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The Solar and Wind Economy in Ohio: Industry Analysis and Policy Implications

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Abstract

After historically being driven by coal and, in more recent years, natural gas, Ohio's energy industry has experienced notable growth in installed solar and wind capacity. Due to changes in consumer tastes and preferences, an overall decline in expenses, and environmental concerns about coal mining and hydraulic fracturing, among others, both public and industry support for renewables has grown. However, Ohio's renewable energy policies have not consistently aligned with this support. This paper synthesizes reports and analyzes energy industry employment and capacity data in order to summarize the trends within Ohio's present-day energy industry. After a brief surge, wind activity has stagnated, in part due to expansion of the turbine property line setbacks law. Wind employment has also been relatively erratic, seeing spikes and rapid declines that average to a growth of 13.6% per year from 2013–2016. Conversely, solar energy capacity has grown a bit more steadily due to fewer regulatory restrictions as well as supportive state net metering policies. Correspondingly, solar employment has grown more consistently at a rate of 11.3% per year during our study years. This paper highlights these trends, discusses policy implications moving forward, and makes recommendations for Ohio to stimulate the deployment of additional renewable energy capacity in future years. To accomplish this task, and to enhance sustainable development via renewable energy, we suggest that Ohio ease its wind setbacks and continues to protect the state's renewable portfolio standard and net metering laws.

Keywords: Renewable Energy, Solar, Wind, Public Policy, Economic Impact, Ohio

Introduction

Over the past couple of decades, both solar and wind energy have experienced substantial growth in the United States (U.S.). For instance, in 2015, 26% and 41% of the nation's added power generation capacity came from solar and wind respectively (United States Energy Information Administration 2018), outpacing many traditional resources. This development has come as part of a nationwide trend away from coal and toward other energy sources such as natural gas, solar, and wind. This trend is particularly pronounced in the state of Ohio, where the coal industry has consistently declined since the 1990s. The Utica and Marcellus shale plays are creating fuel booms in the natural gas industry, and reduced development costs have spurred growth in the solar and wind sectors. In particular, power generation capacity in Ohio from natural gas has grown by more than 8 gigawatts (GW), from 1,251 megawatts (MW) in 1996 to 9,660 MW in 2016 (Untied States Energy Information Administration 2018) – one of the largest gas growth spurts in the country.

While the majority of Ohio's energy generation growth has been in natural gas, solar and wind have also experienced rapid growth in the last decade. From an environmental sustainability perspective, these two sectors have numerous advantages when compared to coal and natural gas. For example, in 2016 the Ohio power sector produced 144,210 short tons of sulfur dioxide (SO_2) and 81,618,000 metric tons of carbon dioxide (CO_2), largely due to the burning of fossil fuels (United States Energy Information Association 2018). In turn, this has resulted in the state being ranked second and fifth in the country in overall emissions of each gas, respectively (United States Energy Information Association 2018). These pollutants have added to the growing concentration of greenhouse gas (GHG) emissions in the state, which is one of the most influential contributors to harmful climate change impacts (Wubbles and Jain 2001). Since electricity generation is one of the largest contributors to GHG emissions and given the fact that energy demand and consumption continues to rise, developing sustainable energy solutions remains a critical issue.

Solar and wind generation expansion has been shown, both in literature and in practice, to reduce these pollution figures. A national study by the National Renewable Energy Laboratory (NREL) found that, on average, producing one megawatt hour (MWh) of electricity with solar photovoltaic (PV) energy reduces emissions by eight pounds of SO_2 and 1,400 pounds of CO_2 (NREL 2004). Similarly, according to estimates by the American Wind Energy Association (AWEA), producing 1 MWh of wind energy reduces emission by 1.5 pounds of SO_2 and 1,550 pounds of CO_2 (AWEA 2016). This is important given the fact that these emissions (such as CO_2) have been shown to have eminent negative effects on health (e.g., lung damage from inhalation) and climate change (more severe weather, changes in food growth patterns, etc.). On top of the pollution caused by the burning of fuel for electricity, coal and natural gas also rely on extensive by-product disposal and resource gathering techniques, such as hydraulic fracturing (i.e., 'fracking') and coal mining, which result in damages to forested areas and pollution in the water supply. While renewables such as solar and wind do create problems such as land and habitat losses, high water use, and the use of potentially hazardous materials in the manufacturing process, the benefits of sustainable electricity generation, acid rain declines, emissions reductions, and climate change mitigation still outweigh these costs, especially when compared to the alternatives.

Moreover, the costs of solar and wind energy development continue to decline every year. Estimates by the International Renewable Energy Agency (2016) show that solar PV could see up to a 57% cost decline by 2025 and that wind could see declines of up to 15%, positioning these industries as a viable supplement to the Ohio energy portfolio in the future. Nevertheless, coal and natural gas continue to dominate Ohio's electricity generation, with 86.6% of total power capability (defined as the production output of a system at peak conditions) consisting of either natural gas or coal-fired power plants (United States Energy Information Administration 2018).

