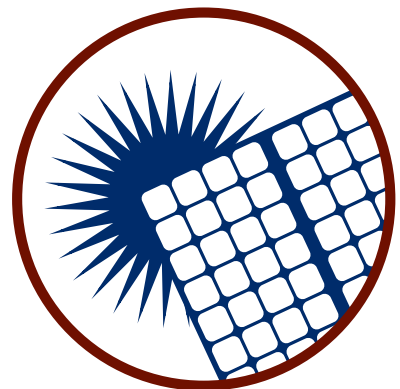


Clean Energy Economic Development Series

OHIO'S ADVANCED ENERGY JOURNEY



NOVEMBER 2012

Prepared by Collaborative Economics
for Environmental Defense Fund

Report prepared for

Environmental Defense Fund - Environmental Defense Fund's mission is to preserve the natural systems on which all life depends. Guided by science and economics, we find practical and lasting solutions to the most serious environmental problems. What distinguishes Environmental Defense Fund is the combination of what we protect and how we protect it. We work to solve the most critical environmental problems facing the planet. This has drawn us to areas that span the biosphere: climate, oceans, ecosystems and health.

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Collaborative Economics works with senior executives from business, foundations, government, education and community sectors - helping them create breakthroughs in how people think and act regarding their region. Collaborative Economics' clients have the passion, vision and commitment to blaze a new pathway for their community. They understand that a new kind of leadership is required to create great places, with thriving economies and world-class quality of life.

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ABOUT THIS REPORT

Collaborative Economics has analyzed the clean energy economy in all 50 states for the Pew Charitable Trusts and National Governors Association, and for many states and communities from California to Delaware, from Silicon Valley to St. Louis. Collaborative Economics published the country's only Green Innovation Index, focusing on changes in jobs, companies, financing, and other indicators of innovation in California. As importantly, we have worked directly with practitioners at the state and local levels all across the country to develop strategies to encourage development of clean energy sectors.

We have been struck by the determination with which public and private sector leaders are working together to turn the clean energy opportunity into an economic development “win” for their state or community. They focus on the basic “blocking and tackling” of job creation – encouraging market growth, streamlining permitting processes, making strategic investments, training workers, and helping companies find places to grow.

Through tracking the experience of individual firms in the clean energy sector (see LessCarbonMoreJobs.org), Environmental Defense Fund research continues to show that job creation in the clean energy sector – as in all sectors – must begin with creating customers. A focus on job training that ignores the need to simultaneously create customers may see trained job seekers, but little actual hiring. In contrast, regions that focus on nuts and bolts efforts, particularly in the key areas of market demand (notably creating customers now), seeding innovation, company recruitment and workforce development, are most likely to succeed.

The clean energy economy is growing, state by state, community by community, across the country. Job creation and private investment in manufacturing, installation, R&D, and other services are signs that the market is rewarding innovative, competitive companies. The reason for this success goes well beyond any single public policy, investment, or training program. Indeed, the formula that is working is a mix of federal, state, and local government initiatives, private sector economic development efforts, and industry associations and collaborations. It is also the result of bipartisan efforts to help stimulate market demand, seed innovation, then capture the economic benefits for people and places in these states. While these actions can occur independently, economic growth can be more successful with a multi-faceted approach that involves collaboration across sectors and stakeholders.

Every state and community that has experienced the benefits of a growing clean energy economy has blazed its own trail. Each one has a distinctive energy mix, set of natural assets, and existing industry strengths in manufacturing, agriculture, research, or other areas. What they have in common is the recognition that clean energy is a tangible opportunity for economic growth, just as it was biotechnology, information technology, or other opportunities in years past. In these states and communities, leaders find more reasons to work together on practical steps to promote job creation, than oppose one another to gain political advantage.

Their stories – their journeys – are clearly in the early stages. They would be the first to say they have a long way to go. But, as Colorado, Iowa, Ohio, and others have shown, states and communities can take action and get results in the form of new jobs, companies, and innovation that helps meet immediate needs and set the stage for future economic growth.



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OVERVIEW OF OHIO'S ECONOMIC JOURNEY INTO ADVANCED ENERGY

Ohio has demonstrated that the advanced energy¹ technology industry has important potential to diversify and contribute to the state and local economy.

- **Ohio's public and private stakeholders work collaboratively to build strong advanced energy activity throughout the state economy.** Stakeholders from both sides of the political aisle have endorsed programs that support the commercialization of promising technology and stimulate demand for advanced energy products. The Advanced Energy Economy Institute estimated that more than 400 establishments and at least 25,000 workers are directly linked to the advanced energy industry, across the multitude of subsectors and professions (AEEI, 2012).
- **Ohio's manufacturers are diversifying to produce advanced energy products.** Ohio's manufacturing leaders like Timken Co., Parker Hannifin and Owens Corning have developed products that serve advanced energy end markets. New companies and smaller-scale manufacturing and machining businesses are also participating in the sector.
- **Ohio is a national leader in advanced energy research, stemming from the state's universities, as well as other public and private sector research efforts.** These stakeholders have established specialized research centers that encourage collaboration across institutions and connect researchers with private businesses. Ohio's patent registrations in advanced energy nearly doubled over the last decade and climbed in national rankings.
- **Ohio cultivates growth in diverse advanced energy technologies.** Ohio has one of the largest wind supply chain networks in the United States, is a national leader in research activity for fuel cells and batteries, developed a strong thin-film solar manufacturing cluster, and is home to the most energy efficiency product manufacturers in the Midwestern United States. Strategic economic development efforts are also targeting emerging sectors like industrial waste heat recovery and smart grid.

Ohio's rapid expansion across the advanced energy economy cannot be attributed to any single effort; stakeholders have worked across jurisdictions, sectors, and political party lines to collaboratively build multiple advanced energy technology clusters and opportunities for workers across the skills spectrum. Businesses, state and municipal government leaders and nonprofit organizations have taken action to strategically leverage the state's historical strengths in research and manufacturing. Stakeholder initiatives included stimulating local demand for advanced energy projects, investing in promising advanced energy technologies and capturing economic benefits locally by building industry networks and training the workforce. Taken together, these efforts propelled Ohio into national leadership in advanced energy technology innovation and production, and prompted strong growth in technology deployment. The efforts have cultivated business growth and employment opportunities for Ohioans with a range of skills, from specialized machinists to financial services professionals.

