POWERING OHIO

A Vision for Growth and Innovative Energy Investment

Synapse Energy Economics, Inc.

IN PARTNERSHIP WITH

Case Western Reserve University | Great Lakes Energy Institute

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Synapse Energy Economics is a research and consulting firm specializing in energy, economic, and environmental topics. Since its inception in 1996, Synapse has grown to become a leader in providing rigorous analysis of the electric power and natural gas sectors for public interest and governmental clients.

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Founded in 2008, the Great Lakes Energy Institute (GLEI) is an interdisciplinary research institute dedicated to catalyzing breakthroughs in energy sustainability that address the most pressing problems facing our world. Located in Cleveland, Ohio and housed within the Case School of Engineering, we empower our faculty, students and partners to expand knowledge, deepen understanding, and create innovative and sustainable energy solutions.

COVER PHOTOS

LEFT: Jeremy Chenoweth and Benjamin Werkowski of EDP Renewables work atop one of the 52 windmills the company operates in Paulding County. *Source: AP*
TOP MIDDLE: Solar PV Manufacturing Associate in Perrysburg. *Source: First Solar*
BOTTOM MIDDLE: An autoworker assembles a transmission at the General Motors Transmission Plant in Toledo. *Source: AP*
RIGHT: Greg Alexander of Dovetail Solar and Wind installs solar panels in Westerville. *Source: AP*

Acknowledgments

We recognize the group of leading organizations and individuals that support a prosperous, modern Ohio energy economy and contributed to the vision in this report.

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Foreword

The U.S. energy industry is undergoing a transition toward clean energy that has the potential to unlock new investment, create jobs, attract business and advance economic growth. As a global financial institution operating in more than 60 countries, JPMorgan Chase & Co. has seen firsthand an increase in investments that large corporations, small businesses and governments are making in sustainability.

Individual states have a unique opportunity to encourage, and benefit from, this evolution. For this report, Synapse Energy Economics came together with the Great Lakes Energy Institute at Case Western Reserve University and leading businesses and organizations to explore how commitments to clean energy, advanced manufacturing, and smart technologies can create economic benefits for Ohio's communities and businesses. This report also illustrates the continued role of energy efficiency in enhancing business productivity and saving money for Ohio families. The state's skilled workforce, manufacturing base, clean energy resources and business-friendly environment provide a strong foundation from which Ohio can play a critical role in the energy transition within the state and across the nation.

JPMorgan Chase is committed to driving inclusive economic growth in communities where our employees, customers and clients live and work, and sustainability and clean energy are an important part of that. We have a long history in Ohio, proudly having served Columbus for 150 years. The state is also home to more than 21,000 of our employees, 4 million individual customers and nearly 250,000 business customers.

Currently, we are developing an on-site solar photovoltaic installation at our Polaris Corporate Center in Columbus, one of the largest single-tenant office sites in the world. Comprising up to 20 megawatts of capacity – enough to power the equivalent of 3,280 homes – it will allow us to lock-in long-term energy cost savings and increase the resilience of our energy supply in Ohio.

This effort will contribute to our goal to source renewable energy for 100 percent of our global power needs by 2020. In 2017, we also committed to facilitate $200 billion in clean financing through 2025 – which includes lending, underwriting and advisory services for companies and projects that facilitate renewable energy as well as clean water, transport and technologies. Together, these two commitments reflect JPMorgan Chase's objective to leverage our financial resources and expertise to support our clients and customers, and advance more sustainable development in our communities, including those in Ohio.

This report provides concrete examples of how many leading companies, operating in Ohio, are making investments in clean energy and developing new strategies to support the transition to a lower-carbon economy. We invite you to read more and join us in the conversation about how Ohio can leverage the opportunities from the energy transition to grow its economy.

MATTHEW ARNOLD
Global Head of Sustainable Finance
JPMorgan Chase & Co.

Introduction
and Executive Summary

Ohio can attract billions in investment and create tens of thousands of good jobs by embracing clean energy, while building on Ohio's traditional and emerging strengths. Decisions made in the coming years by political, business, and investment leaders will determine whether Ohio captures economic growth by developing a modernized energy economy, or risks losing valuable business to domestic and international competition.

Fortunately, Ohio builds from a strong foundation: The state is a manufacturing powerhouse, a center for innovation, and home to a skilled workforce. It also has enough wind, solar, and efficiency potential to power the state multiple times over. Ohio has the right ingredients to attract capital, projects, and jobs.

Because the stakes are high, a group of leaders is coming together to develop a pro-growth vision for what Ohio can achieve through energy innovation. The non-partisan vision in this report draws on the insights and experiences of representatives from some of Ohio's largest private employers, growing small companies, experienced state policymakers, city officials, labor voices, universities, and research and development institutions. We share a collaborative approach and a commitment to help Ohio move forward into a prosperous energy future. Many of us are already investing in this future.

We invite you to share your feedback on Ohio's biggest energy growth opportunities by joining the conversation at **www.poweringohio.org**. Your thoughts will contribute to a summer 2018 report that lays out a roadmap to the highest priority collaborative actions that Ohio business, government, labor, and civil society leaders can take through 2020. We will explore a set of pragmatic steps Ohio can implement to capture economic opportunity and create jobs across rapidly converging clean energy industries: transforming transportation, renewable energy generation, energy efficiency, and building and using the electric grid of the future. Please join us!

Ohio can

BUILD from its strong foundation.

Ohio has all of the components necessary for major growth and economic opportunity.

- **OHIO IS A MANUFACTURING POWERHOUSE.** Ohio's 15,500 manufacturers produce $106 billion of annual industrial output and employ more than 685,000 Ohioans, placing the state third nationally in manufacturing employment.
- **OHIO INNOVATES.** Ohio is home to dozens of corporate and federal research-and-development centers, and it has ranked tenth in the country in patents since 2010.
- **OHIO HAS A SKILLED WORKFORCE.** The state graduates more than 20,000 science, technology, engineering, and math students each year and is home to 34 accredited engineering programs. More than 150 apprenticeship programs train Ohioans to be machinists, and the state supports over 11,000 registered apprentices in construction.
- **OHIO SUPPORTS BUSINESS OPPORTUNITY.** Ohio offers a low cost of doing business, programs that support entrepreneurship, and a history of effective partnership between business and political leaders.

Ohio competes on regional, national, and global stages for investment. To avoid being left behind, Ohio must embrace a shared vision for clean energy success and take the actions necessary to make that vision a reality.

ATTRACT INVESTMENT from world-leading companies.

Ohio can attract additional investment if companies are able to meet their business and clean energy objectives here. Nearly half of the Fortune 500 companies—and 71 of the Fortune 100 companies—have set targets to increase their clean energy use or reduce greenhouse gas emissions from their operations. Ohio houses facilities for 61 percent of these committed Fortune 500 firms, and 73 percent of those in the Fortune 100. This includes 39 companies that are either headquartered in Ohio or among the state's 100 largest employers.

Some firms meet their commitments through remote transactional agreements with wind farms in Texas or Oklahoma, but many would rather meet those needs locally. If a company can pair an in-state renewable energy investment with its local facility, it increases energy cost certainty. Fixed price electricity contracts, only possible with renewable generators, reduce energy price risk for data centers and other large electricity consumers. The renewably powered data center investment opportunity alone is worth at least $6.2 billion over the next 10 years. As leading businesses push their supply chains to become more sustainable, Ohio can support local firms' pursuit of the resources they need to compete.

LEADING OHIO COMPANIES INCLUDE:

- General Motors, Owens Corning, and Procter & Gamble, which are using both in-state and out-of-state solar and wind to power their Ohio facilities.
- Kroger, which has reduced energy consumption almost 35 percent, saving more than $50 million.

LEAD a transportation transformation.

Vehicles are evolving. New models are lighter and more efficient, and the industry is transforming to build a connected, automated, and electrified future. Morgan Stanley projects that global sales of internal combustion cars will peak within the next five years, while Bloomberg New Energy Finance projects U.S. EV sales will grow 30 percent per year for the next decade and beyond.

The auto industry in Ohio faces both great risk and great opportunity from this transformation. Ohio could be left behind as demand for internal combustion vehicles falls, or Ohio could embrace electric drive manufacturing and extend its automotive leadership.

Ohio's expertise in materials and engines has benefitted the state by allowing Ohio's industry to lead efforts to make vehicles more efficient. The state will need to embrace further change to leverage its current leadership in the automotive industry and smart transportation into leadership in a connected and electrified future.

Our analysis shows that the difference between continuing the status quo and embracing new options is striking: by 2030, more than $6 billion in capital investment, over $900 million per year of manufacturing value added, more than 9,000 middle-income jobs in the industry, and 18,000 additional jobs throughout the rest of the economy. These additional jobs result from increased supply chain purchasing and from wages and profits re-spent in the economy.

LEADERS INCLUDE:

- Smart Columbus, which has leveraged $50 million in grants to rally $500 million from the private sector to enable an automated, connected, shared, and electric transportation system.
- GM and Ford, which will offer dozens of electric vehicle options within the next half decade.
- Workhorse Group, which is building electric commercial fleet vehicles and growing shipments at more than 200 percent per year.

BUILD AND DEPLOY clean electricity.

We recognize that natural gas is likely to play a continued important role in Ohio energy supply for years. While the Ohio natural gas industry has grown rapidly and offers economic benefits, the state can also look to capture renewable electricity generation benefits that all corners of the state can share if state policies allow this market to thrive. Wind and solar generation deployment draws on local supply chains for everything from steel to fiberglass to power-electronics. Meanwhile, these facilities will also provide new income streams for rural Ohioans who host, install, and maintain them.

Our analysis shows that over the next decade steady growth to 5.2 gigawatts (GW) of onshore wind and solar—only a few percent of the state's resource potential—would attract over $7.8 billion in investment to Ohio, create over 5,500 jobs, and boost annual GDP by over $2 billion. Ohio can also take the lead in the nascent industry of offshore wind in the Great Lakes, which alone presents an additional $7.4 billion opportunity to develop 1.5 GW between now and 2030.

ACTION IN OHIO INCLUDES:

- 604 MW of wind and 171 MW of solar PV have been built. Another 900 MW of wind and 275 MW of solar are permitted, although additional wind permitting is effectively stalled due to statewide siting restrictions.
- First Solar recently completed a retooling of its existing manufacturing facility and announced plans for an additional facility. By late 2019, First Solar will be capable of manufacturing 1.8 GW of solar modules annually at its Perrysburg facilities.

