and limitations related to their size that normally do not apply to large facilities. Consequently, the interest, potential and opportunities for making IEE gains among Ohio's manufacturers could vary considerably depending on how energy-intensive and how large they are.

The IEE Potential

A number of the most energy-intensive industries in the United States have made significant strides in reducing their energy costs and improving their energy-efficiency over the past few decades. For example, the U.S. steel industry reportedly has decreased the energy it consumes to produce one ton of steel by 29 percent since 1990.[34] Alcoa, the world's largest aluminum company, recently reported that it has beaten its carbon reduction goal a decade early. It lowered its 2010 greenhouse emissions to 22 percent below 2005 levels, and reduced its carbon intensity to seven points below 2009 levels. The reductions are a result of energy efficiency improvements, as well as from repositioning operations to benefit from hydroelectric power, and other changes.[35]

Despite these gains, several analyses show that U.S. manufacturers lag in their energy-efficiency achievements compared to many of their international trading partners. For example, the National Academy of Sciences (NAS) in its 2010 study, *Real Prospects for Energy Efficiency in the United States*, reported that in 2005, the U.S. steel industry still had a higher energy-intensity than that of Korea, Germany and Japan,[36] and that the America's cement industry is among the least efficient in the world—it uses 80 percent more energy to produce "clinker" (the main component of cement) than the world leader Japan.[37] Similarly, the International Energy Agency (IEA) reports that the U.S. pulp and paper sector lagged behind Germany, France, Italy, Sweden and several other countries in its electrical energy efficiency, and the U.S. chemical manufacturing sector is well behind Germany, [38] Japan, France, India, Brazil, and China in achieving its energy efficiency potential.[39]

That U.S. manufacturing lags other developed nations in IEE is not that surprising, since the latter generally have to contend with significantly higher energy prices and more stringent environmental regulations. However, even several major developing countries, such as China and India are expanding their commitments to energy efficiency and conservation, largely in response to concerns about shortages in energy supplies needed to fuel their rapidly growing economies. Thus, U.S. manufacturers might have reason to worry about the potential implications of competing with nations that already benefit from many competitive advantages relative to the United States and other developed economies—low labor costs, lax environmental and labor regulations, government subsidies, non-tariff trade barriers, currency manipulation, and the like—also becoming more energy-efficient.

Measuring the potential. The IEE lag between the United States and its international competitors underscores the potential that exists for making efficiency improvements. The NAS study and the IEA report, *Tracking Industrial Energy Efficiency and CO_2 Emissions,* have estimated both the global and U.S. potentials for improving manufacturing energy efficiency. The IEA analysis suggests an overall global energy-savings potential of 18-26 percent. Japan and Korea lead the world with the highest levels of IEE potential, followed by Europe and North America. The largest percentage savings would come from petroleum refining, pulp and paper, iron and steel, cement, and chemical manufacturing.[40] For example, the total energy and feedstock savings potential was estimated to be 28-33 percent for cement, 13-16 percent for chemicals/petrochemicals, 9-18 percent for iron and steel, 15-18 percent for pulp and paper, 6-8 percent for aluminum, and 13-25 percent for other non-ferrous metals and minerals.[41]

Independent studies using different approaches reviewed by the NAS study found that the economic potential for improving IEE is large. The NAS concluded that of the 34.3 quads of energy that U.S. industry is forecasted to consume by 2020, 14-22 percent or 4.9-7.7 quads could be saved through "cost-effective energy efficiency improvements (those with an internal rate of return of at least 10 percent or that exceed a company's cost of capital by a risk premium)."[42] However, the report also notes that because U.S. industry has experienced a large shift to offshore manufacturing of components and products, if the net energy embodied in imports and exports are considered, the total energy consumption by U.S. industry would increase by 5 quads.[43]

The NAS also reports on assessments of the economic potential for IEE improvements conducted in two states—New York and California. An assessment of the electric and gas energy efficiency potential in existing industrial facilities in four California utility areas, by the year 2016, estimated a 15.1 percent reduction in electricity use and a 13 percent cut in natural gas use could be achieved by cost-competitive energy efficiency investments. Similarly, a 2003 New York Energy Research and Development Authority (NYSERDA)-sponsored assessment estimated that 15 percent of the electricity base projected for 2022 could be displaced by cost-competitive electricity-efficiency measures.[44]

The American Council for an Energy-Efficient Economy (ACEEE) also has done a series of state energy-efficiency studies, including one for Ohio. The ACEEE report evaluating energy-saving opportunities for Ohio identified a diverse set of efficiency measures that could yield a potential total economic electric savings for industry of 16 percent, plus an additional economic savings of 5 to 10 percent for process-specific efficiency measures, primarily in large energy-intensive facilities. This would result in an overall industrial efficiency resource opportunity for electricity between 21-26 percent.[45]

Sectoral variations in potential. A number of studies performed under Department of Energy (DOE) auspices, as part of its now defunct Industries of the Future program, estimated the "theoretical potential for efficiency reductions," based on the thermodynamic characteristics of production processes of several EITE industries. They also attempted to measure the "technical" potential for efficiency reductions energy based on what might be doable and though not necessarily cost-effective in the real world.[46] These and many other analytical studies demonstrate that potential gains in IEE are plentiful throughout the nation's industrial sector. However, this potential will vary greatly depending on the industry and plant, as many opportunities are tied to specific locations and production processes.

In particular, the size and nature of IEE gains will depend on the kinds and scale of manufacturers, and the technologies and processes employed within a manufacturing industry. McKinsey & Company estimates that as much as 61 percent of energy savings potential resides within the EITE sector, in the United States.[47] This is not surprising, since energy accounts for a major portion of EITE industries' costs. Even small IEE improvements can yield large savings in energy costs.[48] Programs such as the DOE's IACs and some notable state programs[49] indicate that a 10 percent energy consumption cut is possible at these facilities with limited effort, and greater gains are possible with additional effort and investment.[50]

At the same time, about 31 percent of the IEE potential in U.S. manufacturing lies within the non-EI sector. Even though energy represents a much smaller part of the production cost structure of large non-EI industries (auto manufacturing, fabricated metal products, machinery), important energy cost savings are achievable, if only because of the scale of their operations. But the savings will largely be found in measures and technologies that are "low-hanging fruit," tied to more ubiquitous plant operations and production processes, rather than process-specific measures that apply to a single industry (e.g., pulping and bleaching in pulp and paper, clinker production in cement, and secondary hot rolling in iron and steel).[51]

SMMs, both EITE and non-EI, also have significant unrealized efficiency gains. The ACEEE notes that relative IEE potential of smaller industrial plants may actually be larger relative to that of larger facilities because they have not yet taken advantage of many of the efficiency opportunities that larger facilities may already have implemented. ACEEE notes that an assessment of the Department of Energy's (DOE) Industrial Assessment Centers (IAC) program, located at 26 universities across the country, corroborates savings projections for SMMs. ACEEE's review of the data indicates that SMMs participating in the IAC program have realized on average $30,000 annually in energy savings and $30,000 in waste and productivity savings, totaling $60,000 per assessment, with replication and long-term implementation support adding an additional $15,000.[52] As discussed below, this potential derives from the limited capabilities SMMs historically have had in being able to introduce energy saving measures.

IEE technologies and processes. The IEE potential of manufacturers reflects the technologies and processes they employ in their production. Many of these were reviewed in the earlier OU-OSU report. Table III replicates a table in that study illustrating the full-range of technology areas representing IEE opportunities cutting across manufacturing sectors and specific to selected EITE industries.

- *Cross-cutting energy support systems* are not central to a plant's production process, but can be applied in multiple industry sectors and processes—tailored to specific purposes they are applied to. They can be used in EITE and non-EI industries alike. McKinsey estimates that 33 percent of the efficiency opportunities in U.S. manufacturing can come from improvements in these systems. Cross-cutting energy support systems include a range of ubiquitous technologies used in industry, including motor systems, steam systems (steam generation (boilers), distribution, and condensate-recovery systems) and buildings (HVAC, lighting, building shells).[53]

Table III. Industrial Energy-Efficiency Technology Options

INDUSTRY	PROCESS-SPECIFIC TECHNOLOGIES	EMERGING TECHNOLOGIES
Iron & Steel and Ferroalloy Products	• Pulverized coal and natural gas injection • Direct smelting—eliminating coke oven • Thin slab casting • EAF—oxy-fuel burners • DC-arc furnace • Scrap preheating • Improved blast furnace controls	• Paired straight hearth furnace • Molten oxide electrolysis • Hydrogen flash melting
Petroleum Refineries	• Improved separation efficiency for distillation • Advanced separation technology • Improved pre-heater efficiency • Improved catalyst efficiency • Convert condensing turbine to electric motor drive	• Alternative hyrdotreater and desalter designs • Progressive distillation design
Chemicals	• Improved efficiency of cold fractionation and refrigeration systems • Improved "cracking" processes and transfer line exchangers	• High temperature furnaces • Gas-turbine integration • Advanced distillation columns • Biomass-based systems
Pulp and Paper	• Cradle and dry debarking • Automated chip handling and thickness screening technology • Improving digester efficiency • Chemical recovery boilers that generate steam • Heat chlorine dioxide with waste heat • Advanced dryer control systems • Optimize water removal in forming and pressing	• Black liquor gasification • Advanced dryer technologies (impulse, gas-fired, multi-port)
Cement	• High efficiency roller mills and classifiers • Replace energy-intensive-"clinker" with fly ash, slag, or other mineral components • Switch from older, less efficient "wet process" • State-of-the-art dry processing • Improve efficiency of "finishing grinding"	• Oxy-combustion for CCS • Alternative fuels-biomass • Pre-combustion membranes • Superheated Calcium Oxide (Cao)

CROSS-CUTTING TECHNOLOGIES & PRACTICES	MAJOR CROSS-CUTTING TECHNOLOGIES
• Energy monitoring and management systems • Variable speed drives for pumps and fans • Preventative maintenance • Improved process control • Improved efficiency of boilers, heaters, turbines, conveyors, furnaces, and motors • Facility-wide opportunities (lighting, HVAC) • Insulation for steam distribution systems and boilers	• High efficiency motor systems • Combined Heat and Power (CHP)/Cogeneration • Waste heat recovery • Materials recycling • Carbon capture and storage (CCS) (Long-term)