Ohio's first core policy that helped pave the path for renewable energy development, especially of the distributed variety, was its net metering policy. Originally passed in 1999 as Senate Bill (SB) 3, this program enabled customers to generate electricity (from sources including solar, landfill gas, wind, biomass, and hydroelectric) and supply excess generation back onto the grid, providing credit toward future bills through the production of net excess generations credits (DSIRE 2016). Furthermore, unlike many other states, Ohio's net metering program has no capacity limits. In essence, this policy allows for customers to pay only the net amount of energy consumed from the grid per month. Ohio's net metering policy received positive remarks from national reviews. Freeing the Grid, an annual report which examines each U.S. state's net metering policies, grades Ohio's policy as an A on an A–F scale (Freeing the Grid 2016). Additionally, in 2008, Ohio adopted a Renewable Portfolio Standard (RPS) which requires the state's investor-owned electric utilities to generate or procure a select amount of energy generation portfolio from renewable sources by a specific date (DSIRE 2017a). Initially, this requirement was set to 12.5% by 2024, with 0.5% (the 'carve-out' or 'set-aside') required to be solar energy specifically (DSIRE 2017a). This solar carve-out included a solar renewable energy credit (SREC) mechanism, which allows owners of solar PV energy systems to sell credits to electric utilities for every MWh of energy generated in order to help the utilities meet the mandated carve-out (DSIRE 2017a).

Despite passing these policies aimed to enhance renewable energy deployment from 1999 to the late 2000s, more recent policy developments have been less supportive. For instance, with SB 310, the state actually froze these RPS mandates from 2014 to 2016, pushing the final requirements back two years (DSIRE 2017a). In 2017, the Ohio House of Representatives passed a bill that would have continued the freeze for another two years, but Governor John Kasich vetoed it (DSIRE 2017a). Another relevant bill, House Bill (HB) 483, was passed in 2014, which particularly impacted Ohio's wind energy industry. This bill increased the minimum distance required between the blades of a wind turbine to the nearest property line from 550 to 1,125 feet (Runnerstone 2016). Moreover, it mandated that the turbines be measured starting from the nearest property line rather than the nearest habitable structure, which further limited turbine zoning and resulted in over 1,400 megawatts (MW) in planned wind projects to be put on hold (Runnerstone 2016). One of the nation's most stringent setback laws, this policy was passed without public testimony or written justification (Dvorak, 2017). There have been several efforts to partially revert the property line setbacks, though none have passed through the Ohio House of Representatives.

Additional policy-related efforts that have adversely affected the solar and wind industries include a 2002 ruling by the Ohio Supreme Court that limited the credit of net excess generation to the utility's generation cost rather than the full retail rate, which greatly reduced the overall value of excess generation via net metering mechanisms (DSIRE 2016). In 2015, in response to proposals from utilities, the Public Utilities Commission of Ohio (PUCO, the state's regulatory agency for electric utilities) placed Ohio's net metering standards under further review, debating whether to classify the credit as a subsidy (Upgrade Ohio 2017). In November 2017, the PUCO passed new net metering rules, which included the explicit declaration that customers may now have systems sized large enough to produce 120% of their annual electric usage, which is a favorable percentage compared to other states. However, as a policy compromise, additional changes included adding several different fees to these distributed energy system investors (mostly solar energy) in order to cover costs associated with system maintenance as well as overhead costs for generating power, such as the transportation of natural gas and coal (Upgrade Ohio 2017).

Overall, while these recent policy alterations have seemingly made the state's net metering policy more straightforward, it remains unclear whether the modified fee structure will encourage or discourage net-metered, distributed generation investment. Some environmental groups and solar industry representatives have claimed that the new rules will slow growth, as they "would not credit customers with the 'capacity' portion of their overall rate. Instead, customers would get just the energy-only portion, which comes to only about 85 percent of the bundled rate" (Kowalski 2017b, para. 7). Such an alteration may change the economics and return on investment calculations for prospective investors.

Amidst these complex renewable energy policy developments in Ohio, this paper's primary goal is to provide a measure of the economic contributions of solar and wind to the state, with the purpose of adding perspective to these recent policy decisions. To accomplish this, recent trends including installed capacity (or capability), generation, job growth, and the overall economic impact of the wind and solar industries were analyzed. We focus on Ohio as an exemplary 'swing state' with convoluted politics and interesting geographic foci, such as tech and data centers in many of its large cities, and a history of coal and resource extraction in the Southeastern part of the state. Ohio has been a traditional laggard state, especially regarding renewable energy policies, so this analysis can also be used by other, similar states with complex policies and less progressive legislatures. Overall, understanding the trends and projections for Ohio energy jobs and capacities has numerous implications for policymakers and economic development practitioners alike, which are highlighted in our conclusions.