LOWER COSTS and boost business with efficiency.

Every dollar that Ohio families and businesses spend on wasted energy is a dollar they cannot spend on local products, services, or investments for the future. Ohio can keep its factories on the cutting edge of productivity by supporting upgrades to increase efficiency. This will drive down costs and help Ohio's plants compete. By investing $6.6 billion to increase energy efficiency in factories and buildings through expanded efficiency programs, Ohio can save hundreds of millions of dollars per year on energy, increase annual GDP by $500 million by 2030, and support 5,000 local installation, manufacturing, sales, and other jobs.

Energy consumers around the world are also demanding more efficient products as well as systems to improve product efficiency. Ohio's manufacturers can meet this need with increased exports of efficient technologies. Ohio's innovators continue to develop and manufacture more efficient lighting and appliances, design and implement new control systems to increase building and industrial performance, and produce materials and products—such as high-performance insulation—that are incorporated into more efficient buildings and processes.

LEADING OHIO COMPANIES INCLUDE:

- Walmart, which worked with Current by GE to install more than 1.5 million LED lights, saving more than $100 million in energy costs.
- Whirlpool and Stirling Ultracold, large and small manufacturers both pushing the limits of appliance efficiency.

HARNESS a 21st century electric system.

Sensors and controls are revolutionizing manufacturing, building operation, and the electric grid by providing visibility and new flexibility to improve performance. Ohio is home to early leaders in this rapidly developing area, and it can further attract and empower innovators if manufacturers, utilities, and regulators establish fertile ground for growth.

Innovators build companies where they have access to infrastructure, can draw upon existing networks, and get rapid feedback from local markets. A modernized grid will signal industrial and building-system innovators to come to Ohio, and to develop and deploy their 21st century solutions for export around the world. And last but not least, a smarter electric grid will provide increased reliability and resiliency for Ohio customers.

OHIO INNOVATORS INCLUDE:

- Case Western Reserve University, NASA Glenn Research Center, the University of Toledo, Eaton, Siemens, and Johnson Controls, which are collaborating to develop new tools for building, grid, and renewable energy integration.
- Duke Energy, AEP Ohio, and many of Ohio's municipal and cooperative utilities, which have deployed advanced meters to 20 percent of Ohioans and plan to double that number in the next few years.

How do we make this vision a reality?

Capturing all of the opportunities identified in this report would provide benefits beyond the sum of their individual contributions to transform the energy economy of Ohio. Getting the most out of each transformation – whether it is smart and electric transportation, manufacturing and building clean electricity generation, increasing energy productivity, or operating a smart grid that connects it all together – will depend on complementary actions in other sectors. Ohio becomes more attractive for investment and for workers with each forward step.

We believe that coherent and coordinated action will be required across multiple fronts to implement this vision. We have identified workforce, regulation and policy, and investment innovation as key drivers and enablers. These actions are not solely the responsibility of government: leading businesses, investors, educational institutions, labor, and advocates must each also do their part.

If Ohio cultivates an innovative workforce, develops smart technologies, and provides energy policy certainty, it can turn these synergistic opportunities into broadly shared and sustained economic success.

We look forward to engaging with Ohioans with diverse perspectives. Please visit the report's website at **www.poweringohio.org** to join the conversation.

CORPORATE LEADERSHIP

Support dozens of leading Ohio companies and attract new businesses.

$6.2 billion in investment

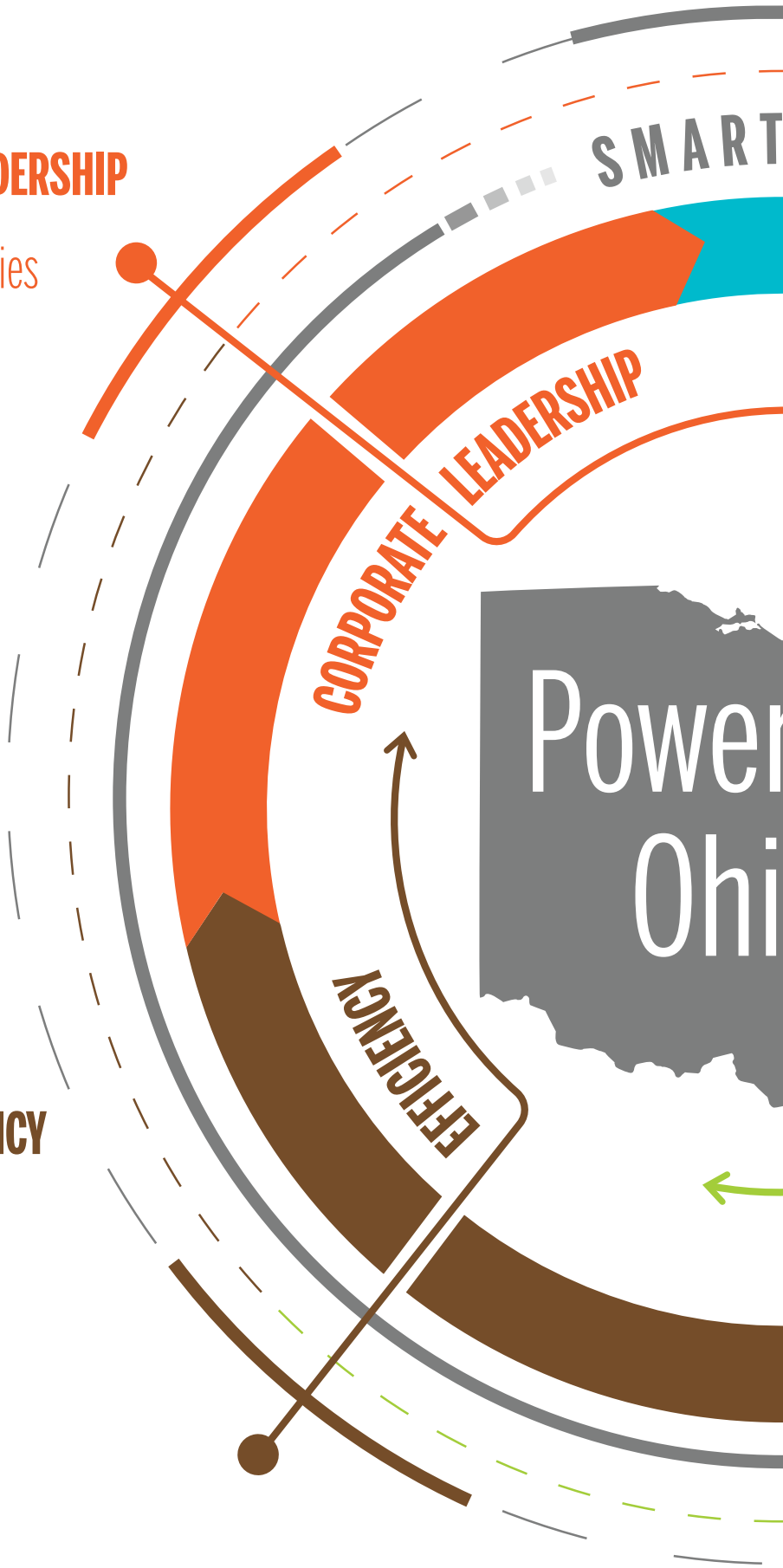
- 1,300 jobs
- From attracting 12 more data centers

EFFICIENCY

Invest in energy efficiency to enhance productivity and save money.

$6.6 billion in investment

- 5,000 jobs
- $500 million annual GDP



TRANSPORTATION

Expand automotive leadership into an electrified future.

$6+ billion in investment

9,000+ jobs

$900+ million annual GDP

CLEAN ELECTRICITY

Boost supply chains and create local jobs by developing 5.2 GW of wind and solar.

$7.8 billion in investment

5,500+ jobs

$2+ billion annual GDP

CLOCKWISE: Jeremy Chenoweth and Benjamin Werkowski of EDP Renewables work atop one of the 52 windmills the company operates in Paulding County. ***Source: AP*****; Greg Alexander of Dovetail Solar and Wind installs solar panels in Westerville.** ***Source: AP*****; An autoworker assembles a transmission at the General Motors Transmission Plant in Toledo.** ***Source: AP*****; Solar PV Manufacturing Associate in Perrysburg.** ***Source: First Solar***

Ohio's Energy Economy

Energy is a critical component of Ohio's economy: It lights, moves, and powers Ohioans' lives and businesses.

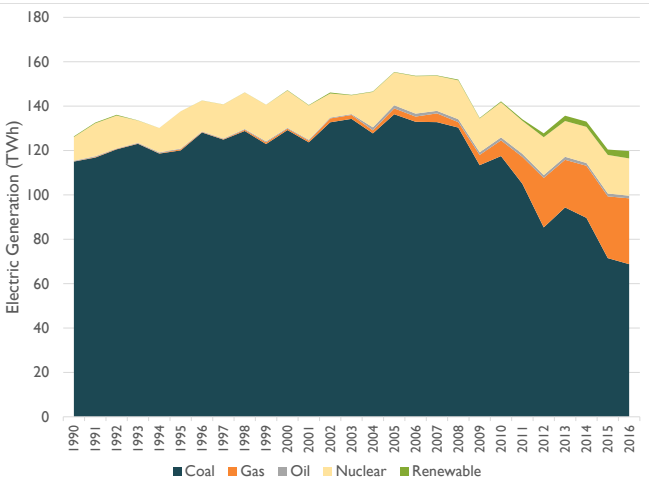
Ohioans spend almost $40 billion each year directly on energy—primarily electricity, natural gas, and motor fuel. This is equivalent to 6 percent of the state's GDP, and almost 40 percent of Ohio's $106 billion in industrial output.[1]

Of Ohioans' direct energy spending, less than half goes to the raw input fuels themselves. The rest goes to the wires, pipes, generators, gas stations and other infrastructure, and operations and maintenance of that infrastructure. For electricity, of the $14.9 billion that Ohio electric utilities and energy suppliers collect from customers, only about 30 percent pays for fuels. As electricity shifts more toward clean sources with no fuel costs, infrastructure costs will become even more dominant. Prudent and cost-effective investment in Ohio's energy infrastructure requires a clear and consistent long-term vision for the future.