Sources: McKinsey & Co., "Pathways"; Yudken and Bassi, *Climate Policy and Energy-Intensive Manufacturing;* EDF, *Think U.S. Industry Can't Be More Competitive;* McKinsey, *Unlocking;* EPA "whitepapers," http://www.epa.gov/nsr/ghgpermitting.html. ACEEE, *Shaping Ohio's Energy Future.*

- *Motor-driven systems* (pumps, fans, air compressors, motor-driven industrial process systems) alone represent 65 percent of total energy consumption in industry. Efficiency improvements such as matching component size with load, using speed controls, and improving maintenance represent 77 of the potential gains possible in the use of motors.[54] The ACEEE estimates that the share of industrial electricity consumed in Ohio in 2008 by motors was 57 percent—13 percent for material processing, 12 percent for material handling, 10 percent for pumps, 8 percent for compressed air, 7 percent for fans and blowers, 4 percent for refrigeration, and 1 percent for other motors.[55]

- *Combined heat and power* (CHP) systems are especially promising as means for achieving sizable energy savings in both EITE and non-EI industries. CHP systems employ the heat byproduct of electric generation units to provide heat used in other processes in a facility. CHP units can achieve efficiencies of 85-90 percent about three times the efficiency of electric-generation-only units. The chemical and iron sectors together employ 47 percent of the total CHP potential in the nation, due to their large steam energy needs.[56] Table IV identifies 27 CHP units in Ohio used in a wide-range of manufacturing plants with a total generation capacity of 648 MW, the first placed into operation in 1928. Pulp and paper, chemicals and primary metals have the largest number of units.[57] Recycled Energy Development (RED) estimates that in the petroleum, chemicals, pulp and paper, and ethanol industries, the thermal load requirements at just a few of the largest facilities could be optimized to generate between 850-2,000 MW of electricity.[58]

Table IV. Combined Heat and Power Units in Ohio Manufacturing

Industry	No. of Units	Op Year	Prime Movers	Fuel Type	Capacity (kw)	Percent Manuf.
Misc. Manf.	1	1988	BS/T	Coal	200,000	30.9%
Pulp and Paper	7	1928-2009	B/ST(6), CT	Coal(5), NG(2)	191,730	29.6%
Primary Metals	4	1934-2000	B/ST(3), ERENG	NG(2), Waste(2)	102,050	15.8%
Refining	2	1986, 2008	OTR, B/ST	Waste	52,000	8.0%
Chemicals	6	1960-2001	B/ST(3), ERENG(2), CT	Coal(3), NG(3)	47,425	7.3%
Rubber/Plastics	2	1953-1997	B/ST(1), ERENG(1)	Coal, NG	41,900	6.5%
Wood Products	2	1972-1993	B/ST(2)	Wood	10,900	1.7%
Furniture	1	1988	BS/T	Wood	1,000	0.2%
Machinery	1	1987	ERENG	NG	700	0.1%
Transportation Eqmt.	1	1990	ERENG	NG	75	0.0%
Total Manufacturing	**27**	**—**	**—**	**—**	**647,780**	**100.0%**

Source: U.S. Department of Energy, Energy-Efficiency Association (now ICF Intl.); http://www.eea-inc.com/chpdata/States/OH.html

CODES

Prime Mover Code	Description	Fuel Code	Description
B/ST	Boiler/Steam Turbine	Coal	Coal
CT	Combustion Turbine	NG	Natural Gas, Propane
ERENG	Reciprocating Engine	Waste	Waste, Waste Heat, MSW, Black Liquor, Blast Furnace Gas, Petroleum Coke, Process Gas
OTR	Other	Wood	Wood, Wood Waste

- *Waste heat recovery systems* entails extracting useful energy from the waste streams released by industrial processes, which can be used to generate additional electric power or in other thermal processes. Heat recovery steam generators allow the gases to contact water circulating in tubes, converting water to steam, which then can be used to generate additional electric power or used in another thermal process. RED estimates a potential generation of 50-200 MW at several integrated steel mills in Ohio capturing waste heat from coke oven batteries and blast furnace operations to generate electric power and process steam, without any increase in fuel usage. It also identifies waste recovery opportunities at several steel mini-mill and glass facilities in Ohio.[59]

- *Process-specific measures* include energy-efficiency and carbon abatement improvements of existing equipment, processes, and practices, and the retrofitting or replacement of old equipment, by new, more energy-efficient, low carbon equipment specific to an industry. For example, pulverized coal and natural gas injection, which can more efficiently smelt iron ore, eliminate the need for highly energy- and emissions-intensive coke ovens. These can be applied in both EITE and non-EI sectors, and by both large and small firms.[60]
- *Emerging technologies* are advanced production technologies that may not yet be technically and commercially available or ready to be used at a commercial scale for many years, but hold the promise of substantial energy efficiency gains in the future. These may include breakthrough or transformational technologies involving substantial modification of existing equipment or introduce new technologies that replace older methods of production.[61] A number of references identify a emerging technologies that could result in significant gains for EITE industries. In many industries, research and development is currently underway, and some already are in the demonstration phase.[62]

IEE Barriers—Making the Business Case

Despite the potential for achieving significant IEE gains throughout the manufacturing sector, manufacturers confront a number of barriers that can prevent them from actually realizing this potential. These include *internal behavioral and organizational barriers* that make it difficult for managers to identify, plan, design, justify investments in and implement energy saving measures. They also include *external technical and economic barriers* arising at least in part from factors and conditions in the larger economy. Many of these barriers have also been examined in the earlier OU-OSU report and therefore will only be touched on briefly below. In any event, these barriers must be addressed in any effort to make the *business case* for making IEE investments in a manufacturing facility.

- *Internal behavioral and organizational barriers* refer to inherent factors within the operation of manufacturing facilities that limit the ability of managers to appreciate the importance of IEE measures, much less justify expending scarce company resources on energy projects that compete with other non-energy projects.[63] These include:
  - Plant managers' lack of information and awareness about investment options and the benefits of IEE, which may also deepen their existing aversion to making perceived "risky" new IEE investments;
  - Elevated "hurdle rates" and rapid payback requirements to justify energy-related, as opposed to production-related, investments;
  - High transaction costs associated with introducing new technologies and procedures;
  - Capital budget allocation constraints, and the capital investment cycles (4 to 7 years, or longer) for manufacturing facilities that can affect the timing when new equipment investments can be justified within a company;
  - The lack of internal technical expertise and an adequately trained workforce with knowledge and skills associated with identifying and implementing IEE opportunities

within a firm can also hinder or discourage managers from investing in and introducing new IEE technologies or practices.

- *External technical and economic barriers* may relate to internal company characteristics and behavior, but are affected by factors in the larger economy that may largely be out of their control.
  - *Capital availability* is probably the largest single concern of managers in determining whether or not to make new IEE investments, though it is directly tied to internal factors such as financial hurdle rates and payback requirements.[64]
  - The availability of *new technologies, processes and products* that can be introduced into manufacturing usually involves investments in R&D and commercialization, as well as the development of industry-wide energy-efficiency standards for new equipment. External agencies, both public and private, are often needed to support such initiatives.[65]

Although these barriers apply generally to both large-EITE and non-EI manufacturers, as well as to SMMs—there are sector-specific barriers that also need to be considered. That is, EITE firms face different constraints than non-EI manufacturers, and SMMs confront some unique obstacles that large plants do not.

- *EITE barriers to IEE investments*—Most EITE manufacturers have been investing for years in technologies and measures aimed at reducing energy use and costs. There still may remain many incremental low-cost/no-cost opportunities possible in this sector, including opportunities to introduce CHP and waste heat recovery systems in some of the most energy-intensive industries. However, some EITE industry experts question whether more significant longer-term gains can be made without substantial new investments in next generation process technologies.[66] These include the emerging technologies shown in table III that require further investments in research, development, demonstration and commercialization, before they become economically viable.
- *Non-EI barriers*—Large non-EI manufacturers have much smaller incentives than EITE manufacturers to reduce their energy consumption. The internal and external barriers to IEE investments are likely to weigh more heavily within the non-EI sector, and their investment hurdle rates are higher than might exist within EITE firms. But as the price of natural gas, petroleum liquids and electricity rise or become volatile—which has occurred over the past decade—non-EI managers may be more likely to explore ways to reduce their energy costs.
- *SMM barriers*—Smaller manufacturers confront a number of limitations that larger firms tend not to have. For example, the ACEEE reports that many small plants lack the capacity to identify and implement opportunities to save energy because their staff must deal with a broad range of issues and therefore have limited time and resources to focus solely on energy issues. They also often have to pay higher prices for energy and use energy less efficiently than large companies: they usually do not quality for large volume discounts available to larger firms—i.e., they lack the economies of scale to negotiate advantageous utility rates that large firms do, and may not have the choice of where to purchase energy; they often used less efficient equipment and processes; and they lack the access to capital and technical skills available to larger firms to carry out IEE improvements.[67]

Overcoming the Barriers to IEE

To address the barriers confronting businesses will require a combination of actions on their part and a public policy environment that encourages and enables them to invest in cost-effective IEE technologies and practices. The improvements in manufacturing competitiveness that would result from such as strategy would spur economic growth and create good jobs in Ohio's economy, while also substantially reducing carbon emissions. That is, what is being suggested here is a private-public partnership that achieves enduring gains in both business bottom-lines and environmental sustainability.

Business strategies for IEE. Companies will need to undertake cultural, behavioral and organizational changes if they want to benefit from the opportunities associated with reducing their energy costs and lowering their carbon footprints. Large, enduring gains can be made even through making incremental improvements in their business operations, though for some industries, long-term improvements will require investments in more advanced, next generation process technologies. However, even here, if manufacturers pursue a strategy of continual improvements in their industrial energy efficiency, they will be better positioned over time to make such investments—albeit, as discussed below, some programs and policies to assist them in these efforts may be needed and warranted.

