Economic Impacts from Indiana's First 1,000 Megawatts of Wind Power

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National Renewable Energy Laboratory

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Technical Report
NREL/TP-5000-60914
August 2014

Contract No. DE-AC36-08GO28308

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Prepared under Task No. WE11.1121

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List of Acronyms & Abbreviations

AWEA	American Wind Energy Association
FTE	full-time equivalent
GEC	Global Energy Concepts
GW	gigawatts
GWh	gigawatt-hours
I-O	input-output
JEDI	Jobs and Economic Development Impact
MW	megawatts
NREL	National Renewable Energy Laboratory
O&M	operations & maintenance
VCEPS	Voluntary Clean Energy Portfolio Standard

Executive Summary

The magnitude of Indiana's available wind resource indicates that the development of wind power infrastructure has the potential to support millions of dollars of economic activity in the state. Since the creation of Indiana's Wind Working Group[1] in 2005, the state has been engaged in forming strategic alliances with the agricultural, energy, legislative, and regulatory sectors to communicate wind's benefits and challenges to stakeholders (Indiana OED 2013; EERE 2013). As of June 2013, Indiana had 1,543 megawatts (MW) of wind power installed, the 13th largest installed wind fleet by capacity in the United States. The potential economic impacts of wind power development include direct effects such as jobs, land lease payments, and increased tax revenues, indirect effects on businesses in the supply chain, and induced impacts resulting from additional spending on local goods and services (Lantz and Tegen 2008).

Table 1. Indiana Wind Power Statistics

Power capacity - existing projects (MW):	1,543
State wind resource potential at 80 meters[2] (MW):	148,228
Wind resource rank (by *potential* capacity) out of 50 states:	16th

Sources: American Wind Energy Association (2013), Lopez et al. 2012

The Jobs and Economic Development Impact (JEDI) models, developed by the National Renewable Energy Laboratory (NREL), are tools used to estimate some of the economic impacts of energy projects at the state level. JEDI calculates results in the form of jobs, earnings, and economic output in three categories: project development and onsite labor, local revenue and supply chain, and induced impacts.

According to this analysis, the first 1,000 MW of wind power development in Indiana (projects built between 2008 and 2011):

- Supported employment totaling more than 4,400 full-time-equivalent (FTE) jobs in Indiana during the construction periods
- Supports approximately 260 ongoing Indiana jobs
- Supported nearly $570 million in economic activity for Indiana during the construction periods

[1] A Wind Working Group is made up of people interested in appropriate deployment of wind technology in their state. Group members discuss concerns regarding and benefits from wind energy to ensure responsible wind power installations. The groups were first formed by interested parties within the state with support from the Department of Energy's Wind Powering America initiative and other interested organizations.
[2] The wind resource is based on the predicted mean annual wind speeds at an 80-m height with spacing of 5 MW/km2. Areas with annual average wind speeds around 6.5 meters per second and greater at 80-m height are generally considered to have a resource suitable for wind development. Utility-scale, land-based wind turbines are typically installed between 80 and 100 m high. See the Indiana state resource map with capacity curves and assumptions for the 80-m potential at http://apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp?stateab=in

- Supported and continues to support nearly $40 million in annual Indiana economic activity during the operating periods
- Generates more than $8 million in annual property taxes
- Generates nearly $4 million annually in income for Indiana landowners who lease their land for wind energy projects.

These estimates are based on project expenditures and local content assumptions provided by the developers and operators and assume 20% of construction expenditures are made in Indiana and 40% of operations & maintenance (O&M) expenditures remain in-state.

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1 Introduction

In 2010, Indiana ranked seventh among the states in coal production. By July 2013, the main component in Indiana's power generation mix was coal (88.7%), half of which was imported from other states. Natural gas (9.3%) and non-hydroelectric renewable energy (1.6%) were the other largest sources of electricity. Wind power constitutes 90% of the renewable energy capacity in Indiana (EIA 2013a; EIA 2013b).

Research at the National Renewable Energy Laboratory (NREL) and elsewhere has expanded knowledge of Indiana's wind resource and shown far greater potential for wind-generated electricity than was thought possible in previous years due to wind measurements at higher hub heights and taller wind turbine tower technology (see Section 2.2). Estimates from this research indicate a technical potential for land-based wind in Indiana of 148 gigawatts (GW), capable of producing 377,000 gigawatt-hours (GWh) each year (Lopez et al. 2012). The wind energy potential at an 80-m hub height is shown as a map in Figure 1. For comparison, the total electricity consumed in the state in 2011 was 359,788 GWh, 95% of the potential annual wind power production (EIA 2013a).

In 2005, Indiana's Office of Energy Development created the Indiana Wind Working Group. The group organized the Windiana annual conference until 2011 to share Indiana's plans to develop wind energy with multiple stakeholders and the wind energy industry (Indiana OED 2013; EERE 2013). Indiana had no installed wind capacity by the end of 2007. Two years later, at the end of 2009, the state had 1,036 megawatts (MW) of installed nameplate capacity, making it the state with the third fastest wind capacity growth that year (AWEA 2010). In May 2011, the state legislature passed a Voluntary Clean Energy Portfolio Standard (VCEPS) that set a voluntary goal of meeting 10% of state electric generation using clean energy sources by 2025 (DSIRE 2013). As of June 2013, the state had 1,543 MW of installed wind capacity, the 13th highest in the United States (AWEA 2013).