Methods and Materials

To analyze the overall growth, impact, and infrastructure of the solar and wind industries in Ohio, as well as the evolution of these industries over time, we first collected and analyzed capacity data from 2009–2016. Furthermore, by differentiating between distributed (e.g., small, residential and commercial PV and turbines) and utility-scale[1] (e.g., large, utility owned and operated centralized PV and turbines) capacity, the impact of Ohio's net metering laws (which more pointedly impact the former deployment category) on the solar industry could be evaluated. These data were derived from the United States Energy Information Administration's (2018) Ohio Energy Profile.

Secondary employment data from 2013 to 2016 was then used to evaluate the impact of the solar and wind industries on Ohio's economy. Annual state reports from The Solar Foundation (TSF) provided the solar employment data for our analysis (The Solar Foundation 2015; The Solar Foundation 2017). These reports surveyed hundreds of thousands of known and potential energy establishments, resulting in more than 2,000 completed surveys (The Solar Foundation 2016). Our wind employment figures came from reports from two different organizations: Environmental Entrepreneurs and the American Wind Energy Association (AWEA). Environmental Entrepreneurs sponsors two surveys, Clean Jobs Ohio and Clean Jobs Midwest, which detail the economic potential of the renewable and sustainable energy economy in the locations described. The specific data used in this paper came from the 2014 Clean Jobs Ohio report and the 2015 Clean Jobs Midwest report (Clean Jobs Ohio 2015; Clean Jobs Midwest 2016). Both the 2013 and 2016 data

[1] Utility-scale energy refers to large-scale power plants, such as 1 MW and larger for solar PV, typically owned and operated by electric utilities or independent power producers.

came from AWEA, which produces annual reports on the current status of the wind industry in each state, based on data tracked by WindIQ (Green Energy Ohio 2014; AWEA 2018). This is a comprehensive online database that tracks all operational, under construction, and advanced development wind projects, as well as wind-related manufacturing facilities. However, their data has the limitation of being a range of values (e.g. 2,001–3,000), so for the sake of comparison with the solar data, we averaged the range of values for each year.

In addition, we used NREL's Jobs and Economic Development Impact (JEDI) model to forecast the impact of American Electric Power (AEP), Ohio's plan to install 400 MW of solar and 500 MW of wind generation capacity in the state in the near future (Matyi 2017). The JEDI model uses input-output multipliers based on data from the U.S. Bureau of Economic Analysis (BEA) to compute output impacts associated with power generation capacity development. Due to its various limitations, such as the use of default (i.e., industry average) values for various model parameters, the results of the model should be taken as rough approximations of the actual employment, wage, and economic impact metrics. AEP Ohio is the largest investor-owned electric utility in the state, with more than 1.5 million customers (AEP Ohio 2015). In October 2017, AEP Ohio issued a request for proposals regarding development of solar energy in the state, with the Appalachian region as a site preference for these installations, as well as a preference for projects committed to hiring Ohio military veterans. This effort is, in fact, part of a larger PUCO settlement through 2024 that focuses on clean energy investments through three core strategies: 1) maintaining current fixed monthly charges for residential utility customers; 2) strengthening grid reliability and resiliency through microgrid development; and 3) investments in electric vehicle infrastructure, such as charging stations. Taken as a whole, these initiatives seek to enhance the clean and renewable energy industry in Ohio as part of AEP Ohio's recent electric security plan.

Finally, we used IMPLAN (Impact Analysis for Planning) version 3.1 to estimate the economic impact of the 2015 wind and solar activity in Ohio by inputting the employment estimations for each respective industry. We used 2015 data due to data limitations at the time of modeling. Like JEDI, IMPLAN uses input-output multipliers based on data from the BEA and U.S. Bureau of Labor Statistics (BLS) to model direct and indirect output based on employment. The average wage and value of production, which we refer to as 'economic impact,' of each industry were approximated from the results of the model. As with JEDI, these results should be understood as informed approximations due to the various limitations and assumptions introduced by the specifications of the model. For instance, both JEDI and IMPLAN suffer from limitations around variable or figure alteration capabilities, as well as not accounting for potential behavioral changes from exogenous shocks. Nevertheless, these tools still offered a sound platform for analysis given their state-level modeling capabilities and ability to review income and tax data results.