For example, McKinsey & Company advises that "strong company-wide energy-management practices supported by a part-time or full-time on-site energy manager have proven effective in achieving greater energy efficiency" in business enterprises.[68] It further calls for companies to implement process and support system measures that improve monitoring and control of production processes, improve operating practices, and assure timely repair and regular maintenance of production equipment, which would also improve efficiencies in their operations.[69]

The most effective strategies however do not entail piecemeal actions. Experts emphasize the need for businesses to undertake an integrated, comprehensive approach, which might include the following elements:

- *Energy management plan and system*—Just as many businesses have adopted environmental management systems to guide their efforts to comply with federal, state and local environmental regulations, manufacturers should develop similar plans to guide and implement effective industrial energy efficiency measures within their organizations. It should have a top-level, multi-year planning horizon, and establish an internal organizational management structure that would be responsible for paying attention to and advocating for IEE opportunities within a firm or facility.[70]
- *Energy auditing and monitoring*—The energy management plan should prioritize conducting energy audits and developing internal mechanisms for monitoring energy use throughout organizations and facilities. The audits provide baselines for performing feasibility analyses on industrial facilities as a way to determine the benefits of energy efficiency improvements. They can reveal cost-effective opportunities that would otherwise be overlooked.[71]
- *Plant and line-level performance goals and tracking*—Manufacturers' energy plans should establish clearly defined performance goals that should be set at both the plant and shop-floor levels, especially linked to production activities. The audits and feasibility analyses can help establish these goals, and monitoring mechanisms would help managers and employees keep track on how efficiency measures are doing.[72]

- *Designated energy managers and personnel*—Designating accountable, knowledgeable energy managers and champions within organizations is an essential requirement for enabling the success of energy management plans.[73]
- *Workforce training*—Involving mid-level managers, engineering personnel and frontline employees would greatly help in ensuring the successful design and implementation of energy management systems on a day-to-day basis. Training internal personnel in the goals and objectives of such a program, and the knowledge and skills required to participate effectively in all relevant aspects of the program, therefore would be essential.[74]
- *Targeted and prioritized budget allocations*—Company executives and plant managers should prioritize end-use energy efficiency measures as at least equal to other O&M and production process investments as they develop their operational budgets. Budgeting should recognize that IEE projects could greatly improve firms' bottom-lines. Conducting life-cycle analyses would build in longer time horizons for evaluating the payback from IEE investments—i.e., reducing the "hurdle rate"—as well as take into account ancillary benefits, such as the health and safety of their employees and the gains for the community from reducing their energy use and carbon-footprints.

Government IEE programs and policies. Despite the well-documented benefits to businesses that embrace IEE strategies—and the existence of genuine success stories, e.g., Flambeau River Papers—the economic environment manufacturers operate within, both historically and at present, has not been especially conducive to encouraging them to invest in IEE improvements in their facilities. SMMs especially have limited capabilities to adopt the kind of strategy outlined above. Manufacturers do have a strong incentive to adopt environmental management systems and invest accordingly, because of their need to comply with government regulations. No such "incentives" exist to encourage comparable actions in industrial energy efficiency—though climate change mitigation policies and potentially, EPA GHG emissions measures could provide such an impetus. Manufacturers must instead look to making reductions in their costs and improving their bottom-lines as sufficient incentives for adopting IEE strategies.

Nonetheless, there are a number of good programs and policies at the federal level and in Ohio that can provide assistance to manufacturers desiring to adopt IEE strategies and invest in IEE measures. SMMs can especially benefit from such programs, which help them overcome the lack of internal resources needed to make IEE improvements. The most important of these measures are outlined below. Consideration should be given, however, to strengthening and expanding these programs, to more broadly disseminating information about how these programs can help, and ensuring manufacturers easy access to them.

- *Financial assistance programs and policies* include tax credits, grants, loan guarantees, and utility-administered public benefit funds and rebate programs, provided to manufacturers to introduce IEE technologies and measures. Relevant programs include:
  - <u>American Recovery and Reinvestment Act (ARRA) State Energy Program</u> (U.S. Department of Energy (DOE))— Administered in partnership with the Ohio Air Quality Development Authority (OAQDA), this stimulus supported initiative provides industrial efficiency grants, as well as renewable energy generation projects. In 2009, ARRA/SEP allocated $96 million to Ohio, for five areas of focus for investment, including energy efficiency improvements for manufacturers. The program has finished accepting solicitations and most of the current funds have been awarded.[75]

- *Ohio Energy Efficiency Program for Manufacturers*—Administered by Ohio Department of Development's (ODOD) Ohio Energy Resources Division, this is a multi-phase energy efficiency program that provides facilitation services and financial assistance to Ohio manufacturers to diagnose, plan, and implement cost-effective energy improvements at their facilities. In the first phase, a company will follow a structured process with a facilitator to examine how it thinks about energy and identify opportunities to achieve sustainable energy cost savings. The facilitator then provides a technical assessment and plan to increase the energy efficiency of the facility. Companies that decide to move forward are eligible to receive a grant for 50 percent of project costs, up to $15,000. Companies may then be eligible to receive grant funding to implement energy efficiency measures identified in the technical assessment.[76]
- *Ohio Advanced Energy Fund* (AEF)—Administered by ODOD, the AEF provides grants in support of renewable energy and energy efficiency projects in the industrial, commercial, agricultural, public, and residential sectors. Since its inception in 1999, the AEF has provided almost $41 million in grants. Of the 599 projects funded by the AEF, 67 were industrial projects rather than residential, commercial, or institutional. The AEF was originally funded at $5 million per year collected through a rider (Public Benefits Fund) on customers' bills from Ohio's Investor Owned Electric Utilities. The rider ran out December 31, 2010, and has not been renewed. Due to its now limited funding, AEF projects no longer will be funded at the same levels. Details about its new programs are scheduled to be released in the fall of 2011.[77]
- *Ohio Bipartisan Job Stimulus* Program (Advanced Energy Program)—This bond-funded program creates an Advanced Energy Job Stimulus Fund administered through a public process managed by OAQDA. It provides $150 million over three years, in awards ranging from $50,000 to $2 million, to increase the development, production and use of advanced energy technologies in the state. Most of the grants have been for renewable energy or clean-coal projects, though CHP/co-generation projects are eligible.[78]
- *Ohio Energy Gateway Fund*—An equity fund created through a public-private partnership, with ARRA SEP and Ohio Bipartisan Jobs Stimulus Program, which focuses on clean energy, efficiency and manufacturing investments. ARRA/SEP and the Ohio Bipartisan Jobs Stimulus Program provided an infusion of $40 million, leveraging an equal amount with private investor partners, EnerTech, LLC and Arsenal Venture Partners. Eligible projects include renewable energy and energy efficiency projects, including the retooling of existing manufacturers to strengthen Ohio's advanced energy supply chain. One of the first its kind, the fund caps risk for the state, leverages private dollars, and offers profit incentives to private investors.[79]
- *Tax Incentives For Improving Air Quality in Ohio*—OAQDA can provide a 100 percent exemption from tangible property taxes (personal, real estate, a portion of the corporate franchise tax) and sales and use tax (some or all of which could be federally exempt) on eligible air quality projects. Energy efficiency and conservation projects (lighting, chillers, central air conditions, CHP/cogeneration, processing and manufacturing equipment, among other technologies) are eligible.[80]
- *Utility Rebate Program*—Overseen by the Public Utility Commission of Ohio, (PUCO), and administered by the state's electric power and natural gas public utilities—FirstEnergy, AEP Ohio, Dayton Power and Light, American Municipal Power, Duke Energy, Vectren Energy Delivery of Ohio, and Columbia Gas of Ohio, among others—this program provides rebates to residential, commercial and industrial customers in their

service areas, for implementing energy efficiency upgrades. The incentive payment is capped at 50 percent of total project costs. Some utilities also provide services, including technical assistance to assess energy efficiency opportunities and financial incentives directly to customers. The program was created in response to the passage of SB 221 in May 2008. Among other things, SB 221 established an Energy Efficiency Standard, requiring utilities to implement energy efficiency programs to achieve over 22 percent energy savings by 2025, with incremental benchmark savings each year.[81]

- *Property-Assessed Clean Energy* (PACE)—PACE financing allows property owners to obtain low-interest, 30-year loans to pay for energy improvements. The amount borrowed is typically repaid via a special assessment on the property over a period of years. Only some local governments have been authorized to establish such programs, as described below. Special energy improvement districts established by authorized local municipalities enable property owners to finance installation of solar PVs or solar-thermal systems properties, other renewable energy systems (geothermal, wind, biomass, gasification systems) and energy efficiency improvements permanently fixed to the property within the district.[82]
- *Ohio Capital Access Program* (CAP)—Although not an energy financing program, it can be useful for helping SMMs obtain funds for implementing IEE and other projects. The program encourages state chartered financial institutions to make loans to for-profit or nonprofit small businesses that are having difficulty obtaining business loans through conventional means. The loans are backed by a loan guarantee "reserve" that receives contributions from the borrower, lender, and state. The maximum loan to provide working capital is $250,000 and for construction of fixed assets or purchasing of equipment the maximum is $500,000. CAPs have proven very cost-effective in leveraging private loans. With low numbers of defaults, some state CAPs have leveraged up to $33 of private investment for every $1 of public funds.[83]

▪ *Technical assistance programs* provided by state and federal agencies to promote energy-management practices, conduct audits and recommend IEE measures, provide expertise and other forms of assistance that help manufacturers reduce internal behavioral and organizational barriers to IEE. These include:

- *Ohio's Energy Efficiency Program for Manufacturers*—Described above, this ODOD Ohio Energy Resources Division program provides facilitation services to Ohio manufacturers to diagnose, plan, and implement cost-effective energy improvements, as well as financial assistance to carry out these improvements.[84]
- *DOE Industrial Assistance Centers Program (IAC)*—Sponsored by the DOE's Industrial Technologies Program (ITP), the IACs provide no-cost energy assessments to eligible SMMs. Currently 26 universities across the country participate in the program, including the University of Dayton in Ohio. Centers at the University of West Virginia and University of Michigan have also have provided assistance to a number of Ohio manufacturers. The IACs conduct energy audits or industrial assessments and make recommendations to manufacturers for improving productivity, reducing waste, and saving energy. To-date, IACs have conducted 930 assessments, resulting in 6,764 recommendations, of which a little over half (3,263, or 51.31 percent) were implemented, with an average payback period of 1.2 years.[85]
- *DOE Save Energy Now LEADER Program*—This ITP program is a national initiative involving industrial company partners who have pledged to reduce their energy intensity

by 25 percent or more in 10 years. It reportedly has already helped 2,100 U.S. manufacturing facilities save an average of 8 percent total energy costs. Industry partners in the program receive priority access to technical resources such as energy assessments and tailored assistance for establishing an energy intensity baseline and developing an energy management plan to meet LEADER requirements.[86] The program's website provides information about 44 plant-wide energy assessments it conducted at large manufacturing facilities in Ohio.[87] Several manufacturers interviewed as part of this project also noted that they have benefited from participation in this program.[88]

- *EPA ENERGY STAR Partnership*—This program helps industrial companies develop and refine corporate energy-management programs. Its services include energy management guidance, benchmarking and tracking tools, and recognition opportunities. It also provides sector-specific and technology-focused guidebooks that highlight operational best practices and provide tools for doing energy-saving assessments. Over 3,000 companies and organizations have joined this program. Several Ohio companies have received *ENERGY STAR* awards, including two Honda auto assembly plants (in East Liberty and Marysville)[89] and the Ohio Refining Division of Marathon Petroleum Company in Canton.[90]
- *Hollings Manufacturing Extension Partnership* (MEP)—A federal program administered by the U.S. Department of Commerce's National Institute of Standards and Technology (NIST), MEP works with SMMs to help them create and retain jobs, increase profits, and save time and money. The MEPs nationwide network of over 400 centers, field offices and partners, provides a variety of services, such as supplier development, environmental services, improving company innovation and techniques, providing relevant information on research and development happening at local universities, and advocating on behalf manufacturers in public policy debate. Ohio has nine MEP partners, MAGNET in northeast Ohio and TechSolve in the southwest, as well as the seven Edison Technology Centers around the state. According to the Ohio Department of Development, the MEP "implements programs to establish regional and statewide clusters of innovation."[91]

▪ *Technology innovation and R&D programs* that support the development of new clean energy and advanced IEE technologies:

- *DOE Industrial Technologies Program*—ITP is the lead government program working to increase the energy efficiency of U.S. industry. Its R&D program funds advanced, low-carbon, energy efficient industrial process technologies, largely for EITE industries and cross-cutting technologies that benefit multiple industries. ITP tries to collaborate with industry to identify R&D opportunities that offer the largest potential energy savings. It also continues to sponsor a modest amount of research in cost-sharing partnerships to develop transformational technologies for industry.[92] The program has faced serious funding cuts since 2001—including a drop of 83 percent for industry-specific research, and a 50 percent decline for some cross-cutting programs, such as the Industrial Assessment Centers.[93]
- *Ohio Third Frontier Program (OTF)*—Created in 2002, the OTF provides general obligation bonds for R&D and commercialization of new technologies. The program has focused on specific technology clusters such as biomedical imaging, medical devices, liquid crystals, fuel cells, and photovoltaics. In 2010, the Ohio public passed a ballot measured to extend the OTF, including an issuance of an additional $700 million for the program. Through 2010, the program has awarded just over $1 billion in financing, leveraging nearly $6 billion in private investment. It reportedly has created 11,402 direct

jobs, 68,855 total direct and indirect jobs, and has created or attracted 657 companies.[94] Although OTF is not specifically an IEE program, it does not preclude a technology cluster focus on advanced, low-carbon manufacturing process technologies for EITE industries in the future.

- *Workforce development programs* are aimed at developing in-house technical expertise for managerial and engineering personnel, develop needed skills among front-line production workers that can help manufacturers identify, design, plan and implement energy-management systems and IEE improvements*:*
  - *DOE ITP BestPractices Training*—This program within ITP includes curriculum for managers and technical personal to develop expertise on cross-cutting energy support systems. BestPractices offers system-wide and component-specific training programs aimed at helping plant managers and engineers operate their facilities and businesses more efficiently. The training is offered throughout the year and around the country. It offers training sessions on a range of energy efficiency technologies, including compressed air systems, data centers, fan systems, motor systems, process heating, pumping systems, and steam systems.[95]
  - *Manufacturing Skill Standards Council Green Production Module (MSSC/GPM)*—The U.S. Department of Labor, Employment Training Administration has been supporting a partnership of the International Union of Electrical Workers-Communication Workers of America (IUE-CWA), Manufacturing Skill Standards Council (MSSC), and AFL-CIO Working for America Institute, to develop "Green Production" skill standards and training curriculum. Representatives from labor unions and business have participated in this initiative, which also benefitted from inputs from DOE and EPA staff. Still in progress, this project has been developing skills standards and curriculum, with the goal of implementing a training program for certifying front-line workers in skills that can help manufacturers achieve environmental regulatory compliance and make energy-efficiency gains.[96]

Ohio IEE Best Practices and Successes. Although IEE potential for Ohio's manufacturers remains very high, they confront significant barriers to realizing the benefits of achieving IEE gains. Nevertheless, a large number of Ohio manufacturers, both big and small, EITE and non-EI, have embraced IEE improvements with the assistance of federal and state programs. Some also have made their own investments in improving their energy-efficiencies, cutting energy-use and costs, without government incentives.

SMMs in Ohio have availed themselves of IAC services, in fact, more than in most states—Ohio is second only to California in the number of IAC assessments to-date, and third behind California and Illinois in the number of both recommendations and implementations. The University of Dayton IAC, which has conducted over 80 percent of Ohio's assessments, is considered one of the most effective in the nation—it won the Governor's Award for Energy Excellence and 2006 and the U.S. DOE Center of Excellence Award as the top IAC in the nation in 2003. Over the past five years, its assessments reportedly saved clients an average of about $100,00 per year and reduced energy costs by 5.7 percent—about 500,000 kWh/year and $28,000/year in average electricity savings, 1,300 mmBtu/year and $13,000/year in average fuel savings, and average productivity savings of $60,000/year.[97]

Table V summarizes awards given out to manufacturers for IEE improvements, by state and federal agencies, administered by ODOD's Energy Resources Division. The awards go as far back as 2004, though most included in this table were given out over the past three years. They cover the full spectrum of manufacturing industries, though, as expected, EITE manufacturers, not surprisingly, appear to have captured the largest share. The awards also have gone to both large manufacturing firms and SMMs. By far the largest number of awards was made by the federally-funded State Energy Plan, though the largest amount of awards—and largest average awards—were made by the SEP under ARRA. Ohio's Advanced Energy fund has given out 41 IEE-related awards to manufacturers, a total of $2.4 million, and an average of $58,000 per project.

Finally, table VI shows a small sampling of companies that have undertaken IEE improvements with substantial gains. Most of the ones shown were recipients of assistance from the DOE ITP *Save Energy Now* program, which entailed plant-wide assessments, leading to recommendations for undertaking changes in the plants' operations, that subsequently resulted in cuts in energy consumption and cost savings, productivity gains, and short payback periods. It also includes two examples of successful IEE improvements at a bearings plant and metal coating company, resulting from assistance provided by the West Virginia University IAC.

Table V. ODOD Energy Resources Division Administered Awards to Industry for Energy Efficiency Projects (as of March 31, 2011)

Program	Number of Awards	Total Awards	Ave. Award	Percent of Total
ADVANCED ENERGY FUND	41	$2,374,062	$57,904	15.6
ENERGY LOAN FUND	10	$456,180	$45,618	3.0
STATE ENERGY PLAN	87	$933,255	$10,727	6.1
ARRA/STATE ENERGY PLAN	27	$11,431,946	$423,405	75.2
Total IEE Awards	**165**	**$15,195,443**	**$92,094**	**100.0**

Source: ODOD Energy Resources Division

The American Trim example in Table VI illustrates how an ARRA/SEP-funded, state-administered program helped the firm achieve major improvements in IEE from investments in installment of a new process technology. It also will provide greater product functionality to American Trim's customers, which include the alternative energy, automotive, and appliance industries.[98] The Akro-Mils example is particularly interesting, however. The firm, which makes plastic storage bins and organization containers, shelving systems and mobile material handling products, used its own resources to finance both incremental IEE measures (lighting) and a new energy-efficient process technology that replaced older, less-efficient equipment. It expects large returns both in saved energy costs and increased manufacturing efficiencies.[99]

It is clear, though, that a great deal more is possible in achieving cost-effective IEE improvements in Ohio's manufacturing sector. The DOE and state financial and technical assistance programs have only reached a fraction of Ohio's manufacturers, both large and small, and DOE-supported IAC assessments in Ohio have been conducted for only a fraction, about 6 percent, of the state's 16,000 SMMs.[100] More research and evaluation of programs designed to help manufacturers achieve IEE gains, is needed. This should include more study of best practices and success stories of Ohio firms across the spectrum of manufacturing industries that have invested in IEE and made significant cost savings. These would be especially useful in assessing the effectiveness of state and federal programs in delivering resources and assistance to Ohio manufacturers seeking to make industrial energy efficiency gains.