The present analysis estimates that continued wind energy development in Indiana has the potential to support millions of dollars of economic activity in the state. The analysis of the economic impact of Indiana's first 1,000 MW of wind power estimates $570 million of in-state economic activity and more than 4,400 jobs during the construction period. The operation and maintenance of the facilities support approximately $40 million in economic activity and 260 jobs on an annual basis.

Wind projects bolster jobs, generate tax revenue for farmers and ranchers, and increase local tax bases for rural communities. Wind turbines have a minimal impact to farmable acreage because they have small footprints and the land can be used almost right up to the base of the turbine. In addition, wind energy conserves water resources and reduces pollution (EERE 2004).

Estimating the economic development impacts of wind power plants allows policymakers and decision makers to design policies targeting economic development goals (Lantz and Tegen 2008). This study captures the economic impacts of the first 1,000 MW of wind energy in Indiana. Specifically, we examine the impact of the first utility-scale wind energy projects in Indiana during construction and operation phases. We use 1,000 MW as a baseline because it can be scaled to get a sense of the economic development opportunities associated with other wind scenarios.

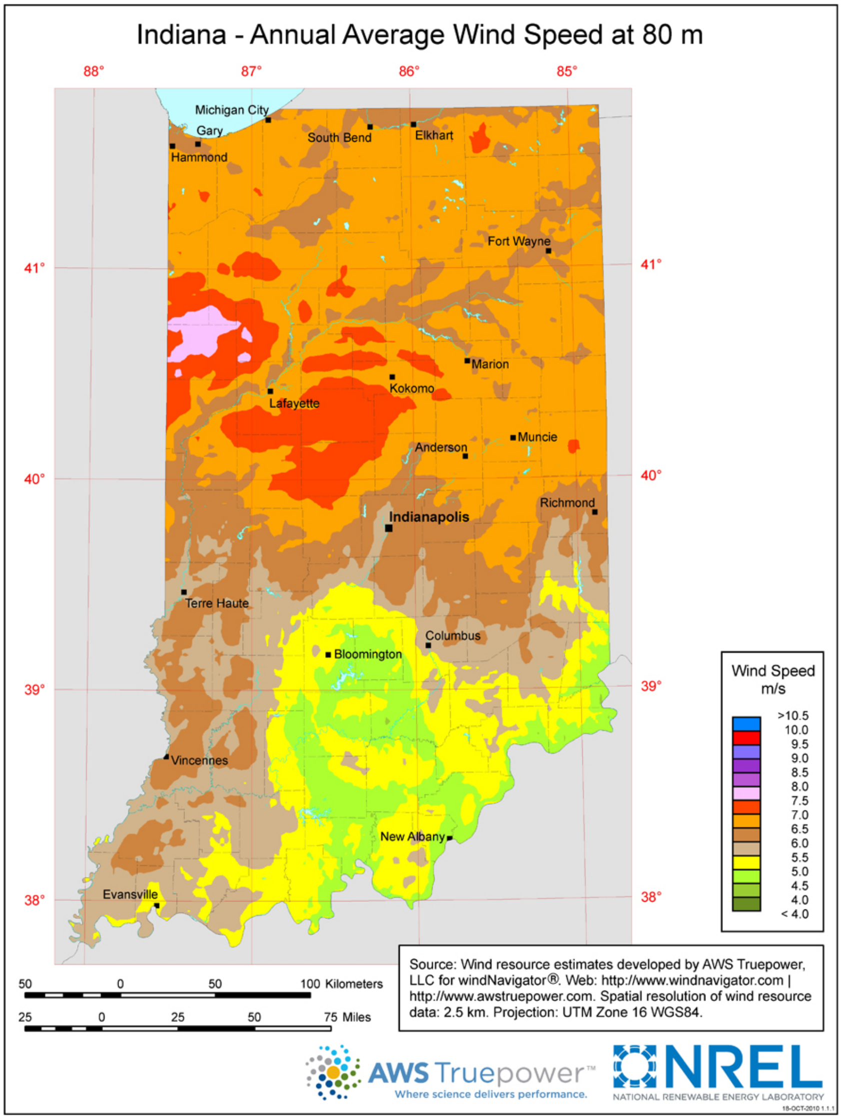

Figure 1. This map shows Indiana's wind resource potential at an 80-m height.

Case Study: Wind Energy Supports Regional Education and Vocational Development in White County

Wind energy and other renewable technology have had impacts on Indiana's future workforce and educational institutions, including Ivy Tech Community College in Lafayette. Indiana's largest public-college system, Ivy Tech has 31 campuses in 14 regions. The college trains students for technical and vocational careers, offering certification programs and associate degrees that provide students with skills to assist them in joining the workforce.