The state's energy economy is changing due to reductions in coal production and consumption paired with rapid growth in natural gas and, to a lesser extent, renewable sources. Natural gas is a significant contributor to Ohio's energy mix, with development in the Marcellus and Utica shales creating economic activity and helping to displace coal generation. While this report does not define natural gas as clean energy or assess its future potential, we note that with the right policies in place—including methane emission reductions—dispatchable natural gas can effectively complement deployment of intermittent renewable energy, fostering clean energy deployment in parallel with the development of cost-effective alternatives such as energy storage.

This report addresses Ohio's clean energy opportunities. We define "clean energy" as vehicle fuel economy and electrification, renewable energy, energy efficiency, and grid modernization.* Together, these technologies represent Ohio's energy future.

FIGURE 1: Ohio's electric generation has shifted as natural gas displaces coal



Source: U.S. Energy Information Administration.

* We are not considering nuclear generation in this report because of our focus on new investment opportunities in the energy sector. No utility or power generator has proposed developing new nuclear generation in Ohio.

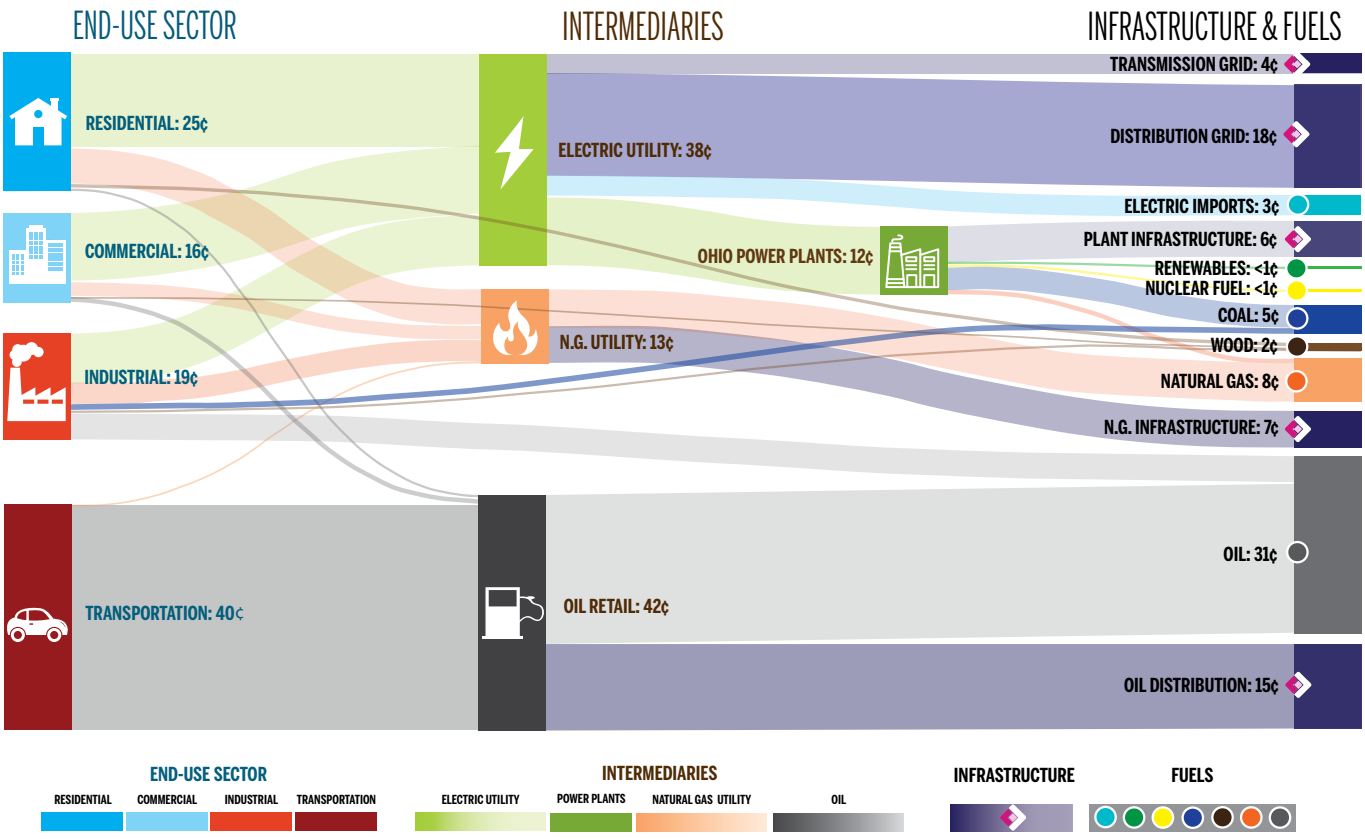


FIGURE 2: A typical dollar flowing through Ohio's $40 billion energy economy

The width of a line is proportional to its share of total expenditure. For example, from each dollar of Ohio energy spending, 40 cents are for transportation, 25 cents for homes, and 35 cents for commercial and industrial businesses. Electric distribution and generation utilities see 38 cents, of which they spend 12 cents on energy from Ohio power plants. As Ohio's energy economy shifts toward clean transportation and renewable electricity, oil spending that leaves the state will fall in favor of in-state electricity.

In examining how Ohio compares to other states on clean energy, there are several metrics to consider:

- The American Council for an Energy-Efficient Economy measures leadership in state policies and programs that improve energy efficiency throughout the economy;
- The GridWise Alliance Grid Modernization Index measures grid modernization policies, customer engagement, and implementation;
- Renewable generator deployment in both wind and solar by state is simply tallied by capacity;
- EV deployment is measured as a percent of sales.

Looking across these clean energy metrics, Ohio has room for improvement when compared to nearby competing states in the Midwest and upper South.

TABLE 1: Ohio's regional standing in various clean energy metrics

Rank in the Region	ACEEE Efficiency Scorecard	Grid Modernization Index	Wind Capacity	Solar Capacity	Electric Vehicle % of Sales
1	Minnesota	Illinois	Iowa	Minnesota	Wisconsin
2	Michigan*	Pennsylvania	Illinois	Pennsylvania	Pennsylvania
3	Illinois*	Michigan	Minnesota	Indiana	Illinois
4	Iowa	Missouri	Indiana	Missouri	Minnesota
5	Pennsylvania	Minnesota	Michigan	**OHIO**	Michigan
6	Wisconsin	**OHIO**	Pennsylvania	Tennessee	Missouri
7	Kentucky	Indiana	Missouri	Michigan	Tennessee
8	Tennessee	West Virginia	West Virginia	Illinois	Indiana
9	**OHIO**	Wisconsin	**OHIO**	Iowa	**OHIO**
10	Missouri	Tennessee	Wisconsin	Wisconsin	Iowa
11	Indiana	Kentucky	Tennessee	Kentucky	Kentucky
12	West Virginia	Iowa	Kentucky	West Virginia	West Virginia

**Tied*

Ohio's Energy Workforce

A 2017 survey of global CEOs by PwC identified three top priorities when pursuing new opportunities: innovation, human capital, and digital and technology capabilities.[2] At the same time, 77 percent of CEOs surveyed see key skill availability as the biggest threat to their business. For Ohio to capitalize on the opportunities identified in this report, the state will need to draw upon the strengths of its workforce, and to continue to make it stronger.

- The more than 100,000 clean energy jobs in Ohio are *good* jobs that help Ohio's working families thrive. The median annual wage in Ohio's clean energy economy is between $40,000 and $50,000, helping to maintain a strong middle class.[3]
- A 2017 survey by the U.S. Department of Energy identified almost 350,000 traditional and clean energy jobs in Ohio.[4] Almost half are in the auto industry, and just under a quarter are in energy efficiency. Only 12 percent are associated with coal, oil, or natural gas, including mining, extraction, and electric generation.
- Ohio's 15,500 manufacturers employ more than 685,000 Ohioans, placing the state third nationally in manufacturing employment.[5] More than one-third of the state's energy jobs are manufacturing jobs.
- Ohio's potential is growing: The state is home to 34 accredited engineering programs and graduates more than 20,000 science, technology, engineering, and math students each year – with more than 50 percent growth in STEM graduates over the last decade.[6,7] More than 150 apprenticeship programs train Ohioans to be machinists, and the state supports over 11,000 registered apprentices in construction.
- Innovators call Ohio home: Ohio is home to dozens of corporate and federal research and development centers, and it has ranked tenth in the country in patents since 2010.[8,9]

Owens Corning uses a 2.4 MW solar array to power its Toledo headquarters

Source: Owens Corning

Attract Investment

from World-Leading Companies

Many of these companies already have a presence in Ohio. The state can expand those existing investments and attract new ones by helping companies meet their business and clean energy objectives here.

The world's largest companies are making the business decision to pursue clean energy and using their operations and purchasing power to demonstrate their commitment. Nearly half of Fortune 500 companies and 71 Fortune 100 companies have set targets to increase clean energy use or reduce greenhouse gas emissions.[10] Importantly, many of these companies already have a presence in Ohio. The state can expand those existing investments and attract new ones by helping companies meet their business and clean energy objectives here.

Corporate demand for clean energy is a large and growing market: According to the Business Renewables Center, corporate renewable energy procurement in the United States and Mexico passed 3 GW in both 2015 and 2017, and the total since 2013 exceeds 10 GW.[11] Developing these resources drew investment of at least $20 billion. States that want to capitalize on this trend need to assess their regulatory frameworks. For instance, states like Ohio that allow customers to choose their own energy supplier are the easiest states for meeting company energy goals, because maintaining choice and access to competitive energy supply is a key tool these companies use to control costs. Ohio can go further. It can help companies reduce energy market risk by reducing siting barriers so that companies can more easily pair stably priced in-state renewable energy investments with their local facilities.

Technology companies needing power for data centers have been among the largest buyers of renewable energy. Industrial firms are also making substantial investments. For instance, General Motors will use a 100 MW wind farm in Ohio to power its plants in Ohio and Indiana as part of its commitment to reach 100 percent renewable energy by 2050. On-site solar is also an attractive option: JPMorgan

Chase will build up to 20 MW of on-site solar at its Polaris Corporate Center, Campbell Soup Company has installed 9.8 MW of solar at its plant in Napoleon, and Owens Corning powers its Toledo headquarters with an on-site 2.4 MW solar array.