Although Ohio's definition of advanced energy includes many subsectors, this report will focus on developments in renewable energy, advanced storage, fuel cells, and energy efficiency technology, with a sampling of examples from emerging sectors such as smart grid and industrial waste heat recovery. It will specifically highlight the Northeastern region of Ohio (including Cleveland, Akron, Canton and Youngstown), to exemplify how multi-stakeholder collaborative efforts in Ohio have increased economic activity in the advanced energy industry.

¹ Ohio's definition of advanced energy encompasses a wide range of subsectors, including wind, solar, biomass, fuel cells, energy efficiency, advanced storage, nuclear, natural gas, smart grid, hydropower, industrial waste heat capture and clean coal

OHIO'S ADVANCED ENERGY ECONOMY ACTIONS

A robust advanced energy economy is based on strong customer demand for advanced energy products and services with ongoing innovation to advance the sector.

A region can develop all or part of this economy locally through focused actions in three different categories: stimulating demand, seeding innovation, and capturing economic benefits. These types of actions may be focused in just one category, but sector growth can be more successful with a multi-faceted approach that involves collaboration across sectors and stakeholders.

The Ohio Action Timeline exhibits a sample of advanced energy initiatives and milestones introduced by stakeholders that stimulated end markets, seeded innovation, and helped the region capture economic benefits in wind and solar technology, fuel cells, advanced storage and energy efficiency technology. Ohio's stakeholders are active at the local, regional and state level, from public agencies, private companies, academic institutions, and nonprofit organizations. These stakeholders have worked across sectors to foster innovation, entrepreneurship and job creation.

Ohio's story is compelling because local and state policies were implemented alongside private business and nonprofit collaborative efforts to accelerate the sector's growth. It is also important to note that Ohio's stakeholders consistently employed strategic actions across all three categories, pulling forward end market growth as well as pushing markets into new innovations and local production since the late 1990s.

ACTIONS TO BUILD THE ADVANCED ENERGY ECONOMY

Stimulating Demand – Initiatives that increase consumer demand for advanced energy by increasing affordability, removing barriers, or setting standards for advanced energy.

Seeding Innovation – Actions to increase local advanced energy innovation by investing in research and development, funding new startup companies, or creating supportive networks.

Capturing Economic Benefits – Actions to recruit and support advanced energy companies while also promoting and aligning job creation and workforce development

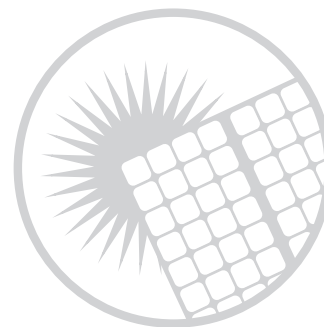
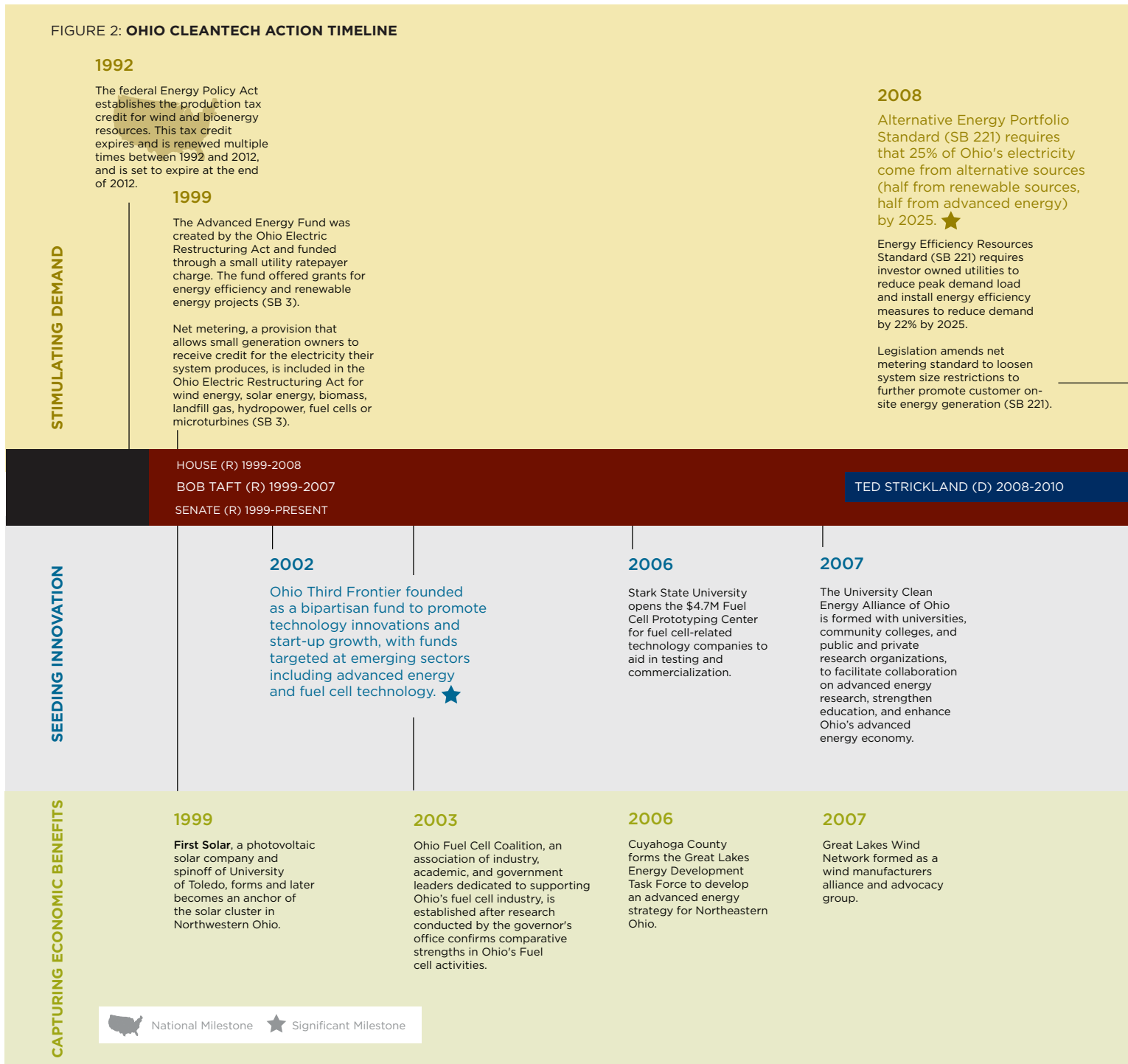


FIGURE 2: OHIO CLEANTECH ACTION TIMELINE



STIMULATING DEMAND

Ohio policymakers have stimulated demand for advanced energy through a mix of regulatory reform, incentives and an advanced energy portfolio standard. State, local, and federal governments often stimulate end markets for emerging technologies by setting standards for use, removing barriers to implementation, or creating incentives for customers to buy the technology. The advanced energy sector requires large amounts of capital investment to develop and bring the technology to market, and therefore represents a risk for private businesses. Market stimulus actions signal to businesses that the

state is supportive of advanced energy technology, and that end market demand for the product will exist.