White County is served by Ivy Tech-Lafayette. When Ivy Tech faculty and leadership learned that wind farms would soon become a part of the county's economic fabric in 2007, they saw an opportunity for their students. They leveraged a U.S. Department of Labor Workforce Innovation in Regional Economic Development grant designed to foster talent, workforce development, and regional economic transformation. Ivy Tech created its Energy Technology program and hired Isaac Slaven as the program's first chair and faculty member.

Figure 2. Ivy Tech Community College students build a residential-size wind turbine as part of their sustainable energy program. Source: Ivy Tech Community College

From the beginning, the college requested help from the companies involved in building, operating, and supplying the area wind farms, including Vestas Wind Systems, which supplied White County's turbines; EDP Renewables, owner of Horizon LLC (the company that constructed and now operates and manages the White County wind farms); and enXco, which maintains the turbines. As part of this effort, Vestas hired Slaven as a faculty intern. According to Glen Roberson, assistant vice president and statewide dean of Ivy Tech's Institute of Technology, this opportunity provided Slaven with hands-on experience that aided in developing classes to teach students real-world technical skills. Roberson oversees not only the Energy Technology program but also other programs such as Chemical Technology and Automotive Technology with a role to play in training the sustainable energy workforce.

"Because of the nearby wind farms, Ivy Tech has a strong focus on wind technology. Students enroll in the wind-related curriculum to gain practical experience, including turbine maintenance skills, in addition to their in-class studies," Roberson explained.

The multi-disciplinary program in sustainable energy provides opportunities for students who can study smart-grid development and maintenance, biofuel development, battery design and development, solar technologies, and more. Ivy Tech Lafayette developed an energy center in partnership with the local industry and the federal government. It has a strong industry presence, showcasing existing and emerging wind, solar, electric vehicle, and home automation technologies. The center is a unique example of how sustainable energy technologies can be integrated to provide a complete energy solution.

"We have 150 students currently enrolled in the Energy Technology program, and our graduates have easily found work after getting their degree," Roberson said.

2 Methodology

2.1 The Jobs and Economic Development Impact Model

This study utilizes the Land-Based Wind Jobs and Economic Development Impact (JEDI) model. The model is one element of a suite of JEDI input-output (I-O) models. JEDI models provide estimated economic impacts that are supported by investment in a number of different energy technologies. NREL and MRG & Associates developed the wind JEDI model to incorporate the unique aspects of wind development in an economic impact tool that can be accessed and used by the public.[3]

I-O models are widely recognized tools that are used to estimate economic impacts associated with investments or expenditures. These models map how economy sectors such as businesses, households, workers, capital, and governments interact with one another via purchases and sales at a single point in time. Because sectors are related to one another, an increase in demand for one can lead to an increase in demand for another. An increase in demand for steel towers, for example, results in increased demand for iron ore.

JEDI and other I-O models estimate economic impacts that are supported by changes in demand for goods and services.[4] JEDI estimates changes in demand for these goods and services with data from the project scenario.

The JEDI project scenario is a set of data that describes a project. Each project contains two sets of line item expense categories such as equipment (blades, towers, turbines), materials and services, and labor. One set covers the construction of the project, the other covers operations and maintenance (O&M) of a project. JEDI models contain default project scenario and cost data, but analysts with knowledge of project details can edit these defaults to better represent the scenario being analyzed.

The JEDI model also allows a model user to specify which portions of expenditures are made within the region of analysis. For example, the model allows users to specify whether wind turbine blades were manufactured in the state where the project is being built or outside the state (assuming the state is the region of analysis). JEDI uses expenditures made within the region of analysis, or "local expenditures," to estimate economic impacts. The local share specification can have a significant influence on model results. The JEDI model does not estimate economic impacts outside the region of analysis (e.g., generator parts from China).

Economic impact estimates from JEDI take the form of a number of different variables at different times. Each data point represents a specific metric, that metric's relationship to the project, and the phase of the project in which it occurs.

JEDI reports economic impact estimates for two phases: construction and O&M. Construction phase results are one-time totals that span the equivalent of 1 year.[5] O&M results are annual and ongoing for the life of the facility.

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[3] Further information about JEDI, including downloadable models, can be found at www.nrel.gov/analysis/jedi/

[4] JEDI currently uses the IMPLAN input-output model. More information about IMPLAN is available at www.implan.com

All impacts are based on expenditures and local content data contained within the project scenario worksheet. JEDI organizes these effects into different categories based on how the user-specified project scenario supports the impact. The workers who install a wind turbine, for example, are onsite. The workers who manufactured that turbine are part of the supply chain. Installers and manufacturers earn wages and spend money within the region of analysis, which supports further economic activity (e.g., the construction workers eat lunch at local sandwich shops). The three categories of impacts used by JEDI are[6]:

- **Project development and onsite labor impacts** represent economic activity that is either directly involved with a project's development and implementation or that occurs onsite. These impacts typically occur in the construction, maintenance, engineering, and professional services, and port staging sectors. These do not include impacts that arise from expenditures for inputs used in a project.
- **Turbine and supply chain impacts** represent economic activity that is supported by inputs purchased for a project or business to business services. These include locally manufactured inputs such as blades and locally procured inputs used to manufacture those blades, such as resin and fiberglass. This category also includes services provided by professionals such as analysts and attorneys who negotiate contract agreements, banks that finance the projects, and all equipment companies and manufacturers of replacement and repair parts.
- **Induced impacts** accrue as money circulates in an economy. Households spend earnings from project development and onsite labor impacts as well as turbine and supply chain impacts. The portion of these earnings spent within the region of analysis supports induced impacts. These effects commonly occur in the retail sales, child care, leisure and hospitality, and real estate sectors.