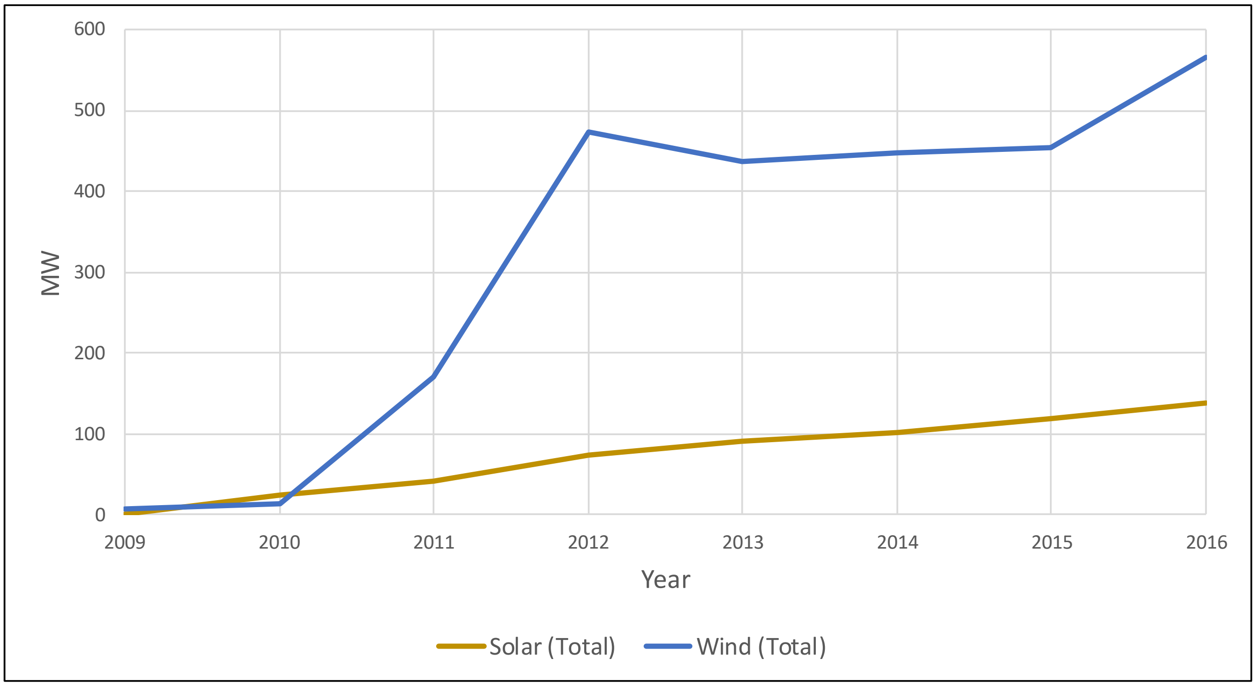
Results

This section analyzes data regarding the generation capacity (i.e., capability), employment, and economic impacts of the solar and wind industries in Ohio. Specifically, this includes each industry's generation capability from 2009 to 2016, along with analyses of their respective utility-scale and distributed deployment. Additionally, we display employment data of each industry from 2013 to 2016. Lastly, as noted, the JEDI model was used to estimate the impact of AEP Ohio's proposal to install 400 MW of solar and 500 MW of wind in the state, and the economic impact of the wind and solar industries was calculated with the IMPLAN model given employment figures from 2015. Overall, the purpose of this study was to quantify the direct job impacts of the solar and wind industries in Ohio, as a key contributor to more favorable forms of sustainable energy development.

As illustrated in Figure 1, both the solar and wind industries showed nearly zero production in 2009, with almost all growth occurring in 2010 and beyond. Most notably, wind spiked from 13 MW in 2010 to 473.5 MW in 2012, which largely corresponded with the construction of the 350 MW Blue Creek Wind Farm near Van Wert, Ohio (Green Energy Ohio 2012). However, from 2013 to 2015, wind experienced almost no growth, coinciding temporally with the aforementioned RPS freeze and Ohio's wind setback law. In fact, capability actually dropped from 2012 to 2013 due to some retirements of existing turbines. However, the industry did recover some growth in 2016, jumping 111 MW, the only substantial growth since 2012. This growth can be attributed to the end of the RPS freeze, continued expense declines, and an increasing consumer appetite for renewable energy, especially in a deregulated state.

Similarly, solar capacity experienced a dramatic jump from 23 MW in 2010 to 74.5 MW in 2012. Overall, however, solar has grown much more consistently, with an 85.1% average annual growth rate and an average annual addition of 19.7 MW during the years of study.