Ohio's state government has demonstrated consistent support for the advanced energy industry over the years and across political party lines. Former Governor and later Senator George Voinovich (R) advocated for low emissions electricity sources, focusing primarily on nuclear energy. Governor Bob Taft (R) supported diverse advanced energy technologies, including fuel cells and renewables, through a series of investment programs. Governor Ted Strickland (D) worked with

2008

The Energy Improvement and Extension Act of 2008 extends the federal business energy investment tax credit by increasing the duration of the credit by eight years, increasing the credit amount for fuel cells, and creating new credits for small wind systems, geothermal heat pumps, and combined heat and power systems. The credit was further expanded by the American Recovery and Reinvestment Act of 2009. (HR 1424)

2009

The American Recovery and Reinvestment Act awards \$658M to Ohio for projects in energy efficiency, renewable energy, electric grid, transportation, and science and innovation.

Energy Conversation for Ohioans (ECO-Link) program offers Ohio homeowners reduced rate financing for energy efficiency and renewable energy home upgrades.

2011

First Energy Northeastern Ohio's Investor Owned Utility commits to purchasing 5,000 MWh Solar Renewable Energy Credits and 20,000 MWh Renewable Energy Credits in equal quantities each calendar year, from 2011 to 2020.

2012

Governor Kasich's energy plan establishes Waste Energy Recovery and Combined Heat and Power as energy sources that can contribute to meeting the renewable portfolio standard and also reaffirms support for alternative energies. (SB 315)

HOUSE (D) 2009-2010

HOUSE (R) 2011-PRESENT

JOHN KASICH (R) 2011-PRESENT

2008

Great Lakes Energy Institute launches at Case Western Reserve University to organize research, industry collaboration and student programs around energy

2010

Ohio Third Frontier program extended to 2015 by voters.

2011

Northeastern Ohio is awarded a \$2M federal Jobs and Innovation Accelerator Challenge Grant to improve speed-to-market for near-production or pilot-production companies in the advanced energy and flexible electronics industry clusters.

US Department of Energy awards over \$1.5M to three Northeastern Ohio groups to study impact and feasibility of deep offshore wind farms in Lake Erie.

2008

NorTech, a Northeastern Ohio cluster promotion group, identifies advanced energy as a focus area and lays groundwork for strategic cluster development in the sector.

Ohio Bipartisan Job Stimulus Plan (HB 554) which includes the Advanced Energy Job Stimulus Program to train workers and encourage development, production and use of advanced energy projects from 2009 to 2011.

2009

Lake Erie Energy Development Corporation was developed and launched by NorTech Energy Enterprise, the Cleveland Foundation, City of Cleveland, Cuyahoga and Lorain Counties as a group to promote offshore wind in Lake Erie.

2010

Ohio Energy Gateway Fund created, which combines \$40M in federal American Recovery and Reinvestment Act funds with state and private funds for investment in fuel cell, solar, wind, and energy storage industries in Ohio.

Northwestern Ohio is identified as Ohio's Solar Hub of Innovation and Opportunity by the state; receives a \$250,000 state grant to help advertise the region as a hub and logical place for alternative energy investment.

2005-2012

Companies originated or expanded in the advanced energy sector in Ohio. Some examples: **Parker Hannifin**, **BASF** (acquired Novolyte Technologies), **LG Chem** (acquired Rolls Royce Fuel Cells), **GrafTech**, **Isofoton**, **Smashray** and **Tremont Electric**

the Republican-led legislature to build on those legacies to codify an inclusive electricity source standard to reduce Ohio's emissions. Current Governor John Kasich (R) has reaffirmed many of the tenets of past policies and broadened the electricity standard to include industrial waste heat recovery.

One of the earliest major milestones for Ohio's advanced energy economy was the creation of the Advanced Energy Fund in 1999 during the gubernatorial administration of Bob Taft (R) by the Republican-led legislature. This program supported renewable energy and energy efficiency projects across the state. Originally, the Advanced Energy Fund gained financing

through a surcharge on ratepayer utility bills. In 2010, Ohio voters allowed the surcharge to expire, and the Fund now exists as a revolving loan fund for renewable energy and energy efficiency projects.

Another major market expansion action came as a result of the Ohio Senate Bill 221 (SB 221) in 2008, which established Ohio's Alternative Energy Portfolio Standard (AEPS) and Energy Efficiency Resources Standard (EERS). This legislation passed under the leadership of the Republican party with bipartisan support in the Ohio legislature, and Ted Strickland (D) as the governor. Ohio's AEPS and EERS established Ohio as not only a place to produce components and

perform research in advanced energy, it created predictable, mandatory end markets for local installation of these technologies as well.

The AEPS requires that Ohio's utilities generate 25 percent of total retail electricity from alternative energy sources by 2025. This standard is split into two main parts.

- 12.5 percent of Ohio's total retail electricity must be generated by renewable energy sources, including wind, solar, hydroelectric and biomass by 2024. This portion includes a mandatory solar-electric energy carve-out, which requires .05 percent of total electricity to be sourced from photovoltaic sources. Also, at least half of the renewable portion must be generated in Ohio, the equivalent of at least 6.25 percent of total electricity.
- 12.5 percent of total electricity must be sourced from what the legislation defines as advanced energy sources, which includes fuel cells, nuclear energy and clean coal by 2025 (DSIRE, 2012).