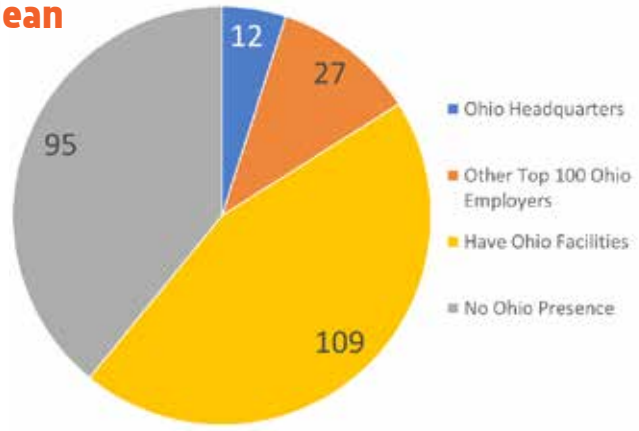
Ohio companies have sometimes invested outside the state to meet their commitments: Procter & Gamble uses 75 percent of the output from a wind farm in Texas, through a virtual power purchase agreement, to match the needs of its Lima facility. And in 2015, Owens Corning signed one of the world's largest wind power agreements by an industrial manufacturer. Through this agreement, the company will use wind from Texas and Oklahoma to match 60 percent of its U.S. electricity use.

Just as important as renewable energy, energy efficiency helps attract and retain commercial and industrial facilities. As a group of companies wrote to the Ohio legislature in 2017, energy efficiency "helps large commercial and industrial facilities reduce their energy costs so that they can compete in global markets."[12] Johnson Controls and Schneider Electric have joined a global initiative of companies pledging to double their energy productivity by 2030.[13]

For retailers, efficiency improvements help the bottom line. Kroger has reduced energy consumption almost 35 percent from a 2000 baseline and is on the way to a 40 percent target by 2020. Since 2000, the company has saved more than $50 million.[14] Walmart worked with Current by GE to install more than 1.5 million LED lights and has upgraded more than 5,000 rooftop heating and air conditioning units. In total, these initiatives have saved Walmart more than $100 million in energy costs.[15,16] JPMorgan Chase is partnering with Current, resulting in reduced energy use at about 4,500 bank branches.[17]

Companies are also looking to reduce the impact of their supply chain. As a result, clean energy is becoming more important for the smaller companies that supply these leading businesses. Walmart, for example, has launched Project Gigaton to reduce greenhouse gas emissions from its suppliers by 1 billion tons by 2030. Smaller companies can find it difficult to follow the leadership of the large companies featured here because they have less purchasing power and economies of scale. By supporting diverse ways to acquire renewable energy supply and enabling energy efficiency, Ohio can act to reduce those barriers and help all its companies compete.

FIGURE 3: Ohio presence of the 243 Fortune 500 companies with clean energy or climate commitments



These 39 Fortune 500 companies

These 39 Fortune 500 companies have made specific clean energy or climate commitments and are among Ohio's 100 largest employers or have their headquarters here:

- ALLIANCE DATA SYSTEMS
- AMAZON
- ANTHEM
- AT&T
- BEST BUY
- CROWN HOLDINGS
- CSX CORPORATION
- CVS HEALTH
- FEDEX
- FIFTH THIRD BANCORP
- FIRSTENERGY
- FORD MOTOR
- GENERAL ELECTRIC
- GENERAL MOTORS
- GOODYEAR TIRE & RUBBER
- HOME DEPOT
- J.C. PENNEY
- J.M. SMUCKER
- J.P. MORGAN CHASE
- KOHL'S
- KROGER
- L BRANDS
- LOWE'S
- MACY'S
- NATIONWIDE
- NORFOLK SOUTHERN
- OWENS CORNING
- OWENS-ILLINOIS
- PNC FINANCIAL SERVICES GROUP
- PROCTER & GAMBLE
- SEARS HOLDINGS
- SHERWIN-WILLIAMS
- TARGET
- U.S. BANCORP
- UPS
- VERIZON
- WALGREENS BOOTS ALLIANCE
- WALMART
- WHIRLPOOL

Tech Leaders Demand Clean Energy

Amazon Wind Farm Ohio-Timber Road, owned by EDP Renewables

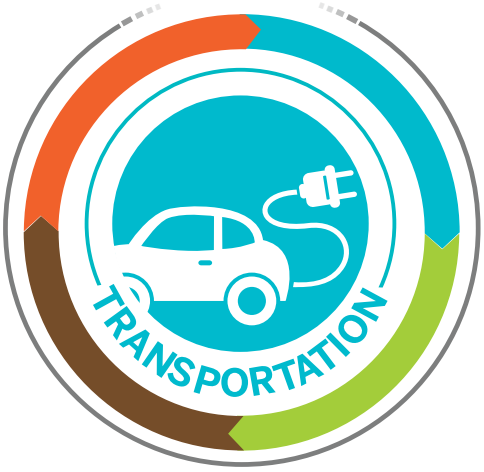
Photo courtesy of EDP Renewables.

Ohio is actively recruiting new data centers, and it can increase its odds of success by enabling these energy-intensive sites to easily meet their energy needs. This includes access to stably-priced renewable energy. Ohio will capture economic benefit from both the data centers and the local renewable energy projects that supply them.

Ohio is already home to several large data centers, and both Amazon and Facebook have committed to powering their Ohio centers with renewable energy. The 100 MW Amazon Wind Farm Ohio-Timber Road, owned by EDP Renewables, is already operational. Amazon has said that its three Ohio data center sites could each support four more data centers.[18]

If 12 data centers the size of Amazon's three existing facilities were built over the next decade and coupled with wind power, it would bring an investment of $450 million per year in data center construction. The projects would also create at least $170 million per year in renewable energy investment. Together, this would drive 350 jobs each year in construction and grow to over 1,000 jobs in the combined operations and maintenance of the data centers and clean energy generators. Spillover economic activity spurred by these investments—ranging from building materials supply to wages re-spent in the local economy—would more than double this positive employment impact.

	All of Apple's U.S. facilities, including offices, retail stores and data centers, are powered by 100 percent renewable energy sources like solar, wind and micro-hydro power, which Apple generates or purchases from local projects. The new campus... will also be powered entirely by green energy.[19]
facebook	Access to cost-effective renewable energy is one of the primary factors used in selecting our data center locations. Unfortunately, procuring such energy solutions is not easy in many locations. We want to increase the development of renewable energy resources, and those resources should be accessible to all companies, regardless of their size.[20]
Microsoft	Our goal is using more clean energy to power our datacenters and operations every year, with a goal of topping 60 percent early in the next decade.... Wherever we operate, we work to bring new clean energy online through investments and partnerships.[21]
amazon	We believe by putting in place thoughtful policy, businesses can accelerate and expand investments in new renewable projects, which will diversify the US electrical energy generation mix where they operate.[22]
Google	We'll continue to pursue these direct [renewable energy] contracts as we grow, with an even greater focus on regional renewable energy purchases in places where we have data centers and significant operations. ... Our ultimate goal is to create a world where everyone — not just Google — has access to clean energy.[23]



Lead the Transportation Transformation

Ohio manufacturing faces both great risk and great opportunity from continued evolution in the auto industry. Roadway transportation is moving away from the 20th century model of driving petroleum-fueled cars and trucks toward an efficient, connected, automated, and electrified future. Mitigating the risks and capturing the opportunities presented by the transportation transformation is worth nearly $1 billion in annual Ohio GDP.

The connected and electrified future will arrive earlier in some places than others, and the leading locations will entice innovators and the investment to fund their ideas. If Ohio embraces new vehicle platforms and mobility paradigms, it can attract the factories and innovators that will produce them, along with their associated supply chains.

A few facts and figures illustrate the pace and scale of the transformation:

- Morgan Stanley projects that global sales of internal combustion cars and light trucks will peak within the next five years.[24] Bloomberg New Energy Finance projects that U.S. EV sales will grow about 30 percent per year from now through 2030.[25]
- General Motors will offer 22 EV options within the next five years, up from two today.[26] By 2022, Ford will offer 40 all-electric or plug-in hybrid vehicles, up from two today.[27] Honda aims to grow sales of electrified vehicles, including hybrids, to two-thirds of global sales by 2030.[28]
- Intel projects that the global market for automated shared vehicles may be worth $7 trillion by 2050.[29] Vehicle-to-vehicle connectivity is already installed in some GM cars and is expected to be widely available within a few years after finalization of federal rules and standards.[30]

Ohio is heavily invested in the portions of the auto industry that will change the most with electrification: internal combustion engines, transmissions, and other drivetrain components. Converting Ohio's auto manufacturing risk to economic opportunity requires the development of an in-state EV component supply chain.

Get a Foothold With Fleets

Commercial fleets can bolster new vehicle technologies. Fleet owners actively seek out new cost savings—savings that accrue quickly thanks to the intensive use of fleet vehicles. In addition, fleets are obvious choices for testing new fuels' refueling infrastructure. Ohio's fleets are natural early adopters for these technologies: Ohio is a leader in logistics; it has access to diverse and affordable choices such as natural gas, propane, biofuels and electricity; and it hosts manufacturers of these technologies.

Emerging commercial and government fleet markets include buses that improve local air quality by using natural gas and propane, which also offer significant cost savings compared with petroleum-based fuels. Plug-in electric trucks that export power for tools negate the need for portable generators. In addition, some fleets achieve substantial efficiency gains through use of advanced routing and traffic analysis to limit idling, driving time, fuel cost, and emissions.

Make It Efficient

Investment, innovation, a skilled workforce, and increasing fuel economy are driving a thriving automobile supply chain in Ohio. A 2017 report from the BlueGreen Alliance counts more than 27,000 Ohio jobs—and 80 facilities—building clean and fuel-efficient vehicle technology.[31] This is the third most in the country after Michigan and Indiana. Despite the threatened rollback of federal efficiency standards for model years 2022–2025, policy requirements for increasingly efficient automobiles and trucks remain around the world. Lightweight components and more efficient engines with their origins in Ohio will continue to be in demand.

Improving fuel efficiency and vehicle performance will require incorporating aluminum, titanium, fiberglass and carbon fiber composites, and new steel alloys. Ohio's manufacturers could benefit from this transition—from raw materials processing through rolling, casting, milling, and pressing into chassis, frames, and engine components. Research and Markets projects the global automotive lightweight material market will grow at an annual rate of more than 13 percent through 2021.[32] Ohio's advanced automotive materials sector currently employs more than 10,000 people and has tremendous potential to supply this growing portion of the supply chain.[33]

Engine efficiency and performance will be another essential mechanism to increase fuel economy and meet strict pollution controls. Ford's Lima engine plant manufactures the 2.7 liter EcoBoost V-6 engine for the F-150 pickup. This engine provides the power of a larger engine but with greater fuel economy.