Table VI. Best Practices in Industrial Energy Efficiency in Ohio Manufacturing

Company	Location	Assessment/Project Description	Savings Identified/ Implemented	Agency/ Program
AMCAST[101] (low-pressure Al castings	Wapakoneta, OH	Plant-wide assessment of energy-intensive plant systems--furnaces, boilers, electrical equipment, compress air, fans, pumps: 12 projects implemented. (Replicated at 5 AMCAST plants)	Potential $3.6 million savings— increased energy efficiency and productivity; payback of 0 to 29 months; total saviings of $6 million.	DOE/ITP
Appleton Papers[102] (paper mill)	West Carrollton, OH	Plant-wide energy survey: 21 recommendations for projects to reduce energy consumption and waste production; improve process efficiency.	Est. $3.5 million annually; ave. payback of 1.2 years per project.	DOE/ITP
Carauster[103] (recycled paperboard)	Rittman, OH	Plant-wide assessment of energy inputs in plant processes, process efficiency, process outputs; 6 projects recommended	Potential savings/yr: $1.2 million, 10,900 kWh; Payback: 1.2-2.5 years	DOE/ITP
Corning[104] (glass)	Greenville, OH	Plant-wide assessment of electricity and natural gas consumed in glassmaking.	Potential savings of $26 million from reduced use of natural gas and electricity	DOE/ITP
Ford Cleveland Casting Plant[105]	Cleveland, OH	Identified 16 short-term energy- and cost-saving efficiency projects—combustion, compressed air, water, steam, motor drive, and lighting systems	Potential savings/yr: $3.3 million, ~18 million kWh, 139,000 MMBtu in fuel.	DOE/ITP
Progressive Powder[106] (metal finishing)	Mentor, OH	Installed infrared oven in production line, increased plant conveyor line speed, production by 50 percent. Reduced natural gas use	Annual savings of ~$54,000. Total cost $136,000, 2.5 years payback	DOE/ITP
American Trim[107] (coatings)	Lima, OH	Install new state-of-the-art coating processing line; consumes far less energy then existing line	Reduce energy consumption up to 95% for processing line.	SEP/ARRA ($994,000)
Burton Metal Finishing,[108] Inc. (metal coatings)	Columbus, OH	Plant-wide assessment: 12 recommendations (7 implemented) in compressed air, lighting, motor management, boilers, chillers	Savings of $19,277/yr; 6.5% reduced energy usage and cost; payback .03 to 2.5 years	WVU IAC
Miba Bearings US, LLC[109] (bearings)	McConnelsville, OH	Plant-wide assessment; 13 recommendations (9 implemented) to decrease energy usage in lighting, boilers, heaters, compressed air;	$100,176 savings; 9% reduced energy costs; 0-30 months payback; 1,927,422 lbs CO_2 emissions cut	WVU IAC
Akro-Mils[110] (plastic products)	Wadsworth, OH	New overhead lighting fixtures, energy-efficient electric injection molding machinery replacing old equipment	Expected savings: 50% in lighting and electricity costs; 15-20% in manufacturing efficiencies	Self-financed

DOE/ITP=U.S. Department of Energy, Industrial Technologies Program; SEP/ARRA=State Energy Plan, American Recovery and Reinvestment Act; WVU IAC=West Virginia University Industrial Assessment Center

Other Clean Energy Manufacturing Opportunities

Aside from the benefits of IEE, there are many other opportunities associated with clean energy that also could stimulate growth in Ohio manufacturing. Ohio is beginning to emerge as an important hub of manufacturing activity supporting renewable energy generation. In addition, there are potentially numerous opportunities for producing products, materials, parts, and components used in the construction and retrofitting of "green" buildings (residential, commercial, industrial), building advanced fuel vehicles (including electric and hybrid vehicles), fuels used by these vehicles (advanced batteries, biofuels), as well as "green" infrastructure and transportation systems (light-rail, mass transit, high-speed rail).

Assessment of these opportunities is beyond the scope of this report. However, it is worth noting that they are not unrelated to IEE opportunities that contribute to lowering the costs and improving the competitiveness of Ohio manufacturers—especially in EITE industries that form part of the supply-chains for other clean energy products. Although Ohio lags other states in developing its renewable energy resources, it is poised to become a leading supplier of wind turbines and solar cells used in the Midwestern region's utility-scale wind farms and solar farms.

Building on the strength of its traditional EITE and non-energy-intensive manufacturing industries, it can also be a major supplier of materials (steel, cement, aluminum, glass, plastics, etc.), parts, and components used in making this equipment, rather than depending on imports from China and other emerging economies to fill this need. For example, most of the manufacturers interviewed as part of this project described at least one energy-driven market opportunity that their company is currently exploiting or anticipates pursuing in the near future. These include in part producing components for machinery related to alternative energy production and utilization, modifying products to be more energy efficient, and/or making products to improve the energy efficiency of equipment or buildings.[111]

A Policy Matters Ohio report notes that several studies have ranked Ohio as one of the states with the greatest clean energy manufacturing potential, and actual growth.[112] A 2009 Pew Charitable Trusts report, ranked Ohio 4th in number of jobs in the clean energy economy in 2007, and 7th in clean energy patents between 1999 and 2008.[113] An Environmental Law and Policy Center report on solar and wind energy supply chains in Ohio, found that the state has about 170 businesses in the wind turbine and solar panel manufacturing supply chain, with about 9,000 workers in the two sectors.[114] The Renewable Energy Policy Project, similarly has estimated that Ohio has 2,100 firms—the fourth highest number in the nation—in industries related to the manufacture of components for renewable energy systems. It projects that with a national clean-energy building boom, the state could see almost 23,000 new jobs and $3.6 billion in investment in manufacturing components.[115]

The opportunities for Ohio manufacturing therefore could be significant, especially if a proactive strategy of private-public partnership is pursued, and builds on the state's existing manufacturing strengths. For example, building on its legacy as the glass making capital of America, Toledo has become a center for thin-film photovoltaic solar cell manufacturing. First Solar, a leading PV company that employs 1,000 people just outside Toledo, was started by glass innovator, Harold McMaster. Recently, a combination of federal, state and private venture capital enabled the successful start-up of the Xunlight Corporation in Toledo, a producer of flexible and lightweight thin film silicon solar modules.

Xunlight began as a spin-off from research by Xunming Deng, a physicist at the University of Toledo. Aided by R&D funding from the U.S. DOE, U.S. Department of Commerce and Ohio's Third Frontier, loans from the State of Ohio, and millions of dollars in private investments from several venture capital firms, the start-up was able to develop and commercialize its product. As John Griffin, director of ODOD's Technology and Innovation Division notes, "Companies like Xunlight are an excellent example of how the public and private venture capital pipeline in Ohio can lead to company creation and product commercialization."[116] Similarly, the Isofoton example above illustrates a successful public-private partnership, involving state and local business partners and agreement with a state utility company (American Municipal Power) in attracting a major solar manufacturer to the state.

These opportunities also exist for other areas of "clean" energy products and systems, such as buildings, vehicles, and infrastructure. In short, given its tremendous manufacturing strengths and capacity, policies that encourage a strong collaboration between the state's private and public sectors, as well as drawing on its substantial academic and R&D capabilities, Ohio could emerge as a leading national center for multiple clean energy manufacturing clusters, supplying a wide-range of materials, parts, and end-use products for local, domestic and international clean energy markets.[117]

Conclusions

This report examines industrial energy efficiency opportunities for Ohio manufacturers, which have the associated benefits of lowering carbon emissions and increasing their competitiveness—a step towards Ohio becoming an economically sustainable clean energy economy. The IEE "roadmap" presented here starts with an assessment of the *potential* for IEE gains for Ohio manufacturers. This potential is shown to vary, depending on whether manufacturers were EITE or non-EI, and according to the size of manufacturers' facilities. The report also shows that a wide-range of technologies currently are available for enabling cost-effective, short-to-medium term IEE gains, and there are a number of emerging process technologies that in the long-term could dramatically reduce energy use and GHG emissions for EITE industries. These technologies however require further investments in R&D and demonstrations before they are commercially available.

The second step of the "roadmap" involves identifying and assessing *barriers* confronting manufacturers in realizing their potential IEE gains. Before making IEE improvements, manufacturers must make the "business case" for making such investments. Both *internal* behavioral and organizational barriers—reflecting the cultures and operational structures of firms—constitute a critical set of obstacles that often prevent firms from making IEE investments, despite the perceived potential gains they might be able achieve.

By the same token, capital availability is the most important *external* problem manufacturers confront in investing in new IEE measures and technologies. The availability of new, commercially viable, next-generation technologies, processes and products is also a major concern of EITE manufacturers in particular, who seek to make significant, longer-term efficiency improvements over the longer-term.

The report further explores the different barriers that EITE and non-EI firms may experience, as well as between small, mid-sized and large manufacturing plants. SMMs in particular face a greater number of difficulties in adopting cost-effective IEE measures than their larger counterparts. However, despite the large number of EITE industries in the state, most manufacturers are SMMs, and require different considerations in assessing and making IEE improvements.

The third and final step in the IEE roadmap entails identifying the opportunities available to Ohio's manufacturers to make IEE improvements. To take advantage of this potential, companies need to act strategically, whenever possible adopting an integrated set of internal behavioral measures that mitigate the negative obstacles and encourage IEE gains. These include developing plant and line-level energy management plans and systems, and training and involving both engineering and front-line workers in the design and implementation of these plans.

However, the report also recognizes the importance of state and federal programs to encourage and enable manufacturers to make investments in and implement IEE improvements in their plants. These programs can often make the difference in influencing company managers' decisions about whether or not a business case can be made for IEE investments. A large number of such programs are identified in and described report, including several operated and administered by Ohio agencies. While financial assistance programs by far are the most important of these programs, technical assistance, R&D, and workforce development programs also are vital for helping Ohio manufacturers make the transition to a high-IEE, low-carbon future. On the whole, these programs appear to have been quite effective.

On the other hand, as ARRA phases out—ARRA supplemented and enhanced many of the state programs—it is anticipated that there will be a shortage of resources that may be available at either the state or federal levels. More research is needed to further evaluate the availability and effectiveness of public sector programs and policies for promoting IEE in Ohio. Moreover, it is clear that the existing programs, while very important, are far from sufficient to promote IEE improvements in Ohio's manufacturing base. New approaches, programs and legislation need to be explored, researched and evaluated that could greatly strengthen Ohio's opportunities to make substantial IEE gains, especially as state and federal resources such initiatives diminish. The IEE roadmap introduced here could provide a useful framework for conducting such an analysis.

1 The Ohio Manufacturers' Association. "The Policy Point: Electricity and Energy Efficiency." *Retooling Ohio.* 2010.

2 Data sources: U.S. Census Bureau, *2007 Economic Census, Sector 31: Manufacturing: Geographic Area Series (GAS): Industry Statistics for the States, Metropolitan and Micropolitan Statistical areas, Counties, and Places: 2007*; —, *2007 Economic Census, Sector 31: Manufacturing: Subject Series: Location of Manufacturing Plants: Employment Size for Subsectors and Industries by U.S. State, County and Place.* (http://factfinder.census.gov/home/saff/main.html?_lang=en); —, *Annual Survey of Manufactures*.