Although 12.5 percent sourced from renewables by 2024 is not an aggressive standard compared to many states' renewable portfolio standards today, it represented an ambitious goal from Ohio's 2007 baseline. Ohio's renewable energy (including hydroelectric) accounted for only 0.5 percent of total net electricity generated in 2007 (US EIA, 2012). The AEPS prompted Ohio's utility companies to

incentivize deployment of advanced energy capacity, which resulted in a dramatic rise in installation of these technologies, especially in wind and solar. Ohio's cumulative wind energy capacity was more than 55 times higher in the second quarter of 2012 than in 2008 (DOE, 2012), and cumulative solar capacity was 35 times higher in the first quarter of 2012 than in 2008 (SEIA, 2012 and Sherwood, 2010). However, in 2012, the AEPS was modified to include industrial waste heat recovery as an eligible renewable technology, which may compete with installations of other renewable energy technology and lower demand going forward.

The Energy Efficiency Resource Standard (EERS) also helped build Ohio's advanced energy sector by spurring investments in energy efficiency technology, and encouraging weatherization of homes and facilities. The EERS mandates that investor owned utilities reduce demand for electricity by 22 percent by 2025 (DSIRE, 2012). Similar to the AEPS, as of 2012 industrial waste heat recovery is now included as an eligible technology in the EERS.

Subsequent state and local measures reinforced these major market expansions. In 2010, the state legislature passed a property tax exemption for utility scale and commercial renewable energy installations. At the local level, Ohio's largest cities (Cleveland, Columbus and Cincinnati) introduced tax abatement programs for energy efficient buildings (DSIRE, 2012). Each of these efforts further expanded local demand for associated technologies, such as high efficiency lighting and energy efficient appliances.

SEEDING INNOVATION

Purposeful actions by the state, universities and private sector have helped Ohio become a leader in advanced energy technology innovation, by leveraging Ohio's system of universities and research institutions. Although patent and research activity has occurred in this sector for several decades, recent collaborative initiatives accelerated activity and encouraged commercialization of new technologies.

One of the most instrumental policies to support the advanced energy sector has been the Ohio Third Frontier (OTF), which is a state program that promotes technology commercialization. Advanced energy technology was identified as a key strategic industry early on in the program, and every subsequent gubernatorial administration has invested in advanced energy technology projects, ranging from wind, advanced storage and biofuels technology companies to various testing facilities around the state.

Ohio's academic community has also worked together to forge connections among researchers, institutions and industry to promote innovation. Since 2007, the University Clean Energy Alliance of Ohio (UCEAO) has brought together researchers from Ohio's fifteen universities, as well as other public and private research facilities including NASA Glenn, to provide a platform for collaboration through annual events and working groups. UCEAO formed as a result of universities seeking additional collaboration in order to be competitive for grants in the advanced energy sector. Since its formation, the alliance has partnered

with industry groups, various state agencies and the OTF to engage diverse stakeholders and promote innovation in advanced energy.

The Great Lakes Energy Institute (GLEI) based at Case Western Reserve University is another example of increased emphasis on cross-disciplinary, multi-stakeholder advanced energy research in the Northeastern Ohio region. GLEI has championed many initiatives, including providing technical assistance to emerging entrepreneurs, supporting private companies with special research projects, and connecting energy researchers in different departments on campus. GLEI formed in 2008, and since then, has quadrupled the amount of energy-related research occurring at the university (Anderson, 2012).

The Ohio Third Frontier program has helped take the fuel cell industry in Ohio to another level. It laid the foundation for the state's leadership in the industry by supporting applied R&D and thus commercialization; we also have the best quality fuel cell supply chain in the world, along with five fuel cell integrators developing technology to drive the industry forward.

Pat Valente, Executive Director of the Ohio Fuel Cell Coalition

The University Clean Energy Alliance of Ohio provides a platform for businesses and researchers to network; collaboration often grows organically and businesses are contacting universities directly for help with research and analysis.

Jane Harf, Director, University Clean Energy Alliance of Ohio

Wind Energy Research and Development Center - In 2011, Stark State College of Technology began construction on an \$11.8 million testing and training facility for wind technology next to the Akron-Canton Airport in Northeastern Ohio. Stark State developed the project in collaboration with the Stark County Port Authority, Stark Development Board and Timken Company, which is a large manufacturing company that produces bearings and other components for wind turbines. Timken invested more than \$6 million in the facility, and will use the space to test new products. It will also be used in wind technician training and hands-on research for students at the college. The project also received OTF funding and loans through Ohio's Advanced Energy Jobs Stimulus Program.

The Ohio Third Frontier (OTF) is a \$2.3 billion state grant program that was enacted by the Ohio legislature in 2002 with bipartisan support. It provides funds to businesses, universities, nonprofit organizations and research centers to support the development and commercialization of promising Ohio-based startup companies and technologies. The program is strongly supported by voters and was re-funded through a ballot initiative in 2010.

Advanced energy has been an important strategic industry for OTF since its inception. For much of the past decade, OTF has devoted funds specifically to fuel cell and photovoltaic technology development, as well as advanced energy in general, which includes wind and advanced storage. The program funds advanced energy projects ranging from technology testing centers to startup company training programs.

OTF has invested roughly \$140 million in advanced energy projects since 2002, nearly 12 percent of the program's total dispersed funds (Chagnon, 2012).

Key OTF investments in advanced energy innovation include:

- Stark State College of Technology's Fuel Cell Prototyping Center and Wind Energy Research and Commercialization Center
- Wright Center for Photovoltaics Innovation and Commercialization at the University of Toledo
- Start-up company accelerators like JumpStart in Northeastern Ohio

CAPTURING ECONOMIC BENEFITS

In order to help the region capture the benefits of the growing advanced energy economy, public and private stakeholders have worked collaboratively to align job creation and workforce development activities with recruiting and supporting companies. This alignment is a critical strategy to ensure that there are both job opportunities and trained workers in an area, and to capitalize on the auspicious business environment created from the stimulating demand and seeding innovation actions. Actions to capture the economic benefits include recruiting companies to locate and grow in the region, encouraging entrepreneurship and expansion of existing businesses and training a skilled advanced energy workforce. In Northeastern Ohio, chambers of commerce, industry organizations, local government and private businesses have been particularly successful in establishing a supportive business environment for advanced energy, developing and diversifying into new technologies, enhancing business networks and preparing the local workforce.