Leverage Smart Connections

The Executive Director of the U.S. Transportation Research Board states that "connected and automated vehicles have the potential to radically transform how the world works, plays, and lives. It could be the biggest transformation in transportation since the automobile."[34] Ohio has unique resources for developing our future transportation system,

Owens Corning

HQ: Toledo; R&D: Granville

Owens Corning's Composites business represents about one-third of the company's revenues, and one quarter of that (or about $500 million/year) comes from transportation.[35] Composites offer light weight, which improves efficiency and vehicle handling, but also offer tight tolerance and repeatable moldings, allowing for improved assembly quality. Composites provide these benefits for all automobiles on the market—traditional, hybrid, and electric. Owens Corning supports collaborators ranging from startups to suppliers to major global automakers with design, modeling, and engineering support to enable them to choose composites.

Given Ohio's strengths in industrial research and automotive manufacturing, it's no surprise that extensive work in vehicle light-weighting has taken place here. For example, researchers at the Owens Corning Science & Technology Center in Granville worked with Continental Structural Plastics (based in Michigan but with manufacturing facilities in Carey, Van Wert, Conneaut, and North Baltimore), Compose Tooling Expert, Altair Engineering, PPE, Hexion (headquartered in Columbus), and Brandolph to develop a new kind of lightweight body component.[36] Combining the best of carbon fiber with glass composites, these firms devised a way to make components 13 percent lighter than aluminum.

and for attracting the innovators that will create new opportunities for growth. These resources give Ohio a leg up on other states in competing for new transportation and mobility businesses.

The Smart Columbus program, supported by $50 million in grants from the U.S. Department of Transportation and Paul G. Allen Philanthropies, is bringing smart systems and sustainable transportation innovation to central Ohio with the goals of improving quality of life, driving economic growth, improving safety, and fostering sustainability. The program includes EV charging, autonomous vehicles, phone apps for bus users, and availability information and reservation of parking spaces. Smart Columbus has already leveraged the grant money ten-fold: local businesses have made $500 million in investment commitments. Smart Columbus was originally housed in a local community-based innovation center called the Idea Foundry, which is fitting given its potential to inspire and inform local innovators of the opportunities available in smart and sustainable transportation. Smart Columbus is also working closely with both the City's Division of Power and AEP Ohio to integrate EVs into central Ohio's transportation vision and pursue decarbonization initiatives.

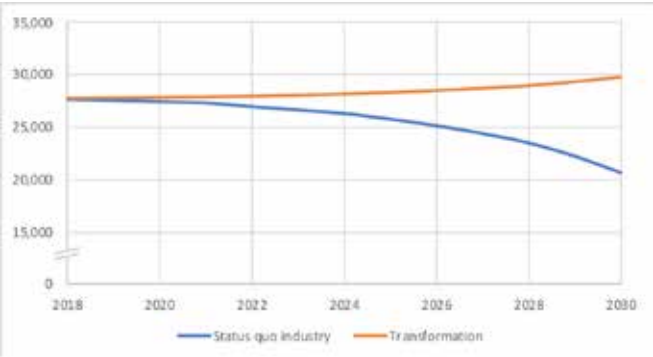
Smart Columbus is not Ohio's only smart transportation leadership resource: The Smart Mobility Corridor, a 35-mile portion of U.S. Route 33 from Dublin to East Liberty, will be a testing ground for real-world applications of connected and automated vehicles. Combined with the Transportation Research Center in East Liberty, this resource will attract vehicle system entrepreneurs and innovators developing and testing new components and integrated systems. The Ohio Turnpike Commission is also outfitting 60 miles of the turnpike as a testbed for automated and connected vehicles.

Make It Electric

Ohio is a top-three state across all aspects of vehicle manufacturing. Its manufacturers focus heavily on the drivetrain: namely engines and transmissions. Ohio is home to 18 percent of the country's engine-manufacturing jobs and 15 percent of the transmission and power train jobs. Many, including General Motors, believe that automated vehicles must be EVs.[37] Regardless of the pace of automated vehicle adoption, a growing number of smarter and more capable cars and trucks will be electric. Electrification presents a risk and opportunity for engine and transmission manufacturers: All-electric vehicles do not have engines or traditional transmissions, but they present opportunities for electric motor and battery manufacturing. As for plug-in hybrid EVs, they require entirely new kinds of drivetrains. Investment and growth in the state's auto sector is at risk if this next generation of vehicles passes Ohio by.

Based on Synapse modeling informed by Bloomberg New Energy Finance EV market projections, we estimate that maintaining a status-quo focus on traditional internal combustion drivetrain systems would cost Ohio over $740 million in annual GDP by 2030, with the loss of 7,000 jobs and the associated $675 million in annual wages. Including indirect and induced effects as these losses ripple through the state's economy, Ohio is at risk of losing an additional 18,000 jobs.

FIGURE 4: Drivetrain and electric vehicle system jobs in Ohio, with and without transforming Ohio's auto industry to keep up with global changes



If Ohio embraces the electrification opportunity, we calculate that the state's auto industry could grow. As the market shifts and grows to include both electric and combustion, by 2030 Ohio's auto sector could grow by more than $180 million in annual GDP if Ohio maintains its share of the combined drivetrain market. Ohio could attract more than $6 billion in capital investment in electric drivetrain facilities. With an additional 2,000 jobs and $135 million

	2030 GDP	2030 Direct Jobs	2030 Wages
Status Quo Risk	-$744 million	-6,942	-$675 million
Transformation Gain	+$188 million	+2,068	+$135 million
Net Opportunity	+$932 million	+9,010	+$810 million

in annual wages, the net opportunity available to Ohio is therefore over 9,000 jobs and $900 million in annual GDP.

Competitive companies around the world are investing in developing and manufacturing new electric powertrain components. These businesses include GKN and ConMet, each of which has an Ohio presence. GKN Driveline makes transmission differentials in Bowling Green,[38] while its sister plants are powering the plug-in BMW i8 and Volvo XC90.[39] GKN Sinter Metals is making gears, clutch pressure plates, and torque-converter components in Gallipolis,[40] while its sister plants are making gears designed for high-RPM electric drive applications.[41] ConMet in Chillocothe supplies interior assemblies to Kenworth;[42] ConMet has partnered with Protean Electric to develop an electric hub with regenerative braking.[43] As these and other suppliers follow the growth in EVs, Ohio could be a natural choice for additional investment if the state can position itself as an EV leader.

Drive It and Charge It

Just as Henry Ford wanted his employees to be able to buy the cars they produced, Ohioans should be able to buy and drive the electric cars and trucks they and their neighbors make. This will require both affordable vehicles and well-paying jobs. It will also require access to charging infrastructure that meets diverse needs such as charging at single-family and multi-family housing, workplaces, and public parking, as well as fast charging along highways. Charging stations are critical for widespread EV adoption. The stations also play a pivotal role as the interface between the transportation network and the electric grid. Ohio can harness more than $10 million in funds from the Volkswagen emission settlement to expand the state's small existing base of charging stations. Still, Ohio must attract hundreds of millions of dollars in additional investment to add 20,000 public charging stations if it is to fully benefit from the EV opportunity.[44]

Workhorse Group Inc.

Loveland

Established in 2007 as AMP Electric Vehicles, the Workhorse Group began by developing electric two-seat roadsters. Since then, the company has found a large market and growth opportunity in powering commercial fleet vehicles. At its Loveland headquarters, Workhouse designs and produces battery-electric powertrains for its step vans, as well as a forthcoming delivery van and pickup.

The E-GEN extended-range electric step van offers four times the fuel economy and lower maintenance when compared with non-electric step vans. The electric van can provide a three-year payback and save customers more than $165,000 per truck over a 20-year service life. The market opportunity for electric drivetrains is substantial: step vans alone represent 20,000 potential orders per year. A new collaboration with UPS will design and test 50 zero-emission vehicles that have no upfront cost premium over conventionally fueled trucks, without any subsidies. Beginning production this year, Workhorse's W-15 work pickup has 6,000 letters of intent to buy, primarily from electric utilities.

Workhorse sees the value that electric drivetrains provide customers today, and it is growing to meet the market demand. Workhorse's shipments are growing at more than 200 percent per year, as is the headcount of its 160-person operation.

Build and Deploy Clean Electricity

Ohio has a tremendous opportunity to capture the benefits of a growing market for renewable electricity generation. As deployment draws on local supply chains for everything from steel to power electronics and fiberglass, it will also provide new income streams for rural Ohioans who host, build, and maintain these facilities.

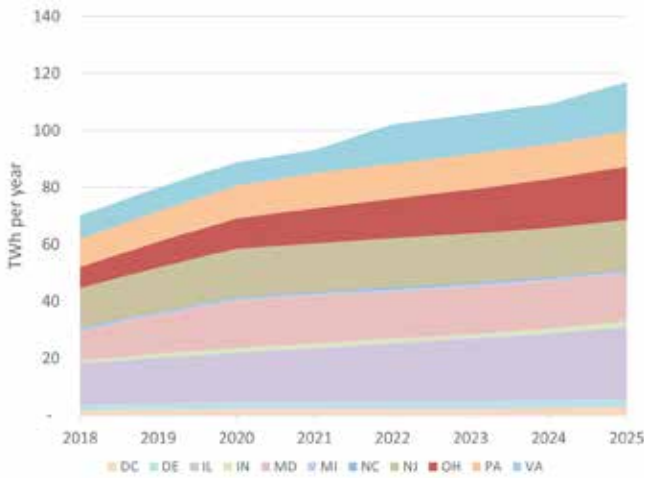
The electric generation dispatch and transmission system incorporating Ohio and all or part of 13 other states is operated by the PJM regional transmission organization. Of these states, 11 have renewable energy requirements called renewable portfolio standards (RPS) that require increasing renewably generated electricity from anywhere within or adjacent to the PJM footprint.

Across PJM, renewable requirements will continue to rise in the coming years. Ohio's RPS requires 4.5 percent of electricity sold in Ohio to be renewable in 2018; this will rise to 11.5 percent by 2025. Under current laws of the PJM states, the required renewable electricity generated across PJM in 2025 will be 67 percent higher than today. Some PJM states will likely expand their RPS programs as they approach the end of their initial program timeframes, as we have seen in other states around the country.