Figure 3 shows a graphical representation of the three types of impacts from JEDI.

[5] If, for example, JEDI reports a construction phase impact of 50 workers to build a project that takes 2 years to complete, this is the equivalent of an average of 25 workers per year (50 / 2 = 25). If the same project took 3 years, the average would be 17 (rounded) workers per year.

[6] Typically, I-O models organize impacts into direct, indirect, and induced effects. JEDI categories differ from these. Project development and onsite labor impacts include less-than-direct effects from project expenditures, and turbine and supply chain impacts are more broad than the indirect effects from project expenditures. The Wind JEDI User Reference Guide (www.nrel.gov/analysis/jedi) contains more information about these differences.

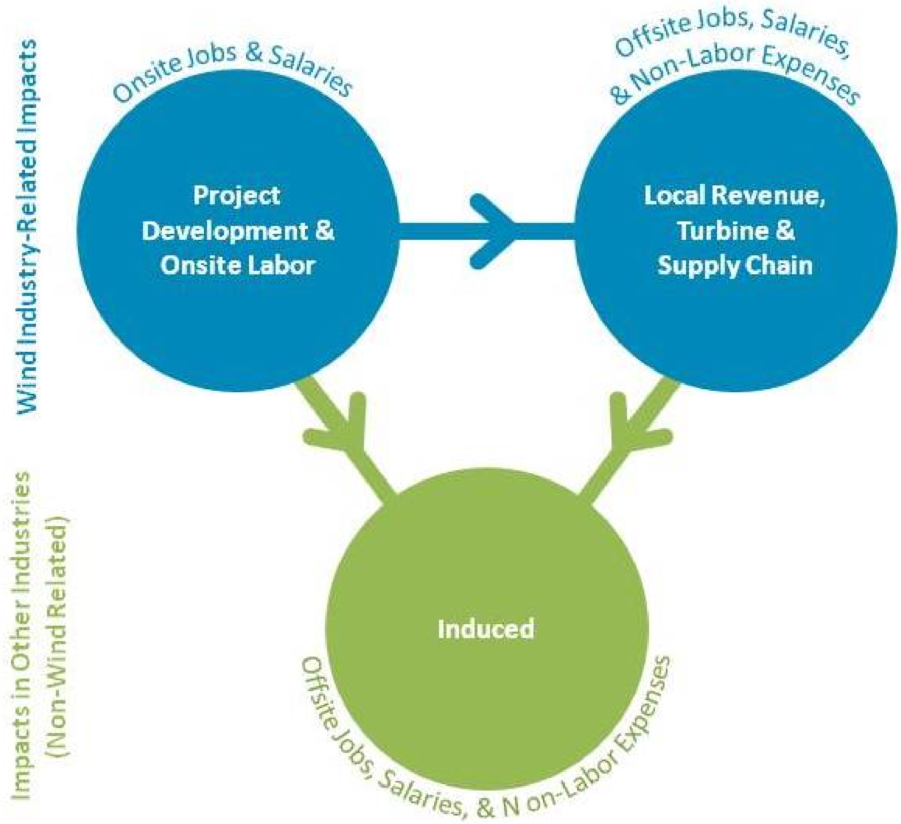


Figure 3. JEDI Wind model economic development impact categories

JEDI reports three metrics for each type of impact: jobs, earnings, and gross output. JEDI utilizes intuitive labels when reporting these metrics, such as "jobs" and "earnings." Each metric, however, has a specific definition that informs how it should be interpreted.

- **Jobs** are expressed as full-time equivalent (FTE). One job is the equivalent of one person working 40 hours per week, year-round. Two people working full-time for 6 months equal one FTE. Two people working 20 hours per week for 12 months also equal one FTE. An FTE could alternately be referred to as a person-year or job-year. Jobs, as reported by JEDI, are not limited to those who work for an employer; they could include other types of workers, such as sole proprietors (self-employed).
- **Earnings** include any type of income from work, generally an employee's wage or salary and supplemental costs paid by employers such as health insurance and retirement. It could also be other non-wage compensation for work performed, such as proprietor earnings.
- **Gross output** is the total amount of economic activity that occurs within an economy (within the region of analysis). It is the value of what is sold within that economy as well as inputs used in production. A $500,000 wind turbine blade that uses $100,000 in locally sourced materials, for example, would result in $600,000 in output.[7]

[7] This should not be confused with gross domestic or state product, which is a measure of the value of production.