Northeastern Ohio's regional chamber of commerce, the Greater Cleveland Partnership (GCP), has been an influential voice of support for advanced energy, and a core regional development organization. The GCP has embraced an all-of-the-above advanced energy economy portfolio, reflecting its pragmatic goal to capture and create diverse economic benefits for the

region through the development of a robust energy economy. The GCP represents over 15,000 members from the business community and local governments and works to connect its members with each other to cultivate a business-friendly environment (GCP, 2012). It has advocated in the state legislature for supportive policies towards all advanced energy subsectors, though focused on offshore wind development, nuclear energy and clean coal (GCP, 2011). The GCP also works closely with Cleveland Plus and Team NEO, the region's marketing and business recruiting organizations, which also identified advanced energy as one of the region's important strategic sectors, and worked to encourage local expansion of advanced energy businesses and draw new companies.

Isfotón North America's new Ohio manufacturing facility is an example of our commitment to the U.S. market, and benefits from the support of key partners, including Samsung, Mercedes AMG, Posco, as well as our highly productive R&D and economic development partnership with the University of Toledo, Ohio.

*Ángel Luis Serrano, CEO, Isfotón
(Beetz, 2012)*

Ohio's development and diversification of local advanced energy businesses are supported by a variety of private and public organizations. NorTech is the GCP's economic development partner that promotes innovation, commercialization and emerging technology-based industry clusters, with a focus on advanced energy technology since 2009.

NorTech also collaborates with the Manufacturing Advocacy & Growth Network (MAGNET), Northeastern Ohio's manufacturing business development group, to help interested manufacturing companies expand into advanced energy end markets. MAGNET leads the Partnership for Regional Innovation Services to Manufacturers (PRISM) program, which helps businesses expand and improve their business models by offering technical assistance on lean manufacturing processes, product design and new markets. Roughly 20 to 25 percent of PRISM clients are related to the advanced energy sector (Schober, 2012). One client, Transformer Engineering, LLC (Trenco) is headquartered in Northeastern Ohio, and develops customized electromagnetic components for a variety of industries including wind and solar energy. Trenco participated in PRISM to learn lean manufacturing principles to improve processes and become more competitive (MAGNET, 2012).

Large Ohio-based companies have also taken a key leadership role in the sector by partnering on research and fueling demand for local suppliers, installers, engineers and affiliated services roles. In the wind industry, companies such as Timken Co., Owens Corning and Sherwin-Williams invested in local research and development, launched new products and forged partnerships with research institutions, suppliers and customers. Leading companies in fuel cells including GrafTech, LG Chem (formerly Rolls Royce Fuel Cells) and BASF Catalysts, have also prompted expansion of local research, workforce training and component supply chains. In Northwestern Ohio, First Solar served as an early anchor of a now substantial solar technology cluster, with several startup companies and a very active university research community.

In addition to homegrown development, the state of Ohio also works with regions to recruit advanced energy companies. One example is Spain-based Isofotón, a photovoltaic manufacturer which begins production in Northwestern Ohio with roughly 120 employees in November 2012.

As the Greater Cleveland Partnership's economic development partner specifically promoting advanced energy in the region, **NorTech** plays several key roles for the sector, including the following key examples.

First, it markets the region as an advanced energy hotspot for businesses and destination for investment. NorTech collaborated with the Manufacturing Advocacy & Growth Network (MAGNET) and other regional groups to secure a two million dollar federal White House Jobs and Innovation Accelerator Challenge grant in 2011 to push forward promising close-to-market advanced energy technology, and train the associated workforce. Northeastern Ohio was one of 20 regions in the nation to win.

Second, NorTech builds networks within and across subsectors to facilitate collaboration on regulatory and business improvements, as well as connect businesses across the value chain (suppliers, customers, project developers, financiers, etc). NorTech's advanced energy network directory contains more than 500 Northeastern Ohio businesses, organizations and research institutions, including over 170 that identify themselves as connected to the wind industry.

Third, NorTech drives strategic growth in the sector. It has also identified and "roadmapped" emerging advanced energy subsectors in Northeastern Ohio in collaboration with industry leaders, and compared Northeastern Ohio's strengths to other regions. Because resources are limited, the roadmaps help the region target support for specific subsectors that are most likely to succeed in the long term.

The Sherwin-Williams Company has developed industry leading coatings technologies at its Cleveland-based research and development center to support our nation's growing investment in alternative energy assets. With regional manufacturing strength in steel, fiberglass, resins, electronic control systems, and storage capabilities, Northeastern Ohio offers significant opportunities for partnerships in this fast growing market.

Christopher Connor, CEO, The Sherwin-Williams Company (Cleveland Plus, 2010)

Individual counties and cities have also taken steps to cultivate the local advanced energy economy. An example is Cleveland's home county, Cuyahoga, which created the Great Lakes Energy Development Task Force in 2006 to bring together stakeholders around a county energy strategy. This task force laid the groundwork for the Lake Erie Energy Development Corporation (LEEDCo), which now actively promotes an offshore wind pilot installation off the coast of Cleveland.

In addition to broad advanced energy sector efforts, subsector-specific organizations have deepened networks within specific advanced energy segments such as fuel cells and wind energy. The Ohio Fuel Cell Coalition, for example, formed in 2002 as an advocacy organization to educate policymakers about the fuel cell subsector and connect researchers, fuel cell integrators and suppliers across the state. The Great Lakes Wind Network (GLWN) is a similar organization that formed in 2007 to support the wind industry, and subsequently connected and mapped more than 300 wind-related businesses across the United States, as a means of helping Ohio manufacturers and businesses participate in the wind turbine supply chain.

In addition to building a favorable business environment, supporting company diversification and enhancing networks, preparing Ohio's workforce for advanced energy jobs has also been important to capturing economic benefits of the sector. Across Ohio, initiatives have been undertaken at the regional, academic and state levels to ensure that local workers are equipped for jobs in the advanced energy sectors.

Training programs at universities and colleges around the state are numerous, ranging from solar installer training to nuclear engineering programs. These have expanded rapidly in recent years to meet the wide

range of skill levels required by the diverse advanced energy subsectors, such as Stark State's development of a Fuel Cell technician training program and University of Akron's College of Engineering research program in fuel cells and other advanced energy technologies. Private industry partners have also invested in cultivating a skilled workforce. For example, in 2011 wind developer Iberdrola Renewables donated \$150,000 to an Ohio career center to create a wind technician training program (Bloomberg, 2011).

It is important for the academic world to play a role in economic development. As experts in our subject matter, we offer research capabilities to the community. We also are responsible to prepare students for careers in advanced energy, as they are our future entrepreneurs and innovators.