RPS policies increase the production of renewable energy, which in turn drives economic development where generators are built, lowers wholesale energy market prices, and improves air quality. As a group of businesses including Schneider Electric, JLL, and Nestlé wrote to the Ohio legislature in 2017, "clean energy standards help businesses cut energy costs, avoid the volatility of fossil fuel prices, and help us stay competitive."[45]

To date, Ohio has housed little of the new development to meet its own renewable energy requirements, or the

FIGURE 5: Renewable energy requirements in PJM will rise by 67 percent from 2018 to 2025



Sources: DSIRE and U.S. Energy Information Administration

requirements of the other PJM states. Ohio's renewable energy producers have the opportunity to help utilities meet RPS benchmarks by providing a Renewable Energy Credit (REC) for each megawatt-hour produced. However, only two of Ohio's four operating utility-scale wind farms provide RECs to an Ohio utility (the others transfer RECs to corporations or non-Ohio utilities). The resulting approximately 1.2 million credits meet less than 20 percent of the state's 2018 renewable standard (and less than 7 percent of the 2025 standard). Instead, Ohio utilities (and thus Ohio electric customers) generally pay developers for the renewable energy generated at out-of-state facilities.

RPS policies aren't the only thing driving renewable electricity development in the Midwest and Plains. More and more corporations are signing power purchase agreements with utility-scale renewable generation facilities to lock in low-risk, long-term electricity supply that aligns with internal and public clean energy targets. Tech giants like Google, Amazon, and Facebook, as well as other blue-chip companies like Mars, Walmart, Philips, 3M, Johnson & Johnson, General Motors, Dow Chemical, Procter & Gamble, and Owens Corning, have signed wind power purchase agreements since 2014.[46] Two of these, Amazon and General Motors, have invested in Ohio wind.

As the regional market for renewable energy continues to grow, Ohio can capture both the investment and economic growth from the construction of wind and solar facilities. Ohio businesses would also have a larger role in the supply chain for manufacturing the equipment used to generate clean energy.

Build It Clean

Ohio has numerous promising locations for wind and solar electricity generation, and the technical potential for wind and solar generation could meet Ohio's total electricity demand multiple times over. We used the Regional Energy Deployment System (ReEDS) model, developed by the National Renewable Energy Laboratory, to project how much wind would be deployed in the state if development were driven solely by economic factors and state renewable energy standards.[47] That is, we assumed no state interference (positive or negative) in siting. We developed our own solar projection because recent demonstrated commercial interest in utility-scale solar development in the state has far exceeded what ReEDS projects for development.

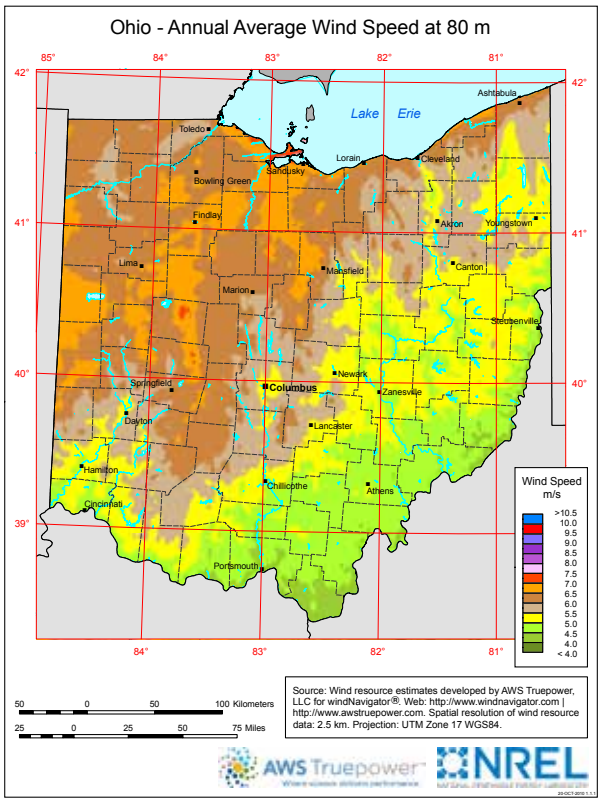
Based on known and proposed in-state generators, our research shows that Ohio could expect 3 GW of wind and 2.2 GW of distributed and utility-scale solar deployment by 2030—if those generators can be sited and built. This would be enough to power more than 1.1 million Ohio households. Ohio's wind and solar resources represent multi-billion-dollar investment opportunities that could bring jobs and income, particularly to Ohio's rural areas. Additional wind and solar generators in excess of the 5.2 GW discussed above will be constructed if corporate and institutional buyers are able to meet their energy objectives with Ohio resources.

Wind

Ohio currently has 604 MW of wind generation deployed, and six new wind farms with total capacity of about 900 MW have been permitted but not constructed. Growing onshore wind deployment to 3 GW by 2026 would bring $4.2 billion of capital investment and sustain 1,000 direct jobs. It would also support 1,000 indirect jobs in the wind industry supply chain and more than 1,000 jobs induced from re-spending of wages in the state's economy, while increasing annual state GDP by $1.2 billion.

Rural areas within western and northern Ohio have strong wind resources for current wind generation technology. Technological improvements will bring greater potential: near-future wind turbines that are 140 meters tall (compared with today's 80 to 100 meters) will be able to reach the steadier winds higher in the atmosphere. At these taller heights, wind developers are likely to find strong wind resources in all areas of the state.

FIGURE 6: Ohio – Annual Average Wind Speed at 80 m



Source: https://windexchange.energy.gov/states/oh

Ohio's Offshore Wind Opportunity

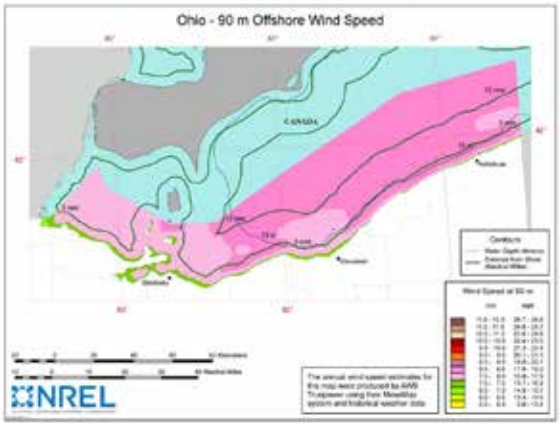
Great Lakes

Ohio can lead the region in offshore wind and thereby seize first-mover advantage over other Great Lakes states. The state that takes the early lead in developing Great Lakes wind will be the natural choice to provide expertise, materials, and maritime services to subsequent developments throughout the area. Ohio is well positioned to take this leadership role: Lake Erie has a promising combination of shallow depths, high-quality wind resources, and interconnection opportunities near load centers on the lake. Offshore wind in the Great Lakes presents a $7.4 billion opportunity to develop 1.5 GW between now and 2030, enough to power half a million Ohio homes. Development costs and resulting power prices will fall with a maturing industry and technological advancements. According to McKinsey, European offshore wind prices will fall 68 percent from 2010 to 2020 as the industry matures there.[48]

Existing U.S. wind manufacturing centers are located near to onshore wind development activity because of high transportation costs. The result is a wind manufacturing void in the areas surrounding the Great Lakes. Ohio has the opportunity to grow a local supply chain for offshore wind, with related benefits for the onshore supply chain as well.

The Lake Erie Energy Development Corporation (LEEDCo) has spent the last decade carefully laying the groundwork for a pilot project intended to spark investment in offshore wind in the Great Lakes. "Project Icebreaker" would site six turbines totaling 20.7 MW of capacity eight miles off Cleveland. Fred Olsen Renewables of Norway has purchased the project and will develop it, supported by about $50 million from the U.S. Department of Energy (DOE). Icebreaker is in the final stages of permitting now and could be constructed by 2020. Cleveland Public Power, American Municipal Power, and Cuyahoga County see the economic opportunity that bringing offshore wind to Lake Erie presents to their members and constituents, especially in northern Ohio. All combined, they have agreed to purchase more than half the project's output through long-term contracts.

FIGURE 7: Ohio – 90 m Offshore Wind Speed



Source: https://windexchange.energy.gov/states/oh

Counties such as Paulding and Hardin have adopted Alternative Energy Zone designations, which are intended to speed permitting and establish reduced, but fixed, taxes for clean energy projects. These zones can attract a valuable secondary and stable source of income for farmers, along with wind turbine maintenance jobs and tax revenue.

However, deploying the remaining 1.5 GW of Ohio's near-term potential, with its associated investment and jobs, is uncertain. Despite regional policies encouraging wind, promising wind resources, and counties interested in hosting wind generation, the permitting of new projects has dried up due to statewide setback requirements that are much more restrictive than in other states.

Solar

Ohio has 171 MW of solar photovoltaic (PV) generation: 104 MW of small-scale (such as customer-sited and net metered) generation and 67 MW of utility-scale facilities. We estimate distributed solar can grow to 950 MW while the utility-scale sector can grow to 1,200 MW by 2030. This growth would spur more than $3.6 billion of investment. It would sustain 800 direct jobs and over 1,700 indirect and induced jobs each year. The result would be a boost in annual state GDP of $1 billion each year.

Although independently developed small-scale facilities have dominated solar PV in Ohio to date, that will change soon: The Ohio Power Siting Board recently approved two

projects totaling 275 MW in Brown and Hardin Counties. In addition, as part of a 2016 regulatory stipulation AEP Ohio is seeking 400 MW of solar, with a preference for sites in Appalachian Ohio and coupled with manufacturing jobs.

Make It Clean

Local deployment supports a local supply chain. Notably, wind and solar construction depend on manufacturing industries in which Ohio excels—steel, fiberglass, machinery, glass—and where Ohio's firms and workforce are well positioned to contribute.

Wind

With the right support, Ohio can make up for lost time in wind industry development. Ohio's lack of state policy support and relatively slow pace of wind development has meant its local manufacturers were largely left out as the onshore wind industry matured over the last decade. The scale of wind construction favors local firms for large components to reduce both transportation cost and schedule risk. Wind-specific manufacturing centers have primarily developed nearer to where most deployment is happening: Texas, Colorado, Iowa, and the Dakotas. U.S. DOE researchers expect little supply-chain expansion into new areas, as noted in their 2015 Wind Technologies Market Report.[49]

And yet, many Ohio firms are ready to produce wind components. The American Wind Energy Association identifies 60 manufacturing facilities in Ohio that supply or have supplied goods to the wind supply chain—more than in any other state.[50] Owens Corning, for example, conducts R&D in Granville focused on fiberglass composites to enable improved turbine blades. Hundreds of local companies have expressed interest in supplying Project Icebreaker.[51]

Enhanced policies, instead of costing Ohio manufacturing opportunities, could promote the steady growth in local deployments would that would bring demand back into the state and boost the local supply chain.