3 Hannah Choi Granade, Jon Creyts, Anton Derkach, Philip Farese, Scott Nyquist and Ken Ostrowsi, *Unlocking Energy Efficiency in the U.S. Economy*, (McKinsey Global Energy and Materials, July 2009).

4 American Council for an Energy-Efficient Economy, Summit Blue Consulting, ICF International, and Synapse Energy Economics. *Shaping Ohio's Energy Future: Energy Efficiency Works.* ACEEE Report Number E092 (Washington, DC, March 2009),

5 Granade et al, *Unlocking Energy Efficiency*, 76.

6 Recycled Energy Development. *Energy Recycling Opportunities for Ohio: An Industrial Analysis.* February 14, 2008.

7 Ohio University, *Advanced Energy Manufacturing Policy Study*, 2011.

8 See U.S. DOE EERE Industrial Technologies Program, "Flambeau River Papers Makes a Comeback With a Revised Energy Strategy." Downloadable from *Save Energy Now* website http://www1.eere.energy.gov/industry/saveenergynow/leader.html. See also Joel S. Yudken and Andrea M. Bassi, *Climate Policy and Energy-Intensive Manufacturing: Impacts and Options*, (Arlington, VA: High Road Strategies and Millennium Institute, June 2009) 176-177, box 4. See also: "GOV. DOYLE ANNOUNCES RENEWABLE ENERGY ADVANCES AT FLAMBEAU RIVER PAPERS." US Fed News Service, Including US State News. August 13, 2008. *HighBeam Research.* (August 31, 2011). http://www.highbeam.com/doc/1P3-1531254361.html; "U.S. Department of Energy Awards Flambeau River BioFuels a Grant to Construct First-in-Class Facility for Production of Renewable Diesel to be Co-located at Pulp and Paper Mill in Park Falls, WI." U.S. Newswire. July 15, 2008. *HighBeam Research.* (August 31, 2011). http://www.highbeam.com/doc/1P2-16865804.html

9 For more detailed review of these trends see Joel S. Yudken, *Manufacturing Insecurity, America's Manufacturing Crisis and the Erosion of the Defense Industrial Base.* A Report Prepared for the Industrial Union Council, AFL-CIO, Washington, DC, September 2010. Downloadable at http://www.aflcio.org/issues/jobseconomy/, and at http://www.highroadstrategies.com/manufacturing-and-the-erosion.html.

10 For more recent data on Ohio's manufacturing base See Joel S. Yudken, "Chapter 2: Task 2, Part 2: Risks and Opportunities for Ohio's Manufacturing Sector in a Carbon-Constrained World." In *Assuring Ohio's Competitiveness in a Carbon-Constrained World: A Collaboration between Ohio University and The Ohio State University.* Forthcoming. ["HRS/OU-OSU 2011"]

11 EITE is a designation made in the Waxman-Markey climate bill (H.R. 2454), which was made to determine which industry would be "presumably eligible" for emission allowance allocations (or "output-based rebates") to "trade vulnerable" industries if the industry's energy intensity or its greenhouse gas intensity is at least 5 percent and its trade intensity is at least 15 percent, or alternatively, if its greenhouse gas intensity is at least 20 percent, regardless of its trade intensity. The eligibility was to be based on specified data sources, including the Census Bureau's ASM and Economic Census, the Energy Information Administration's Manufacturing Energy Consumption Survey (MECS), and data from the U.S. International Trade Commission. Finally, the bill stipulated that, to the extent feasible, the eligibility assessments should be conducted at the most disaggregated level from which public data are available—the six-digit NAICS industry categories. See U.S. Environmental Protection Agency (EPA) et al. *The Effects of H.R. 2454 on International Competitiveness and Emission Leakage in Energy-Intensive Trade Exposed Industries.* An Interagency Report Responding to a Request from Senators Bayh, Specter, Stabenow, McCaskill, and Brown. December 2, 2009: 8-11, especially table 1.

12 See Joel S. Yudken. *Clean Energy Manufacturing in Michigan.* Memorandum Prepared for the Blue Green Alliance Apollo, Green Manufacturing Action Plan (MI GreenMAP). Arlington, VA: High Road Strategies, LLC, May 5, 2011; —. *Clean Energy Manufacturing in California.* Report prepared for Blue Green Alliance Apollo. Arlington, VA: High Road Strategies, LLC. July 17, 2011. (These reports will soon be downloadable at www.highroadstrategies.com.)

13 Ohio Department of Development (ODOD). "Spanish-Based Energy Technology Manufacturer Lands in Ohio, Photovoltaic Manufacturing Facility to Generate 330 Green Jobs." *News Release*. July 6, 2011. (http://www.development.ohio.gov).

14 HRS/OU-OSU 2011, 18.

15 Ibid.

16 Ibid., 24, Figure 3. Natural gas is used in 1 percent of electric power generation and renewables for less than one percent.

[17] American Council for an Energy-Efficient Economy (ACEEE), Summit Blue Consulting, ICF International, and Synapse Energy Economics. *Shaping Ohio's Energy Future: Energy Efficiency Works.* ACEEE Report Number E092 (Washington, DC, March 2009), 114, table 30. More disaggregated data on energy use by the subsectors of the industrial sector at the state level is not readily available. It is a reasonable assumption that the other subsectors—agriculture, mining and construction—are substantially smaller in terms of output and employment, hence in their energy consumption. See also: Ohio University and The Ohio State University *Assuring Ohio's Competitiveness in a Carbon-Constrained World: A Collaboration between Ohio University and The Ohio State University.* Forthcoming. ["OU-OSU 2011"] The Ohio emissions inventory developed as part of the OU-OSU project also suggest very small levels of consumption of fossil-fuel energy, which correlates with GHG emissions levels, relative to the manufacturing sector.

[18] Anna Monis Shipley, R. Neal Elliott, and Adam Hinge. *Energy Efficiency Programs for Small and Medium-Sized Industry*. Report Number IE002, Washington, DC: American Council for an Energy-Efficient Economy, February 2002, 3.

[19] Anna K. Chittum, R. Neal Elliott, and Nate Kaufman. *Trends in Industrial Energy Efficiency Programs: Today's Leaders and Directions for the Future.* Report Number IE091. Washington, DC: American Council for an Energy-Efficient Economy, September 2009.

[20] Ibid.

[21] The Ohio Manufacturers' Association (OMA). "The Policy Point: Electricity and Energy Efficiency." *Retooling Ohio.* 2010, 5]

[22] OMA, *Policy Point*, 7.

[23] OMA, *Policy Point*, 4.

[24] OU-OSU 2011.

[25] HRS/OU-OSU.

[26] Ohio University Voinovich School staff conducted 30 interviews of Ohio manufacturers as part of the *Advanced Energy Manufacturing Policy Study* for which the current report has been produced. These interviews have been summarized in Part 2 of the report entitled, *The Voice of Ohio Manufacturers*.

[27] Ibid., 42, table 10.

[28] *Ibid.* For example, material costs for petroleum refining ranged from 85-90 percent of its value of shipments, and for iron and steel and ferroalloys, it ranged from two-thirds to three quarters, for 2008-2009. If instead energy intensity were measured as the ratio of purchased energy costs and value added—which does not include material costs in the denominator—these industries show substantially higher energy-intensities—18 percent for petroleum refining and 16 percent for iron and steel and ferroalloys. If value of energy feedstocks were added into the value of energy costs, these ratios would be higher still. Data Source: U.S. Census Bureau, *Annual Survey of Manufactures (ASM)*.

[29] This table and table II, and the data in the subsequent discussion, are drawn from two databases: U.S. Census Bureau, *2007 Economic Census, Sector 31: Manufacturing: Geographic Area Series (GAS): Industry Statistics for the States, Metropolitan and Micropolitan Statistical areas, Counties, and Places: 2007*; U.S. Census Bureau, *2007 Economic Census, Sector 31: Manufacturing: Subject Series: Location of Manufacturing Plants: Employment Size for Subsectors and Industries by U.S. State, County and Place.* (http://factfinder.census.gov/home/saff/main.html?_lang=en).

[30] Although its value of shipments is not disclosed (D), its materials expenditures was $12.5 billion in 2007, annual payroll nearly $1 billion, and its capital expenditures, 0.1 billion. U.S. Census Bureau, *2007 Economic Census, Sector 31 (GAS)*.

[31] It also has the third largest number of total establishments in Ohio. Census, *2007 Economic Census, Sector 31, GAS*.

[32] For example, 5 percent of the EITE industries' establishments are large, 23 percent are mid-sized, and 72 percent small, compared to 1 percent, 9 percent, and 89 percent for all manufacturing.

[33] See Yudken, *Manufacturing Insecurity,* 16-18.

[34] See the American Iron and Steel Institute's commitment to reduce energy use at http://www.climatevision.gov/sectors/steel/pdfs/AISI-Energy-Efficiency-Fact-Sheet.pdf. Cited in Environmental Defense Fund (EDF), *Think U.S. Industry Can't Be More Competitive* (Washington, DC. 2010). www.LessCarbonMoreInnovation.org.

[35] "Alcoa Meets Carbon Goal 10 Years Early," Environmental Leader, May 13, 2011. http://www.environmentalleader.com/2011/05/13/alcoa-meets-carbon-goal-10-years-early/?graph=full&id=1; and"Alcoa Ahead of Schedule on Reducing Emissions," *Environmental Leader,* February 18, 2009. http://www.environmentalleader.com/2009/02/18/alcoa-ahead-of-schedule-on-greenhouse-gas-reductions/;

[36] National Academy of Sciences (NAS), *Real Prospects for Energy Efficiency in the United States.* Washington, DC: National Academies Press, 2010: 215 (http://www.nap.edu/catalog.php?record_id=12621). Based on data from the International Energy Agency (IEA), and other sources, it was estimated that in 2005, the U.S. steel industry was 10 percent more energy intensive than Korea, 7 percent more than Germany, and 6 percent more than Japan. See also: International Energy Association's (IEA), *Tracking Industrial Energy Efficiency and CO2 Emissions*,

(http://browse.oecdbookshop.org/oecd/pdfs/browseit/6107151E.PDF) Also cited in EDF, *Think U.S. Industry Can't Be More Competitive*.