*Dianne Anderson, Executive Director,
Great Lakes Energy Institute*

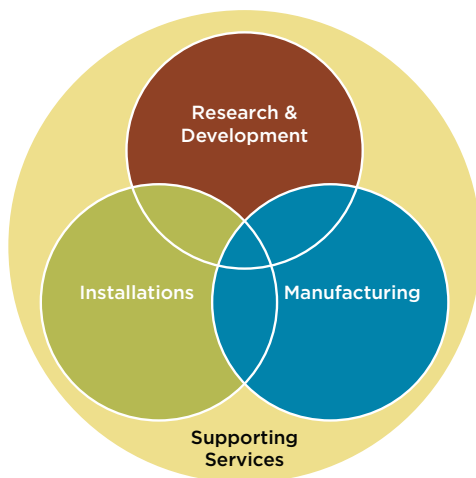
LEEDCo is a nonprofit development corporation working to build an offshore wind industry cluster of activity in Northeastern Ohio. LEEDCo was developed by public and private partners, including NorTech, four counties, the City of Cleveland, the Cleveland Foundation and the private developer Freshwater Wind, LLC. Researchers from universities and the private sector have also supported LEEDCo's efforts to evaluate offshore wind feasibility. The organization sought and received federal support for the project as well, including a U.S. Department of Energy award of \$500,000 specifically to study cost reduction strategies for the pilot offshore project.

ADVANCED ENERGY ECONOMY CREATING RESULTS

The actions that Ohio stakeholders have taken to build a robust advanced energy economy have created impressive results. The region has emerged as a leader in advanced energy product manufacturing and innovation, and demonstrated a growing customer demand for advanced energy products and services.

OHIO'S ENERGY TECHNOLOGY VALUE CHAIN

FIGURE 1
ENERGY TECHNOLOGY VALUE CHAIN



The investment and work in Ohio to stimulate demand, seed innovation and capture economic benefits locally has paid dividends across the value chain. The segments of the value chain may exist independently, but provide a more robust economic cluster when all segments are fully developed and working together. Figure 1 illustrates the interaction of the energy technology value chain segments. Ohio now boasts companies that provide each of these activities:

Research & Development (R&D): R&D activities are carried out primarily by research institutions, such as federal laboratories, universities, or private company research divisions. R&D activities foster an environment centered on developing new products and processes so that the region can become a leader in innovation.

Manufacturing: Manufacturing involves production of a technology and includes companies throughout the supply chain, ranging from component suppliers to those assembling complete units for sale to consumers.

Installation: Installation of clean energy technologies, such as developing wind turbine farms, will occur in response to market demand. Companies involved in activities such as site assessment, logistics, transportation, and construction play an important role in installation.

Supporting Activities: A variety of other activities are critical to supporting clean energy technology. These supporting organizations facilitate interactions among players, provide funding, educate consumers, advocate for business friendly policies, or provide technical support and product maintenance services.

STRONG RESEARCH ACTIVITY

Ohio's research expertise has helped position it as a driver in the advanced energy sector for several decades. Ohio has fifteen research universities throughout the state, along with the NASA Glenn research facility, Battelle and the Air Force Research Laboratory at Wright-Patterson Air Force Base. Many private companies active in the advanced energy economy conduct research and development in Ohio as well, including Rockwell Automation, First Solar and Lockheed Martin, amongst many others. Collectively these entities have encouraged a thriving research community, as evidenced by the extensive patent registrations in the state, across a range of subsectors.

Ohio has exhibited remarkable growth in innovation over the past decade (Figure 2). Since 1996, total advanced energy patent registrations nearly doubled, increasing by 94 percent. Over the same period, Ohio's fuel cell, solar and electric vehicle patent registrations roughly doubled, and wind-related patents tripled. Ohio consistently ranks among the top ten states for patent registrations in the advanced energy sector, as shown in Table 1. In addition to being a leader in advanced energy patents overall, Ohio also remains strong within individual patent segments. Ohio climbed in state rankings for patent registrations in batteries, fuel cells and wind over the past decade (Table 2).

Capital investment is important to furthering research and development efforts in the advanced energy sector. Venture capital, private equity investments and majority stake acquisitions may infuse capital into an organization, or companies can increase their research capabilities and product offerings through acquisition of other companies. Private and corporate investments in advanced energy in Ohio have changed shape over the past ten years (Figure 3). In the early 2000s, venture funding lead investment deals in

Ohio. However, as the sector matured, other forms of private equity and more merger and acquisition deals have been announced. Ohio's large manufacturing companies have been particularly active in acquisition of advanced energy product technologies since 2009, led by Eaton Corporation and Parker Hannifin.

TABLE 1
TOTAL ADVANCED TECHNOLOGY ENERGY PATENTS
Top Ranking States in Patents Registered

	1996-99	2008-11
1	California	California
2	New York	New York
3	Michigan	Michigan
4	Texas	Texas
5	Michigan	Massachusetts
6	Massachusetts	Ohio
7	Ohio	Minnesota
8	Georgia	Pennsylvania
9	Florida	Illinois
10	Pennsylvania	Connecticut

TABLE 2
OHIO'S ADVANCED ENERGY PATENTS
National Rank in Patents Registered

	1996-99	2008-11
Batteries	7	5
Fuel Cells	8	7
Wind	18	7
Solar	13	13
Electric Vehicles	3	3
Total Advanced Energy	7	6