As with all economic models, there are caveats and limitations to the use of JEDI. I-O models in general utilize fixed, proportional relationships between economy sectors. This means that factors that could change this, such as price changes that lead households to change consumption patterns, are not considered.

JEDI provides estimates of economic impacts given the user-specified expenditures and economic conditions when I-O data were compiled. Impacts that extend into the future (such as O&M impacts) are assumed to do so if all else is constant. There can be any number of changes in a dynamic economy that JEDI does not consider, so these future results should not be considered a forecast. They simply reflect how a project might look if it were completed in the current economy under the user-specified cost and local content assumptions.

JEDI results are based on project inputs, and these inputs can change from project to project. This is especially true of nascent technologies or technologies that have not yet been widely deployed in the United States. If an analyst wishes to estimate impacts from a specific project, tailoring inputs to that project should produce more accurate results. JEDI does not evaluate whether inputs are reasonable, nor does it determine whether a project is feasible or profitable.

Results from JEDI models are gross, not net. JEDI only calculates what economic activity would be supported by demand created by project expenditures. Other changes in an economy may take place that JEDI does not consider. These include supply-side impacts such as price changes, changes in taxes or subsidies, utility rate changes, or changes in property values. JEDI also does not incorporate far-reaching effects such as greenhouse gas emissions, displaced investment, or potential side effects of a project such as changes in recreation or tourism.

Case Study: Wind Farm Tours in Benton County

Since the first turbines were erected in Benton and White Counties, they have captured the attention of motorists driving along Interstate 65, the main road through the two counties. Benton County's economic development office recently began to host educational tours for visitors interested in learning about Benton County agriculture and history and decided to add a wind farm component to the range of tours offered.

"The county commissioners contracted with Harry Hoover in May 2010 to run tours for a set per-hour fee," explained Lelia Jozwiak, who manages the tours for the development office. "Harry is a retired Benton County school teacher who has followed and filmed the wind turbines' construction since day one – this combination of interest and skills makes him a terrific tour guide."

Figure 4. Benton County Wind Farm tour advertisement. Source: Benton County

Fees for the wind tours are paid to the economic development office, with income accumulating in a special account that covers supplies for the tours and tour guide. The income is minimal because tour prices are kept affordable, but it ensures that the program can pay Hoover and be self-sustaining.

Among the benefits of the tours is the opportunity to dispel inaccurate notions about turbine noise and vibration, said Jozwiak. She said that after seeing the towers up close, most visitors find their pre-conceived notions are exaggerated and they discover minimal noise and vibration. The tours help educate students of every level, as well as members of the public intrigued by the wind farms.

2.2 Indiana Wind Speeds at Different Hub Heights

The extent of future wind deployment in Indiana is dependent on the wind resource. A greater resource leads to more electricity production from wind plants, decreasing the cost of electricity generated by wind. This resource varies at different heights, making measuring and estimating the resource for a number of wind turbine configurations a vital part of planning for future growth.

The three maps in Figure 5 represent annual wind speed estimates at three potential turbine heights: 50, 70, and 100 meters. AWS TrueWind produced these estimates and NREL and wind energy meteorological consultants validated them. Using these data, NREL estimated that the available wind potential in Indiana could produce more than 377,000 GWh each year, roughly 5% more than the energy consumed in the state in 2011 (Lopez et al. 2012; EIA 2013a). In previous years, only the 50-m dataset was available, so the Indiana wind speed map did not look as promising. With measurements taken at higher heights and wind turbines available with hub heights at 80 m and higher, the Indiana wind speed map shows much greater potential than previously identified.