37 NAS, *Real Prospects for Energy Efficiency.* 219, 221. See also: EDF, *Think U.S. Industry Can't Be More Competitive;* IEA *Tracking Industrial Energy Efficiency*.

38 IEA, *Tracking Energy Efficiency,* 192-193. The IEA estimates that the U.S. pulp and paper sector could improve its electrical energy efficiency by 16 percent using "best available technology''—it currently lags behind Germany, France, Italy, Sweden, Korea, Japan, Spain, Finland, and Norway. See also EDF, *Think U.S. Industry Can't Be More Competitive.*

39 IEA, *Tracking Energy Efficiency, 91, table 4.19.* The IEA also estimates that for U.S. chemicals manufacturing the gap between current energy use and energy use using "best practice technology" is almost 30 percent, well behind Germany (9.8 percent), Japan (10 percent), France (11 percent), India (15.8 percent), Brazil (17.2 percent), and China (20.5 percent).

40 IEA, *Tracking Industrial Efficiency*, 20. The IEA study estimated energy and carbon savings from the adoption of best-practice commercial technologies in manufacturing industries. Its country estimates are based on physically produced industrial output. Moreover it notes that the difference in levels between the nations reflect differences in "natural resource endowments, national circumstances, energy prices, average age of plant, and energy and environmental policy measures" Cited in NAS, *Real Prospects for Energy Efficiency*, 199.

41 IEA, *Tracking Industrial Efficiency*, 22, table 1.

42 NAS, *Real Prospects for Energy Efficiency*, 15. The report further notes that, "A large part of this savings—2 quads at the upper end of the range—would be supplied by further use of combined heat and power systems." The two studies NAS reviews are: Interlaboratory Working Group (IWG). *Scenarios for a Clean Energy Future*. LBNL-44029. ORNL/CON-476. Prepared by the Interlaboratory Working Group on Energy-Efficient and Clean Energy Technologies. Oak Ridge, Tenn.: Oak Ridge National Laboratory; Berkeley, Calif.: Lawrence Berkeley National Laboratory. November 2000. Available at http://www.ornl.gov/sci/eere/cef/; McKinsey and Company. *The Untapped Energy Efficiency Opportunity of the U.S. Industrial Sector: Details of Research, 2008.* New York: McKinsey and Company, 2008.

43 NAS, *Real Prospects for Energy Efficiency,* 17.

44 NAS, *Real Prospects for Energy Efficiency,* 200. See: KEMA, Inc. *California Industrial Existing Construction Energy Efficiency Potential Study, Volumes 1 and 2.* Final Report to Pacific Gas and Electric Company. Prepared with assistance from Lawrence Berkeley National Laboratory and Quantum Consulting. Arnhem, The Netherlands: KEMA, Inc. May 2006; and Optimal Energy, Inc. Energy Efficiency and Renewable Energy Resource Development Potential in New York State. Final Report. Prepared for the New York State Energy Research and Development Authority. August 2003. Available at http://www.nyserda.org/energy_Information/otherdocs.asp#EERER.

45 ACEEE et al, *Shaping Ohio's Energy Future,* 114. For more energy-efficiency studies for other states, see http://www.aceee.org.

46 See Hannah Choi Granade, Jon Creyts, Anton Derkach, Philip Farese, Scott Nyquist and Ken Ostrowsi, *Unlocking Energy Efficiency in the U.S. Economy*, (McKinsey Global Energy and Materials, July 2009). The U.S. DOE Industrial Technologies Program energy-intensive industry web pages include studies of "theoretical minimum" for reducing energy in industrial processes, as well as energy "bandwidth" studies—"bandwidth" refers to the difference between the amount of energy that would be consumed in a process using commercially available technology versus the minimum amount of energy needed to achieve those same results based on the 2nd law of thermodynamics. See http://www1.eere.energy.gov/industry/industries_technologies/index.html.

47 Granade et al, *Unlocking Energy Efficiency*, 76.

48 Shipley et al., *Energy Efficiency Programs*. 2-3.

49 Most notable is the New York State Research and Development Authority's (NYSERDA) *Flex Tech Program.* This is a custom-tailored technical assistance program to help firms lower facility operating costs, increase productivity, improve indoor air quality, and reduce air emissions. Ibid., *20.*

50 Shipley et al., *Energy Efficiency Programs.*

51 Granade et al, *Unlocking Energy Efficiency* , 76.

52 Anna Monis Shipley and R. Elliott. "Ripe for the Picking: Have We Exhausted the Low-Hanging Fruit in the Industrial Sector? Report Number IE061. Washington, DC: American Council for an Energy-Efficient Economy. April 2006, iv-v.

53 Granade et al, *Unlocking Energy Efficiency*, 76. Not discussed here are two other important cross-cutting energy savings technologies, materials recycling and carbon capture and sequestration. See HRS/OU-OSU 2011, 57.

54 Granade et al, *Unlocking Energy Efficiency* . 86. Cited in HRS/OU-OSU 2011, 58.

55 ACEEE et al, *Shaping Ohio's Energy Future,* 114, 117.

56 Granade et al, *Unlocking Energy Efficiency* , 76.

57 Source: *U.S. Department of Energy, Energy-Efficiency Association (now ICF Intl.*); (http://www.eea-inc.com/chpdata/States/OH.html) The database list another 22 CHP units in operation in a range of non-manufacturing facilities.

58 Recycled Energy Development (RED), *Energy Recycling Opportunities for Ohio: An Industrial Analysis.* February 14, 2008.

59 RED, *Energy Recycling Opportunities*.

60 HRS/OU-OSU 2011, 59-60.

61 HRS/OU-OSU 2011, 61-62.

62 See U.S. EPA, Office of Air Radiation (OAR), "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from te Iron and Steel Industry." Washington, DC: October 2010, 62; Yudken and Bassi, *Climate Policy and Energy-Intensive Manufacturing*, 61, table 30C; 105-107; U.S. EPA, OAR. "Available Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Manufacturing Industry," Washington, DC: October 2010, 46. Downloadable at http//www.epa.gov/nsr/ghgpermitting.html; See also National Academy of Sciences. *Real Prospects for Energy Efficiency in the United States, America's Energy Future Panel on Energy Efficiency Technologies*, Washington, DC: The National Academies Press, 2010.

63 See Granade et al, *Unlocking Energy Efficiency*, 80-81; R. Neal Elliott, "Discussion Draft: Suggested Legislation to Promote Investments in Manufacturing Energy Efficiency for 112th Congress." Washington, DC: American Council for an Energy-Efficient Economy. December 2010; and "Testimony of R. Neal Elliott before the U.S. Senate Committee on Energy and Natural Resources hearing on Restoring America's Manufacturing Leadership through Energy Efficiency Act of 2009 (S. 661)" March 26, 2009. http://aceee.org/tstimony/032409_senate_RNE.pdf. See also discussion in HRS/OU-OSU 2011, 63-64.

64 A number of manufacturers interviewed as part of the *Advanced Energy Manufacturing Policy Study* project expressed similar concerns about capital availability linked to internal barriers (such as high hurdle rates, short payback period requirements, and non-IEE projects competition for limited budget allocations) limiting their ability to make capital improvements in energy efficiency in their facilities.

65 Elliott, *Discussion Draft*.

66 Some EITE industries, such as iron and steel and aluminum, have steadily invested over the years in "low-hanging" fruit technologies. That is they have gone relatively far down the energy savings curve, and added incremental gains in energy-efficiency would be relatively small for the high marginal costs required to achieve them at current technology levels. Hence, a major "step jump" in advanced low-carbon, energy-efficient production technologies would be needed for any larger IEE gains to be made. See Yudken and Bassi, *Climate Policy and Energy-Intensive Manufacturing*, 60, Box 3.

67 Shipley et al., *Energy Efficiency Programs*, 3.

68 Granade et al, *Unlocking Energy Efficiency*, 83. Several Ohio manufacturers interviewed as part of the *Advanced Energy Manufacturing Policy Study* similarly indicated that their companies had individuals responsible for making decisions related to managing energy. At the same time, most also indicated that energy-related decisions were shared among multiple entities, such as small groups of managers, and involved a variety of positions, departments, skills and teams within their organizations.

69 Granade et al, *Unlocking Energy Efficiency* , Ibid.

70 Granade et al, *Unlocking Energy Efficiency;* Chittum et al, *Trends in Industrial Energy Efficiency*, 19.

71 Shipley et al., *Energy Efficiency Programs,* 15.

72 Granade et al, *Unlocking Energy Efficiency,* 83.

73 Ibid.

74 Elliott, *DiscussionDraft.*; Granade et al, *Unlocking Energy Efficiency.*

75 http://www.development.ohio.gov/recovery/StateEnergyProgram.htm. For a list of recipients of Ohio SEP awards: http://www.development.ohio.gov/recovery/StateEnergyProgram/Awards.htm

76 For more details see http://development.ohio.gov/Energy/Efficiency/Industrial/Manufacturers.htm.

77 That is, the funds come from a fee, calculated at $0.09/month per utility bill on retail electric service rates. To qualify for funding, projects must be located in Ohio and in the service territories of one of the four participating electricity distribution companies: AEP-Ohio, Dayton Power & Light, Duke Energy, or First Energy. According to the program's website, "the Ohio Energy Resources Division will offer new strategies and programs that are better aligned with market conditions, complement other incentive programs available to Ohioans and model options from other high-performing state clean energy funds." See http://www.development.ohio.gov/Energy/Incentives/AdvancedEnergyFundGrants.htm.

78 See http://www.ohioairquality.org/advanced_energy_program/.

[79] See http://www.development.ohio.gov/OhioEnergyGatewayFund/ See also PMO Apollo research memo….

[80] See http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=OH01F&re=1&ee=1.

[81] Types of high efficiency equipment eligible under this program include industrial process improvements, refrigeration, controls, lighting, HVAC system replacements, motors, compressed air, boilers, furnaces, boilers, boiler controls, water heaters, and other technologies that reduce energy consumption and peak demand. See http://www.dsireusa.org/incentives/index.cfm?getRE=1?re=undefined&ee=1&spv=0&st=0&srp=1&state=OH.