FIGURE 2
ADVANCED ENERGY PATENTS TRENDS
BY TECHNOLOGY TYPE OVER TIME
OHIO

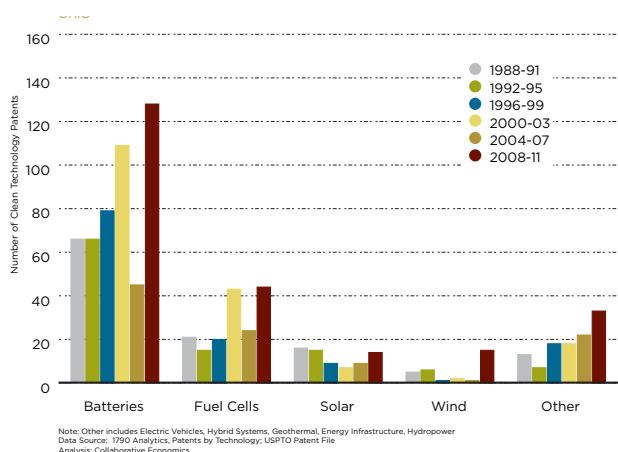
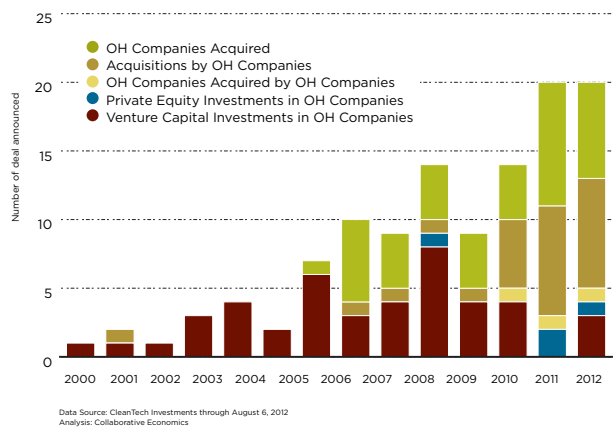


FIGURE 3
ADVANCED ENERGY INVESTMENTS AND MERGERS AND ACQUISITIONS
ANNOUNCED DEALS INVOLVING OHIO ADVANCED ENERGY FIRMS



Ohio's Fuel Cell Research Leading to Economic Expansion - Fuel cell research has been strong in Ohio for many decades, with universities like Case Western Reserve and Ohio State, and research institutions such as Battelle, along with many private companies leading the way. This research leadership has led to extensive economic expansion, both through investments in research and component supply chains.

Investments in the sector gained momentum throughout the 2000s and into the present. The Ohio Third Frontier had a specific Fuel Cell Program from 2002 to 2011, which drew private and other public investment to the sector with a leverage ratio of 4:1 (Ohio Third Frontier, 2009). A recent corporate acquisition suggests the private sector is increasingly keen on investing in promising Ohio-based fuel cell technology. LG Chem acquired a majority stake in Rolls Royce Fuel Cells for \$45 million in June 2012 (Bloomberg, 2012). The technology is still under development.

From 2004 to 2008, the number of businesses participating in the cluster expanded 75 percent (Ohio Third Frontier, 2009), many of them in the fuel cell supply chain. Pat Valente of the Ohio Fuel Cell Coalition notes, "there is not a fuel cell manufactured in the United States that does not have Ohio components."

MAINTAINING MANUFACTURING LEADERSHIP BY EXPANDING INTO ADVANCED ENERGY

Advanced energy manufacturing activity in Northeast Ohio has gained momentum in recent years, helping the state diversify its customer base to maintain its leadership role in manufacturing and attracting new firms. Ohio's manufacturing activity has grown from its historical strengths of specialized businesses, a skilled workforce, and key location for transportation logistics.

Because Ohio's advanced energy sector is diverse, the sector offers opportunities for workers with varying levels of education and skills. There are job concentrations in multiple subsectors, ranging from wind to batteries, as well as in various stages of production, including final products, machining, component parts, raw materials and many others. Both existing and startup businesses are opting to participate in the sector. The Advanced Energy Economy Institute conservatively estimated that more than 400 establishments and over 25,000 workers were linked to the Ohio advanced energy industry in 2010, across the multitude of subsectors and professions (AEEI, 2012).

For example, The Great Lakes Wind Network has gathered information about Ohio's wind suppliers and in November 2011 reported that 174 manufacturers around the state have sold their products into the wind market (Weston, 2011). The majority of those suppliers are machine shops and metal fabricators. Direct employment in the subsector was at least 640 workers in 2010, which includes only the employees of establishments that install, fabricate or develop technology for the wind industry as a major part of their business (AEEI, 2012). Estimates that include direct jobs and jobs farther down the supply chain are significantly higher. The American Wind Energy Association (AWEA) estimates that the wind industry employed over 5,000 people in 2011, the 4th highest state for wind employment in the United States (AWEA, 2012).

Diverse Advanced Energy Business Opportunities - Ohio's advanced energy establishments are coming from many parts of the manufacturing sector.

Several leaders in advanced energy subsectors have facilities located in Ohio. Manufacturing giants like Timken Co., Rockwell Automation, Parker Hannifin, Eaton Corporation and Owens Corning have developed or acquired products that serve advanced energy end markets like wind, smart grid and energy efficiency technology.

At the same time, many small to medium manufacturers have opted to diversify their product offerings into the sector. A study led by a Case Western Reserve University professor suggested that roughly 37 percent of small automotive suppliers attributed more than ten percent of their sales to "environmentally-friendly products" (Helper et al, 2011). This suggests that a solid portion of existing automotive supply chain businesses have diversified their customer base by participating in the advanced energy sector, even if not as their primary activity.

New companies have also emerged in Ohio, in some cases aided by regional early-stage business accelerators like Jumpstart or low-interest loans. Some examples are Catacel, which is commercializing fuel cell technology, Tremont Electric, which sells a movement-powered charger for electronic devices and Smashray, which offers high efficiency LED products.

In the fuel cell subsector there has been substantial growth in component manufacturing and integration of units. Between 2004 and 2008, the number of businesses and research institutions participating in the sector increased by 75 percent (OTF, 2009). At present, the Ohio Fuel Cell Coalition identifies roughly 40 Ohio manufacturers of fuel cell components or units and nearly 20 research and training facilities involved in the sector in the state (OFCC, 2012). Fuel cell industry employment in Ohio accounted for 9.8 percent of total national industry employment in 2010 (Valente, 2012).

The Solar Energy Industries Association (SEIA) noted that 55 solar manufacturing facilities are active in Ohio, and 160 businesses total when including installers, developers and other segments of the value chain (SEIA, 2012). Advanced Energy Economy Institute estimates that 1,350 people are employed by the photovoltaic industry in Ohio (AEEI, 2012). Although many of the manufacturing facilities are clustered around industry leaders First Solar and Xunlight in the Northwestern corner of the state, Energy Law

and Policy Center's supply chain research suggests a strong presence of component part suppliers in the Northeastern part of Ohio as well (ELPC, 2011).

Energy storage is another key subsector in Northeastern Ohio, and accounted for approximately \$105 million in revenues in 2009 (NorTech, 2011). There are roughly 27 organizations in the region involved in research, development and manufacturing. NorTech projects that Northeastern Ohio has potential become a domestic leader in emerging redox flow batteries and distributed energy storage systems technologies, because no other U.S. region has demonstrated comparable activity or strategic local assets (NorTech, 2011).