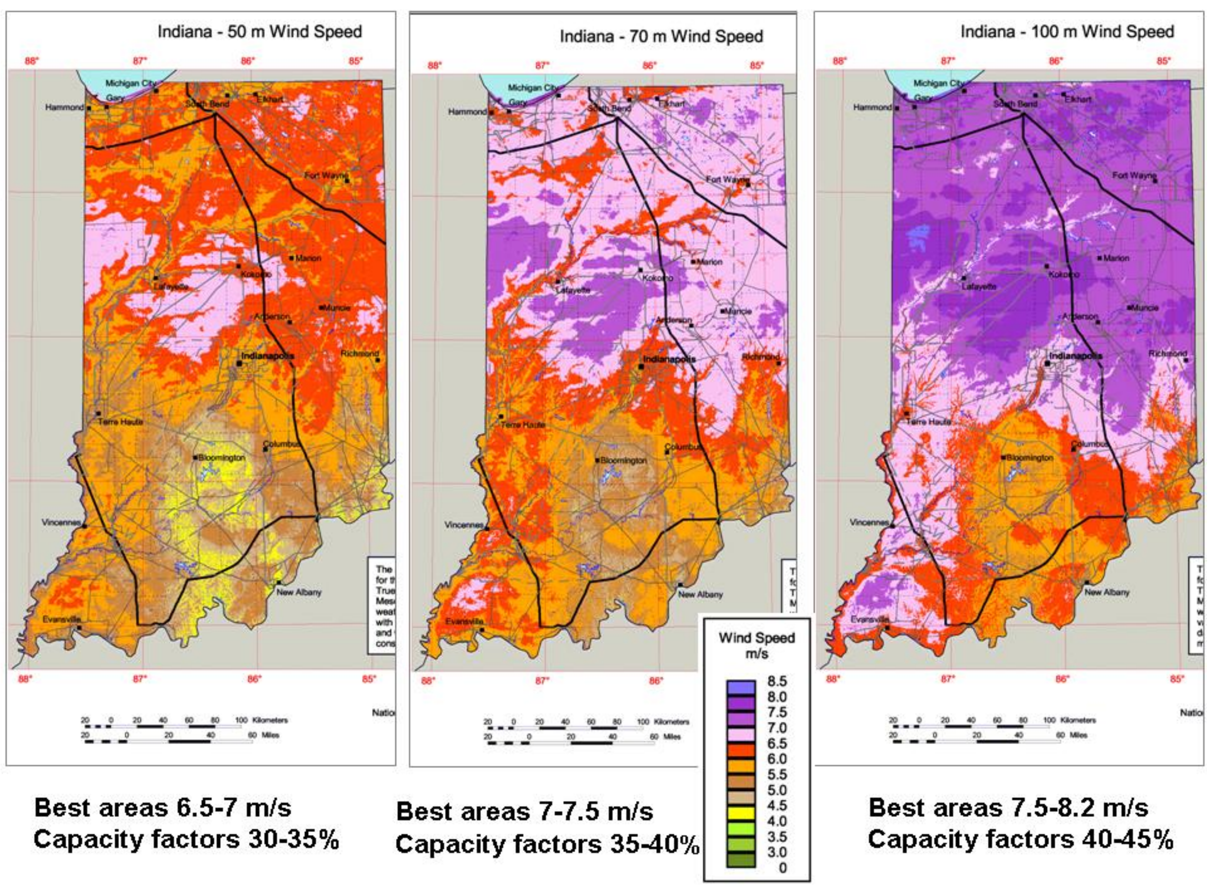


Figure 5. Indiana wind resource at three hub heights

2.3 Scenario and Data

This report relies on empirical data obtained from wind power developers, the American Wind Energy Association (AWEA), and the Global Energy Concepts (GEC) database. Data for each project include information regarding project location, completion status, year online, total nameplate capacity, turbine manufacturer, owner, number of turbines, and turbine size. This analysis includes seven projects totaling 1,339 MW (Table 2). In this report, we calculate employment and other impacts from the 1,339 MW in Indiana and also show results in terms of employment and impacts per 1,000 MW to make comparisons and averages easier.

Table 2. Wind Projects Analyzed for this Report

Project	County(ies)	Capacity (MW)
Benton	Benton	131
Fowler	Benton	600
Meadow I	White, Jasper, Benton	200
Meadow II	White, Jasper, Benton	99
Meadow III	White, Jasper, Benton	104
Meadow IV	White, Jasper, Benton	99
Hoosier	Benton	106
Total		1,339

We conducted further research into each of the projects by collecting publicly available project data from media reports and figures provided by developers and operators. These provided information about construction and operating costs, employment, and other data utilized in the JEDI models. Developers and operators later validated these data.

We also conducted extensive interviews with developers, county commissioners, stakeholders, and other industry experts involved with the projects analyzed. Interview data included detailed cost data not available to the public, percentage of expenditures made in Indiana, project employment, and information on wages, land lease payments, and taxes. [8] Each of the Indiana projects analyzed was modeled individually before aggregating results for this report.

The following tables show summaries of the expenditure and local percentage input data used in the JEDI model for construction and O&M.

Table 3. Construction Input Data Summary

Item	Expenditure ($ Mil.)	Percent Local
Equipment	$ 1,830	0%
Materials	$ 331	82%
Construction labor	$ 159	57%
Development & other costs	$ 2,487	59%

[8] Specifics from these conversations are confidential and cannot be disclosed, which is why this report does not list detailed inputs used in the JEDI model. The appendix in Section 5 contains more detailed cost and local content estimates used in JEDI modeling. To avoid disclosing expenditures or purchases at any individual site, these are aggregated across all sites.