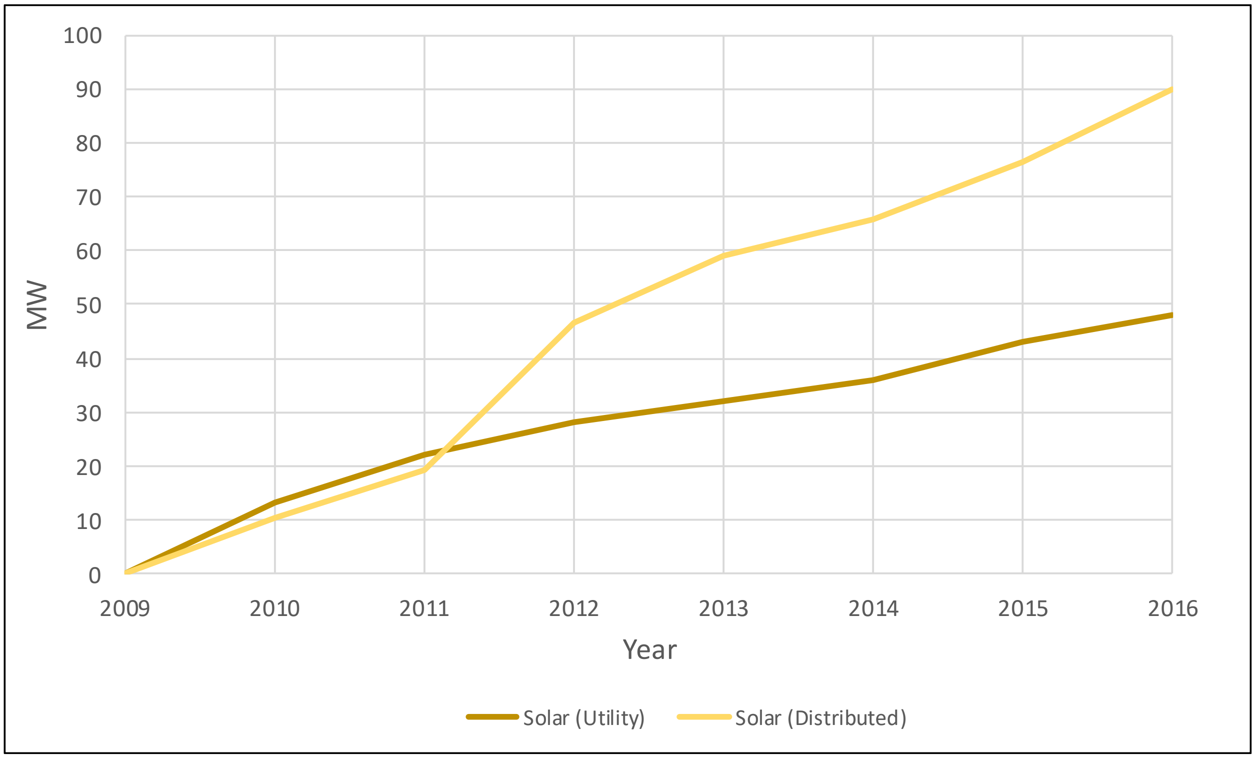
Figure 1: Ohio Aggregate Solar and Wind Energy Capability, 2009–2016



Source: Author's own.

We then examined the development trends of Ohio's utility-scale and distributed solar capability from 2009 to 2016. We did not analyze utility vs. distributed wind energy capability; generally, most wind development is comprised of large-scale turbines built by developers or utilities. In 2009 and 2010, utility and distributed solar grew roughly in parallel (Fig. 2). However, from 2011 to 2013, distributed solar became the main means of solar PV growth in the state, a trend that continued in a less pronounced way from 2013 to 2016. Overall, utility solar annually grew on average 6.9 MW per year, while distributed capability grew 12.8 MW every year. The increasing gap between distributed and utility-scale generation emphasizes the positive impact of Ohio's relatively strong net metering laws, which are geared specifically towards distributed investment, as well as factors such as cost reductions and the increased knowledge of PV installers.