[82] See http://www.dsireusa.org/incentives/index.cfm?getRE=1?re=undefined&ee=1&spv=0&st=0&srp=1&state=OH. See also a recent study of the PACE program, ECONNorthwest, *Economic Impact Analysis of Property Assessed Clean Energy Program (PACE).* Prepared for PACENow. Portland, OR: April 2011 (http://pacenow.org/blog/wp-content/uploads/PACE-Econometric-Study-by-ECONorthwest-for-PACENow-5-4-11.pdf.)

[83] The borrower and lender contribute to the loan guarantee reserve at equal amounts between 1.5-3% of the loan, while the state injects 10% of the loan into the reserve. As the lender enrolls in the program multiple times, the state backs the loans with larger amounts of money - up to 50% by the lender's third enrollment. for more information see http://www.development.ohio.gov/Minority/CAP/.

[84] Since 2007, more than 200 energy assessments have been supported by this program, identifying more than $40 million in potential energy savings. For more details see http://development.ohio.gov/Energy/Efficiency/Industrial/Manufacturers.htm.

[85] For more information see: *http://www1.eere.energy.gov/industry/bestpractices/iacs.html.* The University of Dayton IAC provided over 80 percent of those assessments, 755, with 4,953 recommendations, of which 2,335 were implemented. The West Virginia University IAC conducted 130 assessments in Ohio, making 1,514 recommendations of which 799 were implemented. The University of Michigan has conducted 37 assessments for Ohio SMMs, making 259 recommendations of which 104 were implemented. *http://academic.udayton.edu/kissock/http/iac/default.htm.*

[86] For more information see *http://www1.eere.energy.gov/industry/saveenergynow/partnerships.html*

[87] See http://www1.eere.energy.gov/industry/saveenergynow/partners/by_state_list.cfm?state=OH.

[88]See *Advanced Energy Manufacturing Policy Study*, Part 2: *Voice of Ohio Manufacturers*.

[89] "EPA AWARDS ENERGY STAR LABEL TO HONDA OF AMERICA PLANTS IN MARYSVILLE, EAST LIBERTY, OHIO." US Fed News Service, Including US State News. April 16, 2007. *HighBeam Research.* (October 28, 2011). http://www.highbeam.com/doc/1P3-1255615951.html

[90] Marathon's Canton refinery reports that during the first five years of the program, it has surpassed its ten-year energy reduction target of 10 percent. Overall the refinery has reduced energy consumption by more than 1,200,000 MMBTU per year. This was achieved in part through increased and updated insulation used for facilities, piping, and equipment, and capital-intensive projects such as additional heat exchange on the distillate hydrotreater, which reduced the fuel required for the process heater. "MARATHON PETROLEUM RECOGNIZED BY EPA FOR ENERGY EFFICIENCY AT FOUR U.S. REFINERIES." US Fed News Service, Including US State News. June 15, 2007. *HighBeam Research.* (October 28, 2011). http://www.highbeam.com/doc/1P3-1289239371.htmlFor more information see the ENERGY STAR for Industry website: http://www.energystar.gov/index.cfm?c=industry.bus_industry.

[91] For information about MEP see http://www.nist.gov/mep/. See also Policy Matters Ohio, "The Ohio Blue Green Apollo Green Manufacturing Action Plan, Background Research Memo." Unpublished Draft. Cleveland, OH: July 2011.

[92] For more information see: http://www1.eere.energy.gov/industry/rd/index.html.

[93] Alliance for Materials Manufacturing Excellence (AMMEX). Fact sheet (2010). The fact sheet also noted that the Energy Independence and Security Act of 2007 reauthorized two portions of ITP core activities (IOF and IAC) at $196 million for FY 2010. It also noted that a peer review of the full ITP program found its research activities to be productive but underfunded. It further reported that the DOE received $50 million from the Recovery act to begin refilling the R&D pipeline, and urged that this funding continue.

[94] For more information see http://thirdfrontier.com/ThirdFrontierCalendar/Default.aspx;. See also *Making an Impact* (SRI International, September 2009): http://development.ohio.gov/ohiothirdfrontier/Documents/RecentPublications/OH_Impact_Rep_SRI_FINAL.pdf.

[95] See http://www1.eere.energy.gov/industry/bestpractices/training.html.

[96] For more information about manufacturing skill standards and the Manufacturing Skill Standards Council, see http://www.msscusa.org/. Because it is still underway there is currently no publically available documentation of the Green Production Module. However, a public roll-out of the new module and "Green" workforce certification program is scheduled for October 18, 2011, to be held in Dayton, Ohio.

[97] See http://academic.udayton.edu/kissock/http/iac/default.htm

[98] "American Trim Receives $994,000 in Economic Stimulus Funds to Install a More Energy Efficient Protective Tape Line in Ohio Facility." *PRWeb Newswire*. February 11, 2010. *HighBeam Research.* (August 31, 2011). http://www.highbeam.com/doc/1G1-221657532.html.

[99] "Akro-Mils Invests in 'Green' Initiatives at Wadsworth, Ohio, Manufacturing Facility." Manufacturing Close-Up. April 14, 2011. *HighBeam Research.* (August 31, 2011). http://www.highbeam.com/doc/1P2-28422929.html

[100] For IAC data, see http://academic.udayton.edu/kissock/http/iac/default.htm.

[101] U.S. DOE Industrial Technologies Program, "$3.6 Million in Savings Identified in AMCAST Assessment," *Plant-Wide Assessment Summary—Metal Casting*. August 2003. http://www1.eere.energy.gov/industry/bestpractices/case_studies.html

[102] U.S. DOE EERE Industrial Technologies Progam, "Appleton Papers Plant-Wide Energy Assessment Saves Energy and Reduces Waste," *Best Practices Assessment Case Study* (Washington, DC, March 2002). http://www1.eere.energy.gov/industry/bestpractices/case_studies.html.

[103] U.S. DOE EERE Industrial Technologies Progam, "$1.2 Million in Savings Identified in Carauster Assessment." *Plant-Wide Assessment Summary—Forest Products*. DOE/GO-102003-1699. (Washington, DC, August 2003). http://www1.eere.energy.gov/industry/bestpractices/case_studies.html.

[104] U.S. DOE EERE Industrial Technologies Program, *PWA Finds $26 Million in Potential Savings at Glass Plant*, February 23, 2004, http://www1.eere.energy.gov/industry/bestpractices/news_detail.asp?news_id=7971.

[105] U.S. DOE EERE Industrial Technologies Progam, "Ford Cleveland: Inside-Out Analysis Identifies Energy and Cost Savings Opportunities at Metal Casting Plant," *BestPractices Plant-Wide Assessment Case Study.* DOE/GO-102003-1678 (Washington, DC, September 2003). http://www1.eere.energy.gov/industry/bestpractices/case_studies.html.

[106] Downloadable from website of DOE EERE Industrial Technologies Program, State and Regional Partnerships. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=OH#stateCaseStudies/bs_cs_progressive_powder.pdf.

[107] "American Trim Receives $994,000."

[108] U.S. DOE EERE Industrial Technologies Progam, "Industrial Energy Assessment Yields Energy Savings of 1,411 MMBtu per year," *Industrial Assessment—Metal Coating*. June 17, 2005.

[109] U.S. DOE EERE Industrial Technologies Progam, "Miba Bearings US, LLC: Industrial Energy Assessment Yields Energy Savings of 9%." Industrial Assessment Center Cast Study—Metal Fabrication. March 5, 2009.

[110] "Akro-Mils Invests in 'Green' Initiatives."

[111] Ohio University. *Advanced Energy Manufacturing Policy Study, Part 2: The Voice of Ohio Manufacturers*. 2011.

[112] Policy Matters Ohio, "The Ohio Blue Green Apollo Green Manufacturing Action Plan, Background Research Memo. San Francisco, CA: Blue Green Alliance Apollo, July 21, 2011.

[113] The Clean Energy Economy (2009). Pew Charitable Trusts: http://www.pewcenteronthestates.org/uploadedFiles/Clean_Economy_Report_Web.pdf

[114] Craig, A.; Learner, H. and Gray, P. *The Solar and Wind Energy Supply Chain in Ohio* (Environmental Law and Policy Center, January 2011). http://elpc.org/wp-content/uploads/2011/01/OhioWindSupplyFinal_HQ.pdf

[115] Renewable Energy Policy Project. *Ohio's Road to Energy Independence: Job Growth in Renewable Energy Component Manufacturing.* Summary of Findings, Renewable Energy Policy Project Technical Report, October 2006.

[116] Renee Schoof. "Flexible panels to let Xunlight in." Sunday Gazette-Mail. March 14, 2010. *HighBeam Research.* (August 28, 2011). http://www.highbeam.com/doc/1P2-21403697.html. According to Schoof: "Xunlight develops, manufactures and markets lightweight, flexible photovoltaic modules that convert sunlight into electricity, and serves as one of many successful examples of Ohio's ability to support the entire funding spectrum. Xunlight's start up success was in part a result of the more than $13 million Research & Development funding the company received from the US Department of Energy, US Department of Commerce, Ohio Department of Development and Ohio Third Frontier, and the more than $11 million in loans from the State of Ohio to develop its products and manufacturing process. Additionally, the company received more than $40 million in private investments from Emerald Technology Ventures, Trident Capital, NGP Energy Technology Partners, and Rabo Ventures to commercialize its product." See also "Ohio 2010 Venture Capital Outlook: Public-Private Strategy Is Key to Success; Public programs like Ohio Third Frontier complement private business development and entrepreneur investment." PR Newswire. March 10, 2010. *HighBeam Research.* (August 28, 2011). http://www.highbeam.com/doc/1G1-221271580.html

[117] Ohio is home to many universities, such as Ohio University and The Ohio State University, involved in energy and environmental R&D. The University of Dayton houses one of the DOE's Industrial Assessment Centers. Ohio Centers of Excellence which involve the state's public and private universities are key to helping to foster these clusters. See http://www.uso.edu/opportunities/centers-of-excellence/index.php.