Table 4. O&M Input Data Summary

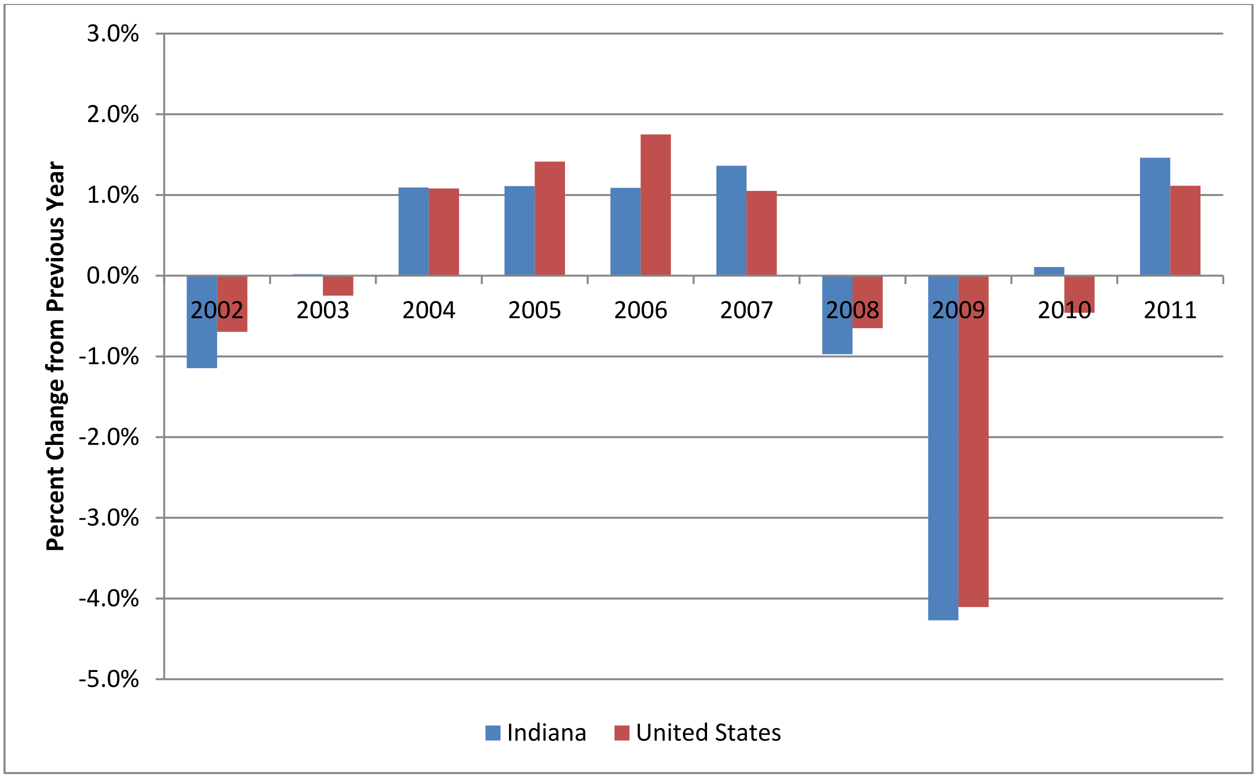
Item	Expenditure ($ Mil.)	Percent Local
Personnel	$8.7	100%
Materials & services	$20.1	21%

2.4 Socioeconomic Statistics

Existing employment and population in Indiana provide context for any impacts supported by the wind industry. Employment and wages are significant drivers of population change (Greenwood & Hunt 1989). If economic growth occurs without a qualified workforce, it will likely drive in-migration of qualified workers. Conversely, if a workforce cannot find jobs in a given region, this will likely result in out-migration of those workers. By supporting jobs, the wind industry can help stabilize populations, especially in regions with high unemployment or slow job growth.

In 2011, Indiana was home to approximately 6.5 million residents, 4.1 million of whom were between the ages of 18 and 65 (U.S. Census Bureau 2013). Total employment in 2011 was 3.6 million, leaving just under 500,000 working-age adults without jobs (BEA 2012, U.S. Census Bureau 2013). Not all of these adults were labor force participants – Indiana's unemployment rate in 2011 was an average of 9%, or 283,000, in 2011 (BLS 2012). Working-age adults not included as labor force participants include people who were not actively seeking employment (applying for jobs) and those who could not work.

Job growth in Indiana during the 2000s was roughly in line with the nation as a whole (Figure 6). The average annual growth rate from 2001 up to the 2008 recession was 0.4%, slightly lagging the national average of 0.5%.



Source: Bureau of Economic Analysis (BEA)

Figure 6. Percent change in employment in Indiana

The wind power projects analyzed in this report are located in three Indiana counties: Benton, Jasper, and White. Benton is the smallest of the three, and its population had just more than 4,300 jobs in 2011. Benton is followed by White and Jasper (Table 2). Jasper, the largest county, had positive annual average job growth between 2001 and 2011, whereas Benton and White, on average, shed jobs over that time period.

Table 5. Indiana County Employment Levels in 2011

County	2011 Employment	Average Annual Job Change 2001-2011
Benton	4,339	-0.7%
Jasper	16,012	0.2%
White	10,346	-1.3%

Source: BEA 2012

Case Study: Wind Power in Benton County

As of June 2013, Indiana had 1,543 MW of wind energy online. More relevant to residents of Benton County, the location of the state's first wind farms, are the resulting jobs generated. Four years after installation efforts began, Dan Bennett, owner of Bennett's Garage in Earl Park, still marvels at the effects of the three wind farms in the county.

"I never would have imagined the impact that they've had on the town," he said.

The first wind farm in Benton County is located about 1,000 feet from the edge of Earl Park where Bennett lives and works. RMT, Inc. (formerly known as Wind Connect) led the effort to site, engineer, and build the 87-turbine Benton County Wind Farm, breaking ground in July 2007 and finishing in May 2008.

"We first got to know the Wind Connect project managers when they introduced themselves at a safety meeting they held at our fire station," explained Bennett.