Solar

Ohio's manufacturing expertise is on display with solar PV components made in the state.

▸ PV Modules

After a recent $145 million factory re-fit, Ohio mainstay and leading U.S. solar manufacturer **First Solar** is ramping up to manufacture 600 MW of its new Series 6 modules per year in an efficient and flexible new production line in Perrysburg. The company recently announced it will build a second manufacturing plant in Lake Township, which will triple the company's Ohio manufacturing capabilities by late 2019.[52] Together these plants will represent more than 40 percent of U.S. PV module production capacity. The current Perrysburg facility employs 750 Ohioans in manufacturing, research and development, supply chain sourcing, customer support, and other roles, and the new factory will employ 500 more.[53] The company has 10,000 MW of solar orders on its books, ensuring manufacturing work for several years to come.[54]

▸ Balance of System

Racking and mounting hardware for solar PV panels uses Ohio's metal shaping, stamping, and extrusion expertise from firms located throughout the state. Examples include:

ECOLIBRIUM SOLAR of Athens makes innovative rooftop mounting systems that streamline rooftop installation.

RBI SOLAR of Cincinnati employs about 100 people to make both steel and aluminum racking mounting systems, as part of an integrated approach offering system design, engineering, manufacturing, and installation.

TALAN PRODUCTS of Cleveland is a diversified stamping and extrusion business that sees growth opportunity as a contract manufacturer of solar components.

Manufacturing in Perrysburg

Credit: First Solar

Lower Costs and Boost Business with **Efficiency**

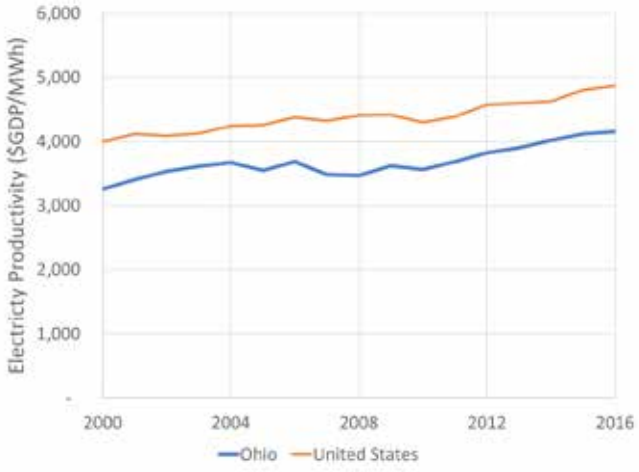
Energy efficiency can lift Ohio's economy by reducing energy costs, increasing in-state productivity, and creating more opportunity to manufacture efficient products to meet the growing global demand.

Increasing productivity means making more with less, and it is a primary driver of economic growth. Ohio businesses enhance productivity through process improvements that reduce waste—wasted time, wasted inputs, and wasted energy. Communities, too, benefit from reducing waste because it allows them to stretch their hard-earned dollars further. Every dollar that an Ohio family or business spends on waste is a dollar they cannot spend on local products, services, or investing for the future.

Ohio's electricity productivity has consistently lagged behind the national average. Although Ohio's electricity productivity has been steadily improving, it remains 15 percent below that of the entire United States. Today, 58 percent of Ohio's energy consumption is wasted and huge opportunities for efficiency remain. Each 1 percent improvement in Ohio's electricity productivity is equivalent to more than $6 billion in additional economic activity.

FIGURE 8: Ohio's electricity productivity lags behind the U.S. average

Source: U.S. Energy Information Administration and the Federal Reserve Bank of St. Louis.



Every dollar that an Ohio family or business spends on waste is a dollar they cannot spend on local products, services, or investing for the future.

Make It Efficient

Ohio's manufacturers and innovators are well positioned to meet market demand for improving energy productivity. They can build on their expertise producing high efficiency products related to lighting, heating, ventilation, air conditioning, advanced materials, and insulation.

According to a 2017 DOE report, nearly 17,000 Ohioans work in the manufacturing of energy-efficient products.[55] That report projects a 5 percent growth rate in energy efficiency manufacturing employment across the country.

In 2015, Americans spent more than $100 billion on products that qualified for the federal Energy Star efficiency standard. Meeting the Energy Star level and capturing the related market opportunities requires innovation, particularly as the standard becomes more stringent over time. Appliance manufacturers with strong traditions of innovation can more effectively build and sell new Energy Star appliances. Whirlpool, for example, has improved the efficiency of dishwashers and washing machines by 70 percent.[56]

Emerson Electric recently opened the new Helix Innovation Center for collaborative heating, ventilation, and air conditioning research at the University of Dayton.[57] The insights developed there will feed into Emerson's compressor technology business, which is based in Sidney. Emerson is expanding its Sidney facility to stay on the cutting edge of research, development, and manufacturing of scroll compressors, which are a key technology for more efficient single- and variable-speed heating, cooling, and refrigeration systems.[58] Owens Corning's Newark plant was the world's first fiberglass insulation plant and remains one of the largest.

Make It Smart

Connected digital controls and sensors are revolutionizing manufacturing processes.[59] The digital sensor and

Stirling Ultracold

Athens & Columbus

Dave Berchowitz founded Global Cooling in 1996 to commercialize free-piston Stirling engines in household refrigeration applications. He had previously developed engines that fly on NASA satellites, where they were used to cool sensors. In 2009, working with TechGrowth Ohio, the company developed a business plan to address the ultralow freezer market.

Ultralow freezers are widely used in the life sciences research arena and operate at -80°C. Conventionally, they use compressor technology similar to that found in a household refrigerator, and they can use as much energy as an average U.S. home. Stirling Ultracold freezers use proprietary technology based on the free-piston Stirling engine and consume about 75 percent less energy than conventional units.

Global Cooling's Stirling Ultracold freezer business is extremely successful. Under the executive team led by CEO Neill Lane, the company's revenues nearly doubled from 2016 to 2017 and are expected to triple in the next three years. The company employs about 100 people and is steadily growing. It has a manufacturing facility in Athens and recently opened a sales, marketing, and development office in Columbus.

Ohio's entrepreneurial ecosystem, with the state leveraging private investments in public-private partnerships, has been key to the company's success. Stirling Ultracold fueled its growth with state grants and loans, combined with investments from the following: angel investors, TechGrowth Ohio, Advantage Capital harnessing New Markets Tax Credits, and the Ohio Innovation Fund.

controls revolution will bring Ohio's cluster of electronics and automation companies, such as Eaton, Parker, Rockwell Automation, ABB, Schneider Electric, Emerson, and Siemens, more deeply and directly into the energy productivity industry. Ohio's research, development, and manufacturing expertise for these technologies means the state is ripe for growth in this area.

Smart systems are critical for process and quality control, identifying maintenance needs, and managing inventory. These same tools can measure and improve the energy performance of buildings and manufacturing. The Smart Manufacturing Leadership Coalition identifies agility, resource efficiency, safety, workforce, sustainability, and economic health outcomes from coordinated and performance-oriented manufacturing.[60] The Coalition estimates that, worldwide, smart plant optimization can achieve 20 percent operational efficiency and 25 percent energy efficiency improvements.

Businesses can also create revenue and savings opportunities by coordinating production with wholesale electricity price fluctuations. Real-time energy prices allow a building or facility operator to purchase lower priced electricity and avoid more expensive times. Demand response can be even more lucrative. Demand response participants reduce energy use when the grid faces high demand or provide services during grid emergencies. Participants are paid by the grid operator through energy markets or from distribution utility programs because they provide even larger cost savings system-wide.

Boost Productivity

Ohio can keep its factories on the cutting edge of productivity by supporting efficiency upgrades. This will drive down costs and help Ohio's businesses compete. Manufacturers take an integrated approach to improving the output of production lines, and they know that increased energy efficiency can bring benefits beyond conservation. It can mean a stronger competitive position and higher production. As large manufacturers increase their expectations for cost savings in their supply chain, smaller and medium-sized businesses can increase energy efficiency as a key step to remaining competitive.

Building owners and homeowners also benefit from lower energy bills. Energy efficiency is the lowest cost resource, so more efficiency means more savings. Better appliances, lighting, heating, ventilation, cooling, building envelopes, and insulation also reduce operational costs and maintenance costs. Co-benefits include increased comfort, and

Hylant Building

Toledo

Energy cost management, reliable systems, and occupant comfort are key performance indicators for commercial real estate. The 14-floor Hylant Building in Toledo is no exception. GEM Energy and Rudolph Libbe Inc. have worked with the property owner over the last decade to ensure that the building competes in the downtown Toledo market, including the use of PACE (property assessed clean energy) financing to upgrade building automation, HVAC, and lighting systems. In the first year, the building achieved a 31 percent energy and utility cost reduction while maintaining occupant comfort and increasing leased square feet by 8 percent.

several studies show that fresh air, comfort, and better lighting improve worker productivity.

Deploying energy efficiency is a multifaceted industry. According to the Department of Energy, more than 61,000 Ohioans work in construction, trade, or services related to energy efficiency deployment.

Utility Programs Boost the Economy

In 2008, Ohio adopted the Energy Efficiency Resource Standard (EERS), which requires the state's utilities to meet an increasing portion of customer needs with efficiency through 2026. These programs play a crucial role in business decisions to pursue cost-saving efficiency measures, and they represent money well-spent by the utility. The programs lower energy system costs while supporting increased customer returns on efficiency investments.

Ohio's utilities have exceeded the requirements to date, although the expectations continue to rise. We calculate that meeting the standards through 2026 will boost Ohio's GDP by $400 million per year on average. This activity will also support 5,000 local jobs and attract $4.2 billion in capital investment in factories and buildings. But the required utility programs will not exhaust Ohio's cost-effective efficiency potential: Expanding and extending them through 2030 would further increase GDP—by an average of $500 million annually through 2030—and attract an additional $2.4 billion in investment. Compared with the current EERS, the expanded efficiency case would also save customers an additional $3 billion in energy costs.