Figure 2: Ohio Utility and Distributed Solar Capability, 2009–2016

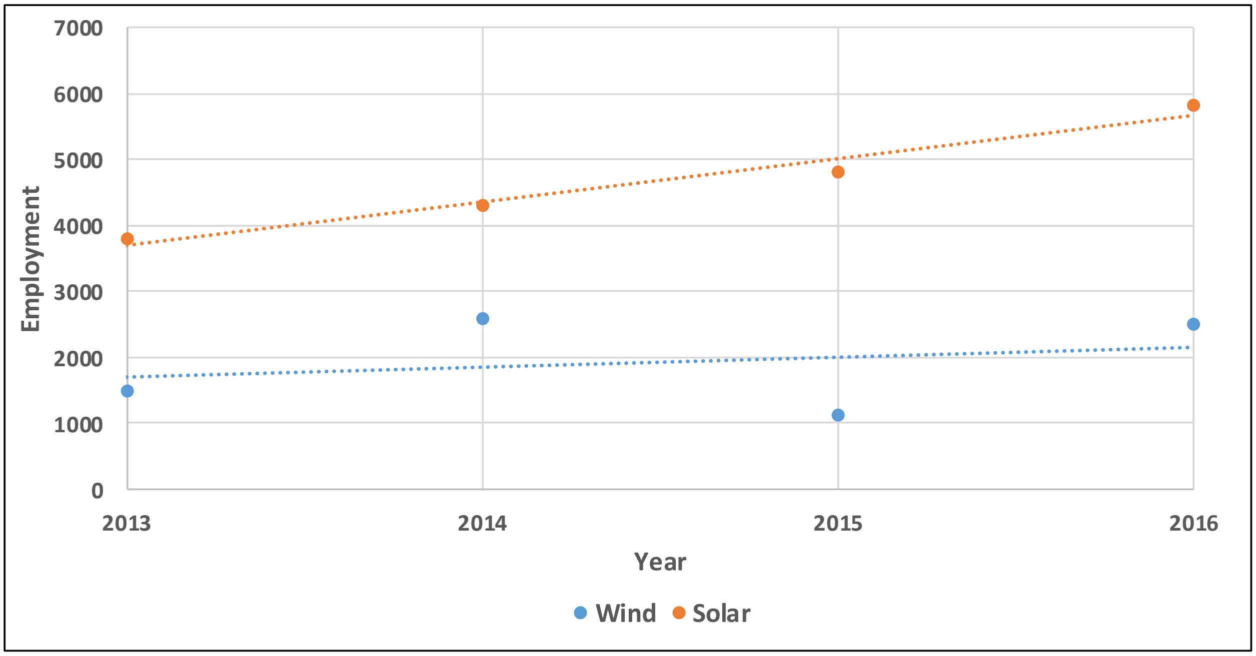


Source: Author's own

After establishing this baseline of solar and wind energy deployment in Ohio, we then focused on the employment within these industries. A secondary data analysis of the solar industry showed 3,800 jobs in 2013; 4,300 jobs in 2014; 4,811 jobs in 2015; and 5,831 jobs in 2016 (Fig. 3). This resulted in an average annual growth rate of 11.3% over the analyzed period. The state's expanding solar manufacturing sector, based primarily in Northwest Ohio and headed by companies such as First Solar, one of the largest PV manufacturers in the Midwest, will most likely fuel additional employment growth in the future. In fact, in April 2018, First Solar announced plans to build a 1.2 GW capacity factory in Lake Township, Ohio. The plant will be used to manufacture First Solar's Series 6 PV modules, bringing the company's U.S. manufacturing capacity total to 1.8 GW annually, all of which is located in Ohio. The continuation of the state's RPS may also encourage investment in utility-scale solar, while Ohio's strong net metering policy will continue to incentivize consumer investment in small-scale residential and commercial PV (e.g., rooftop solar), all prospectively contributing to positive employment growth.

A similar analysis of the wind industry in Ohio showed 1,500 jobs in 2013; 2,589 in 2014; 1,138 jobs in 2015; and 2,500 in 2016 (Fig. 3). The employment shifts in this industry are remarkable, as marked by the growth from 2013 to 2014 and 2015 to 2016 and the decline from 2014 to 2015. These shifts amounted to an annual growth of 13.6%, although careful attention should be paid to the inconsistency of growth, figures, and data sources. However, with the revival of Ohio's RPS and improvements in wind turbine technology (and other factors), a reversal of this downward trend can perhaps be predicted for the future, despite growth being hindered by the zoning restrictions of HB 483.

Figure 3: Solar and Wind Industry Employment, 2013–2016



Source: Author's own

Next, we focused on AEP Ohio's recent announcement of its plans to install 400 MW and 500 MW of solar and wind capacity respectively by the end of 2021 (Editors of Power Engineering 2017). While at the time of writing these developments are still undergoing a hearing and approval process, we sought to model their potential impacts as a particular case study of a sizeable enhancement of state capability figures, and to better comprehend what the economic implications may be. These installed capacity estimates (400 and 500 MW) were used as inputs to the JEDI model, with the limiting assumption that these capacities would roughly be evenly installed over a five-year period resulting in 80 MW per year for solar and 100 MW per year for wind. We also assumed the size of each solar farm to be 10 MW, which is not only the current size of the largest solar farm in Ohio, but also the minimum size project proposal that AEP Ohio was willing to accept per their 2016 request for proposals. The wind farm size was assumed to be 100 MW with a 2 MW wind turbine size, the same size of the turbines at the state's largest wind farm (Krouse 2016). We assumed construction costs to be $1,540 per kilowatt (kW) for solar and $1,590 per kW for wind, based on secondary 2016 costs of construction data (AWEA 2016; NREL 2017). Finally, a 2017-dollar value was assumed, as this was the year of our initial analysis. Note that the construction figures are one-time impacts, while the operations and maintenance (O&M) figures represent annually recurring impacts associated with the daily operation (e.g., monitoring, cleaning, etc.) of the solar and wind energy facilities.

Table 1: JEDI Model Results, 2016

		Jobs	Annual Salary	Net Impact
Solar	Construction	2,220	$88,724	$406,317,278
	O&M	1,271	$65,452	$139,346,377
	Total/Average	3,491	$80,250	$545,663,655
Wind	Construction	2,002	$57,410	$289,649,179
	O&M	126	$57,066	$29,194,259
	Total/Average	2,128	$57,389	$318,843,438

Source: Author's own

According to the model, large-scale solar energy investment results in many more O&M jobs and overall economic impact than wind (Table 1). Solar construction and O&M jobs are also higher-paying than corresponding wind jobs. Finally, it should be noted that all jobs pay much higher than the state's 2016 mean salary of $45,930 (Bureau of Labor Statistics 2016).