Ohio also has the highest number energy efficiency technology manufacturers in the Midwest. The state has 69 manufacturers of ENERGY STAR energy efficient products, including lighting and fans, home building materials and heating and cooling products, roughly double the number of businesses in neighboring Michigan (Energy Star, 2012).

Ohio's Robust Wind Energy Supply Chain - According to the Great Lakes Wind Network (GLWN), in 2011 Ohio had the highest number of wind supply chain manufacturers in the United States (Weston, 2011), many of them existing businesses that identified wind as a new opportunity. An example is Norlake Manufacturing Company, an electromagnetic component part supplier that worked with GLWN to improve efficiency and identify new customers. In 2011, Norlake leveraged GLWN's network to secure a contract with Ingeteam, an electrical systems company working with major companies in the wind industry, such as Siemens (WIRE-net, 2012).

Current market conditions for wind are worrisome for many Ohio suppliers given the uncertainty on the future of the federal wind Production Tax Credit (PTC). The PTC provides an income tax credit for the production of electricity from utility-scale wind turbines, and is set to expire at the end of 2012. As of October 2012, uncertainty about its renewal still loomed, contributing to a slowdown in the U.S. market demand for new wind turbines. According to a GLWN poll in the summer of 2012, there was "overarching pessimism" about the U.S. market among wind suppliers in light of the uncertainty around the PTC (GLWN, 2012). In Ohio, this has led many companies that have previously worked in the wind supply chain to seek out opportunities in other industries.

Despite the uncertainty, Ohio's wind sector has laid infrastructure to branch out strongly into different parts of the wind energy technology value chain. In addition to the many Ohio firms with the capacity to participate in wind manufacturing, there is also strong growth in onshore wind installations, potential for Lake Erie offshore installations, and new technology testing centers including the Wind Energy Research and Commercialization Center at Case Western Reserve University in Cleveland to advance and improve wind technology.

Echogen Power Systems is an Akron-based company launched in 2007 that develops industrial waste heat recovery technology. In light of Ohio's shift to include waste heat recovery into its AEPS and EERS, Echogen is poised to feed a growing demand for this technology.

Echogen's signature product was conceived at the NASA's Jet Propulsion Laboratory. Echogen licensed NASA's patented absorption heat pump technology, and then developed additional patent-pending innovations to arrive at the company's Thermefficient® Waste Heat Engine. The product is in beta-testing, and a large Midwest utility installed a demonstration product in 2009.

As a promising start-up company, Echogen has tapped into Ohio's commercialization support infrastructure. JumpStart, the Greater Cleveland Partnership's business accelerator partner, has invested in the company since 2007.

INSTALLATIONS RAMPING UP

Ohio's natural resources are numerous, including untapped wind and solar assets, offering opportunities for installers, technicians, developers and financiers to participate in the advanced energy sector. Although installations have increased significantly in the past few years, many experts believe there is a large gap between Ohio's potential for installations and what has been deployed to date.

In recent years, there has been a significant increase in wind turbine installations, though Ohio remains behind leading states in installations. AWEA reported that as of the second quarter of 2012, over 400 megawatts of cumulative wind capacity has been installed in Ohio, nearly triple the prior year. Although a significant increase, Ohio still has considerable potential to expand installations. It continues to lag behind the national average of installed capacity, though it has a total onshore wind resource potential of 54,920 megawatts (AWEA, 2012).

Offshore wind installations in Lake Erie have also been discussed widely in Northeastern Ohio, with extensive planning around a pilot offshore wind project. Offshore winds are more consistent than onshore ones, and Lake Erie is shallower than the other Great Lakes, offering potential access to an emerging market in the United States.

Solar deployment has also increased substantially. SEIA estimates that Ohio has installed 49 megawatts of solar power, had the 14th highest installed solar capacity level in the nation as of the first quarter of 2012, and was the leading Midwestern state for solar installations (SEIA, 2012). Since 2010, the amount of solar power installed in Ohio has more than tripled (SEIA, 2012).

CONCLUSION

Ohio's advanced energy economy has grown as a result of multi-stakeholder actions to stimulate demand for advanced energy products and services, foster advanced energy innovation, and help the region capture economic benefits from the sector's growth. R&D activity, advanced energy manufacturing, and renewable energy installations have all substantially increased in Ohio. This progress demonstrates Ohio's success in creating a diverse, robust advanced energy economy and establishing the region as a leader in the advanced energy industry.

- **Ohio policymakers from both sides of the aisle have worked together to stimulate consumer demand for advanced energy products and services.** Ohio's advanced energy portfolio standard and energy efficiency resources standard encouraged customers to purchase advanced energy technology, and indicated that the state is supportive of the advanced energy industry.
- **Ohio is a hub for advanced energy innovation in many subsectors.** Research institutions and private companies are working together to develop advanced energy R&D and commercialize promising technology through programs such as the Ohio Third Frontier. These programs are helping innovative technologies reach the consumer market.
- **Ohio's stakeholders have taken action to capture the economic benefits of the advanced energy industry growth locally.** Organizations such as NorTech and the Great Lakes Wind Network have worked with companies to help them locate and grow in the region. These efforts have created job opportunities for workers across the skills-spectrum.

Ohio, like other states, is vulnerable to market uncertainties such as those surrounding the federal wind production tax credit. However, stakeholders are confident that diverse advanced energy sector activity will continue through collaboration and support from local, state, and federal stakeholders. The time is ripe for Ohio to lead advanced energy innovation and foster strong economic activity to support the advanced energy sector.

ACRONYMS

AWEA – American Wind Energy Association

AEPS – Advanced energy portfolio standard

EERS – Energy Efficiency Resources Standard

GCP – Greater Cleveland Partnership

GLEI – Great Lakes Energy Institute

GLWN – Great Lakes Wind Network

LEEDCo – Lake Erie Energy Development Corporation

MAGNET – Manufacturing Advocacy & Growth Ntwrk

MW – Megawatts

OTF – Ohio Third Frontier

PRISM – Partnership for Regional Innovation Services

PV – Photovoltaic

R&D – Research and Development

SEIA – Solar Energy Industries Association

UCEAO – University Clean Energy Alliance of Ohio

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INTERVIEWS

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- **Ed Weston**, Great Lakes Wind Network

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