Liberty Savings Bank invested $870,000 with Energy Optimizers, USA to save $99,000 per year on energy costs in the historic Liberty Tower in Dayton.

Source: Carl Sjoblom. CC BY-SA 4.0 license.

Harness a 21st Century **Electric System**

Utilities will play a critical role by making prudent investments deploying and utilizing sensors and controls on the grid.

Ohio can become a center for design and manufacturing of the sensing, communicating, and controlling devices necessary to take advantage of the economic possibilities of a smart electric system. Developing and deploying a next generation electric grid in Ohio will also give customers new options to control their energy costs.

Ohio companies have been laying the foundation for a smart electric system for decades. The control systems developed by Eaton, Rockwell Automation, ABB, and other power electronics and control companies (and deployed by industrial and large commercial and institutional facilities) are the precursor to the smart systems being developed today.

An integrated system of utility-scale and distributed electric generators, batteries and energy storage systems, manufacturing and other industrial equipment, residential and commercial appliances, and vehicles would rely on a comprehensive network of sensors, data communication, and decision-making. Innovators could harness declining costs, the miniaturization of electronics, improvements in wired and wireless communication, and data analytics. They could use these tools to build new smart components that are ready to take advantage of the decentralized 21st century grid. Utilities will play a critical role by making prudent investments deploying and utilizing sensors and controls on the electric grid. Doing so would allow the utilities to maintain high quality service while simultaneously deploying technology to improve reliability and reduce costs.

One leading example of grid-related research and development is a joint building-grid integration living laboratory by Case Western Reserve University, NASA Glenn Research Center, and the University of Toledo, supported by $1 million from the U.S. DOE. Spanning all three campuses, the project is a partnership with FirstEnergy, Eaton, Siemens, and

Eaton

Cleveland

As an early innovator and manufacturer in automotive, aerospace, and smart grid technologies, Eaton has served Ohio for over one hundred years. St. Clairsville's municipal electric and water utility has deployed Eaton's suite of advanced metering infrastructure products to serve its 3,000 electric and 2,400 water customers.[61] Those products include meters, a radio frequency mesh network to collect meter data in real time, and software to manage all the data. These new systems free up personnel to perform other tasks, allow the utility to identify outages faster, improve customer service with near real-time information, and immediately identify water line breaks. St. Clairsville also has the infrastructure in place to support further smart grid applications in the future.

Eaton is developing some of those next generation solutions as well. For example, Eaton and the Electric Power Research Institute (EPRI) began working in 2016 with 12 utilities, including American Electric Power and Duke Energy, to field test Eaton's new "energy management circuit breaker" in 500 homes.[62] This innovative device essentially puts the power and connectivity of a smartphone into a circuit breaker. By providing utility-grade metering with circuit-level monitoring and control, the device will allow customers to better understand their energy use and lower their bills. At the same time, utilities reduce cost with the ability to secure verified demand response resources and trim peak demand.

Main Street, St. Clairsville

Source: Jon Dawson via Flickr. CC BY-ND 2.0 License.

Johnson Controls. Its researchers will demonstrate how the grid-integrated operation of building control systems, solar and wind power generation, batteries, EV charging stations, and more can maximize value of these distributed energy resources to both the site owner and all other customers on the grid.

Use the Modern Grid

To enable a 21st century electric system, Ohio must use advanced electric meters in combination with the advanced electric rate structures that allow customers to use those meters to save on their electricity bills. Advanced rate structures include time-varying rates that reward customers for shifting their use to low-cost times or allowing utilities to control the flow of distributed energy resources. Customers served by AEP Ohio and Duke Energy, as well as by many of the state's municipal and cooperative utilities, have or will soon have the advanced meters necessary to participate in Ohio's increasingly smart grid. In this, Ohio is catching up to the national average (although it has a long way to go to catch up with neighboring Michigan, which has quadruple the amount as a percentage of residential customers). With respect to advanced rate structures, Ohio is ahead of other states. At 15 percent, the fraction of Ohio customers using these rates exceeds most states, although there remains tremendous room for growth.[63]

Duke Energy Ohio's roll-out of smart grid technology (funded in part by a Department of Energy Smart Grid

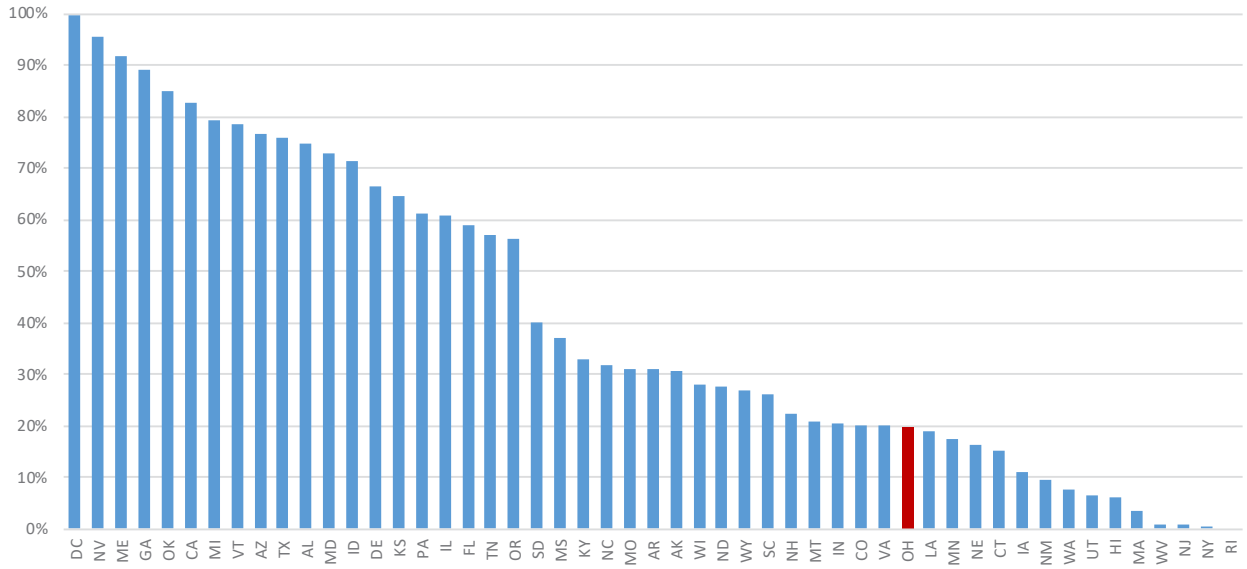
Investment Grant) led to considerable savings. These included both operating savings due to remote meter reading and fuel savings due to voltage optimization that reduced losses in the distribution system.[64] Testbeds (like the Case Western–NASA Glenn–Toledo facilities, FirstEnergy's Center for Advanced Energy Technology in Akron for training and testing new grid technologies, and Smart Columbus) can demonstrate what is possible and help to shape the products and services that make their way to mainstream business and residential use. Data from integrated grid, building, and industrial operations can enable new software and hardware tools for customers. And if Ohio deploys smart systems, the innovators of these tools could come to Ohio to develop the next generation of products while empowering Ohio's building owners and manufacturers.

Smart grids, and the associated time-varying or dynamic rates that they enable, are key to making EVs an attractive option for consumers and businesses while also sharing EV grid benefits with all utility customers. EV charging can lower rates by spreading grid costs over more units of energy, but only if charging does not add to peak demand. Notably, the timing of charging can be very flexible when matched with a 21st century grid. Smart charging allows EV owners to avoid peaks and shift charging to times with lower generation cost. In addition, smart charging could also provide utilities with revenue growth opportunities and enable lower-cost integration of variable renewable generation. EV charging makes an ideal first implementation of advanced rates because thousands of customers with relatively large loads will have the control and the financial incentive to charge their EVs during times of cheap, plentiful, and more frequently clean electricity.

If Ohio deploys smart systems, the innovators of these tools will come to Ohio to develop the next generation of products while empowering Ohio's building owners and manufacturers.

FIGURE 9: Residential advanced meters as a percentage of total residential meters

Source: U.S. Energy Information Administration Form EIA-861.



How Do We **Make This Vision a Reality?**

Taken separately, each opportunity identified in this report can provide benefits to Ohio. As part of a comprehensive and integrated strategy, they can transform Ohio's energy economy. Each sector's successful transformation—whether it be in transportation, clean electricity generation, energy productivity, or a smart grid that connects it all together—will depend on complementary actions in other sectors. For example, technologies that allow EVs, manufacturing plants, and other energy users to interact with the electric grid can maximize the value from clean electricity generation simply by taking advantage of time periods when clean electricity is abundant and low-cost. In contrast, failing to modernize industries, policies, and infrastructure would leave Ohio at risk of being left behind as other locations do more to attract investment.

Ohio becomes more attractive for investment and for workers with each clean energy step it takes. We believe that a coherent strategy and coordinated actions will be required across multiple fronts to implement this vision. We have identified three areas to start:

1. **WORKFORCE:** The workforce of innovators, makers, and doers that invents and builds this future is the workforce that will attract world-leading firms. Ohio will also depend on its workforce to make its businesses and processes productive, invent new solutions, and foster the state's next generation of leaders.
2. **REGULATION AND POLICY:** Economic development and energy policies, utility regulation, renewable siting, tax measures, and other government choices set the parameters for implementing any roadmap. They also provide certainty for investment and Ohioans' career decisions, and they establish the tone for Ohio's approach to energy sector growth.
3. **INVESTMENT:** This vision represents more than $25 billion in investment opportunities across multiple sectors, driving business expansion and good jobs. Innovative financing tools can increase access to capital and make the difference for attracting investment.

These actions are not solely the responsibility of government: Leading businesses, educational institutions, labor, and advocates each have an important role. The cross-cutting group of leaders advising this project came together because they understand that they all have their own part to play, and that increased collaboration will be necessary to make this vision a reality.

We look forward to engaging with Ohioans with diverse perspectives. Please visit the report's website at **www.poweringohio.org** to join the conversation. For our forthcoming roadmap report, to be issued in summer 2018, we will collect, synthesize, and share the best ideas on how to make this vision real.

This transformation will not happen overnight. But the steps Ohio takes to consistently make progress in mobility, industrial innovation, efficiency, and clean electricity will build upon each other to steadily invigorate Ohio's economy.

Turning this interconnected vision into a reality will make Ohio a compelling place for companies to grow, invest, hire, and broadly share sustained economic success.

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