Table 2: IMPLAN Model Results, 2015

	Jobs	Annual Salary	Net Impact	Capability (MW)	Impact/ MW
Solar	4,811	$74,635	$900,777,216	119.6	$7,534,039
Wind	1,138	$68,336	$4,336,450,048	455.1	$9,528,502

Source: Author's own

We then used the IMPLAN software to cross-compare data and estimate the economic impact of Ohio's energy industry in its current state using the 2015 employment data as a baseline for the solar and wind industries. The IMPLAN model was customized so that each industry produced 100% of its primary commodity and trade flows (i.e., the buying and selling of goods between various industries) were reduced to zero. This was done to limit the impact of ancillary industries through unrelated purchases and to more accurately estimate the *direct* effect of solar and wind. Moreover, while the metrics that they model are similar, the IMPLAN and JEDI models make different assumptions and carry different caveats and thus their results are not directly comparable. Bae and Dall'erba (2016) made these differences explicit in their investigation of the economic impact results of solar energy projects in Arizona.

The wind industry, despite employing fewer people, actually provides a higher installed capability due to the greater generation ability of wind turbines compared to solar PV, depending, of course, on their size/scale (Table 2). The model shows that wind industry's net impact far surpasses that of solar, perhaps attributable to the inherent distributed nature of solar compared to wind's reliance on larger-scale, more expensive projects. However, the solar industry generally provides better-paying work, such as for PV installers. Nevertheless, the two industries have a similar overall economic impact per currently installed MW (to provide a homogenous comparison), of around $8,000,000–9,000,000.

Despite these comparative differences, there remains a need to invest in both solar and wind energy resources. Ohio has high pollution metrics from electricity generation, especially with its legacy in coal and other extractive industrial activity in Appalachian Ohio, a region that has seen its ups and downs of boom and bust cycles. With core environmental benefits of transitioning fossil fuel generation to renewable sources, such as GHG reductions and important public health advantages, energy transitions to both solar and wind can reduce fossil fuel-related pollution and provide positive benefits for sustainability. Certainly, more jobs could be created in alternative sectors altogether, yet as environmental regulations and the lack of cost competitiveness continue to push utilities to decommission their large, baseload plants (e.g., coal-fired power), there is an obvious energy generation gap that will need to be met by alternative energy sources. Many of these occupations do not require advanced degrees, and thus match well with declining jobs in many sectors (e.g., former coal economy workers in Southeast Ohio). This can create opportunities for occupational transitions that do not require additional education or advanced-level certifications.

Discussion

Though this research is unique in its focused analysis of Ohio's contemporary energy economy, others have modeled subsets of the state's energy industry. One such prior report is the Greenlink Group's models for three scenarios of development in Ohio's renewable energy and energy efficiency industries: one where Ohio focuses on energy efficiency, one focused on renewables, and one intermediate scenario that balances between the two strategies. These models suggest that efficiency-focused development is actually the most beneficial to Ohio's economy. This model projected that by 2030, Ohio's efficiency and renewables industries combined would employ 82,300 – 136,000 individuals (Cox et al 2016). This would create a $4.6 billion – $7.6 billion payroll boost in the state, as well as contribute $6.7 billion – $10.7 billion to Ohio's gross domestic product (GDP) (Cox et al 2016). These estimates are substantially greater than those presented in our analysis, as the scope of the Greenlink analysis also included energy efficiency defined quite broadly (e.g., green homebuilding), reflecting a much larger portion of the state's economy.

Additionally, the national Solar Energy Industries Association (SEIA), in a study with Greentech Media Research, found that $467.13 million has been invested in Ohio's solar industry as of 2016 and predicted that the state will go on to install 607 MW of solar capacity by 2021 (Solar Energy Industries Association 2016). In comparison, our models show an even more optimistic estimation, with nearly twice the estimated economic impact given projected investments from large electric utilities as well as with more refined models and newer data.

It is clear that Ohio's energy economy is rapidly evolving, driven primarily by continued improvements in technology, changes in state policy, an appetite for sustainability, and increased citizen and business awareness of environmental impacts. Both solar and wind module and equipment costs continue to decrease every year, making them economically competitive alternatives to traditional sources of energy generation. Specifically, residential solar PV installation costs in the state have dropped from $8 per watt in 2009 to well under $4 per watt in 2016 (our years of analysis), with even cheaper prices (around $1 per watt of installed capacity) at the utility-scale level (Michaud 2016). Further research by NREL has shown that the average installed costs of wind projects built in the U.S. in 2014 were $1.71 per watt (Weiner 2015).

The recent PUCO settlement and AEP Ohio's plans for additional renewable energy development in the state will also contribute to sustainability initiatives such as mitigating pollution impacts, maintaining competitive electricity prices, and providing residential and commercial customers alike with more clean energy options. This is an important effort and direction by AEP Ohio, as it represents a wider strategy to adapt to emerging clean energy market demands for customers of the future. Subsequently, this effort will further stimulate jobs and general economic growth potential. AEP Ohio's parent company, American Electric Power, also reports that they have recently adopted a carbon reduction strategy that aims to reduce power plant emissions by 60% by 2030 and 80% by 2050 (American Electric Power 2018). AEP has been working to reduce its reliance on fossil fuels for more than a decade, as evidenced by a decrease in coal-fired generation capacity from 70%

to 40% since 2005, coinciding with an increase in renewable capacity from 4% to 13% during the same timeframe (American Electric Power 2018).

Also, as noted, Ohio's PUCO adopted new rules updating which types and sizes of electric generation facilities qualify for net metering in November 2017, defining the limit for the generation capability of a net-metered facility to be 120% of the user's average electricity consumption. This positive development has been complicated by the negative increased fee structure, which is projected to reduce the net metering credit rate by roughly 30% for Ohio customers (Walton 2017). At this time, the impact these new rules will have on the growth of net-metered renewable energy development remains relatively uncertain. However, consumers may be less inclined to invest in distributed generation (e.g., rooftop solar PV) via net metering due to the reduced credit rate.

This research adds perspective to the recent developments, especially those in policy, of Ohio's energy industry. The continued strong growth of installed solar capability and employment helps show a consistent rise of the industry despite some policy restrictions. Wind energy has shown to be more stagnant in response to more aggressive negative policy such as the setback law. It is certain that future state policy will continue to greatly impact these industry trends and will largely decide whether they reverse or continue.

The strict setbacks placed on wind farms in Ohio in 2014 have limited the wind industry's development. Both the recent employment and capability data have shown that the industry has stagnated despite large initial growth. As this has greatly limited the number of new wind farms, revamping the requirements (e.g., reducing footage or eliminating altogether) for future wind development could lead to growth in the capacity and employment of the industry. Maintaining or expanding these wind setback requirements, which are among the most stringent in the country, will likely lead to continued stagnation, and maybe even contraction, due to lowered investment production, causing more Midwest wind developers to look to other states such as Michigan and Minnesota.

Conversely, solar energy has thus far relied more heavily on distributed, individual investment for expansion, as shown in the large disparity between distributed and utility-scale solar capacities. As such, legislators' continued revision in Ohio's net metering policies will directly influence new consumer investment. At the utility-scale level, Ohio's RPS heavily influences growth in both the solar and wind industries by requiring utilities to invest in these technologies or face steep financial penalties. The expansions or reductions in the carve-out totals, or changes in what type of generation is considered 'renewable,' will also determine future utility investment.

In addition to these core, highlighted policy mechanisms, other state renewable energy strategies may also have an impact on the future of the solar and wind industries, such as low-interest loan programs, tax credits, tax exemptions, and grants. Ohio already provides some of these, including loans and property tax exemptions (DSIRE 2017b; DSIRE 2017c). Many of these policies have been shown in prior research to advance investment in renewables. Policymakers can use those policy evaluation studies to better understand the most cost-effective use of public dollars when it comes to implementation of energy generation strategies. Advanced strategies such as community renewables, which is a mechanism by which off-site customers can invest in a remote energy generation asset instead of on their own property, may also be a viable path forward. However, knowledge of these alternatives remains relatively low, and legislation may be difficult to pass depending on legislative demographics and anti-renewable lobbying efforts. Thus, other potential paths forward may come directly from electric utilities, or even grassroots programs which provide workarounds to policy deficiencies. For instance, solar energy cooperatives have been forming around the country to achieve economies of scale and lessen risk by reducing costs through bulk purchasing strategies. Various stakeholder study groups, coalitions, and others have been pushing for more favorable renewable energy policymaking, but alternative crowdfunding and alternative billing arrangement options will interplay with paths forward, as well as non-policy factors such as technological advancements and improved energy storage technologies.

Moving forward from this paper, there is considerable room for future research. Employment data limitations (often due to data suppression) were a noteworthy caveat to this research, requiring employment estimations from various sources to be trusted as accurate representations for the years analyzed. Future work could perhaps develop methodologies to overcome these limitations, such as using North American Industry Classification System (NAICS) codes and BLS employment data to give more direct estimations that are continuous from year to year, and to expand the years covered. Further, marrying employment figures with wage estimate data could give a more detailed perspective to the annual growth or shrinkage of wages, especially in comparison to the median state wage, and would also provide greater context to the estimations provided by the IMPLAN and JEDI models. Regardless, it remains clear that state politicians will have to continue to navigate this complex policy environment when considering future energy decisions around renewables such as solar and wind.

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