Many of the first wind farm workers did not live in Earl Park, which meant they had limited familiarity with the local roads. Bennett said that the driver of a truck with only 23 miles on it inadvertently caught the side of an asphalt road, causing him to hit a culvert and wreck the truck. According to Bennett, this occurred due to the driver's inexperience with the roads. As a result of these sorts of difficulties, RMT depended on Bennett and his team even in the first days of the project, which led to a significant increase in business throughout construction.

RMT needed additional employees as construction ramped up. They hired many locals from Benton and nearby counties to work on the wind farms and also leased and bought a large number of pickup trucks in the local area to meet project needs. According to Kelly Kepner, head of Benton County's economic development program, Earl Park and surrounding towns benefitted from visiting construction workers renting houses, staying in hotels, and patronizing local restaurants and other service businesses. Largely because of increased business, by November 2007 Bennett said that he was able to buy a new semi-truck and trailer for his towing business; later, with the installation of a second wind farm in 2008 (Fowler Ridge Phase I), he bought another semi/trailer combination.

The biggest construction push for the Benton County Wind Farm occurred in January 2008. RMT managers believed that the ground would be frozen during this time of year, making delivery of heavy machinery, construction equipment, and materials to the turbine sites relatively easy. Contrary to their expectations, although the ground froze overnight, by 10 a.m. the next day the soil turned to mud as the temperature increased, stranding the semis delivering wind-farm equipment and construction materials. After towing a number of the trucks and other large equipment out of the mud, Bennett approached RMT with an idea to create a hauler with a special dolly that could be attached to a semi or a bulldozer when moving supplies and equipment to the site. RMT approved the hauler – essentially a heavy-duty trailer, capable of carrying up to 60 tons and equipped with tires able to churn through mud – with the caveat that it had to be delivered quickly. Bennett's crew worked 14-hour days to finish the trailer. In less than 2 weeks they completed the hauler. Semis were switched out with a bulldozer, which transported materials onto the muddy soil.

Since then, Bennett has created new versions of the hauler. His wife launched Wind Hall, a business that rents or sells versions of Bennett's original trailer to other wind farm developers in Indiana, as well as states as far west as Utah, as far north as North Dakota, and throughout the Midwest. This new start-up – a play on words featuring his wife's maiden name of Hall – is a profitable business, and developers building wind farms in nearby states now seek Bennett's expertise.

Soon after the first wind farm was completed, work began on the second Benton County wind farm: Fowler Ridge Phase I. The timeline called for installation of more than 220 turbines in 8 months.

Bennett and his team also became involved in the Fowler Ridge construction effort, making an average of 21 runs a day to load, unload, and deliver parts and equipment to the site. In this instance, Bennett hired a wide variety of people, including local teenagers to help with flagging and setting cones to ensure traffic safety throughout the construction and materials' delivery process.

"The teens loved it. They received $10 an hour for flagging, a lot more than they would have otherwise earned," Bennett said.

Benton County farmers receive annual lease payments from both of these wind projects for turbines and turbine-related equipment (e.g., an access road or underground lines) sited on their land. Annual lease rates vary by farm and type of equipment installed but range from $3,000 to $6,000 annually. The Fowler Ridge Phase I project employed approximately 850 workers at the peak of construction, with 36 full-time staff employed to monitor and maintain the wind farm post-construction.

Among other revenue-generation benefits, developers bought concrete and other supplies locally, the county received economic development incentives, and new roads were built (according to Bennett, to a higher standard than previously existed). According to Kepner, between land payments, jobs, and secondary economic benefits (money spent on gas and food at local restaurants and grocery stores, for example), Benton County did not feel the recession until a year after it began.

While the economic developments were appreciated by those living and working in the county, inconveniences also resulted. Roads received wear and tear from the large vehicles driving over them, and disruptions from construction and traffic congestion often proved bothersome. In some cases, construction resulted in broken drainage tiles on farmland. Wind developers replaced these and also compensated farmers for crop-loss damages due to drainage issues. Also, a third wind farm built in Benton County largely relied on out-of-state workers, so the county did not benefit as much.

However, according to Bennett, for most people, the positives seem to outweigh the negatives.

"It's hard now to find someone in the area who doesn't approve of the projects. As a matter of fact, everyone wishes we'd get another wind farm – or a couple," he said.

3 Results: Estimated Economic Impacts

We used the JEDI model to estimate the economic impacts of each of the Indiana wind power projects included in this study. Individual project economic impacts were then aggregated to reflect combined impacts from 1,339 MW of wind energy development in Indiana. This study presents results scaled to 1,000 MW of installed wind to facilitate comparisons with other case studies.

Study results show significant potential economic impacts (see Figure 7). Impacts reported are centered on JEDI model results, which include employment, property taxes, landowner revenue, and local economic activity during the construction and operation periods (see Table 6). Although estimating all wind-related impacts was beyond the scope of this analysis, it is important to note that new wind power installations provide many other tangible (e.g., use tax generation, sales tax generation, water savings, vendor profits, transmission line impacts, etc.) and intangible (e.g., long-term electricity price stability, consumer prices, environmental benefits) impacts.

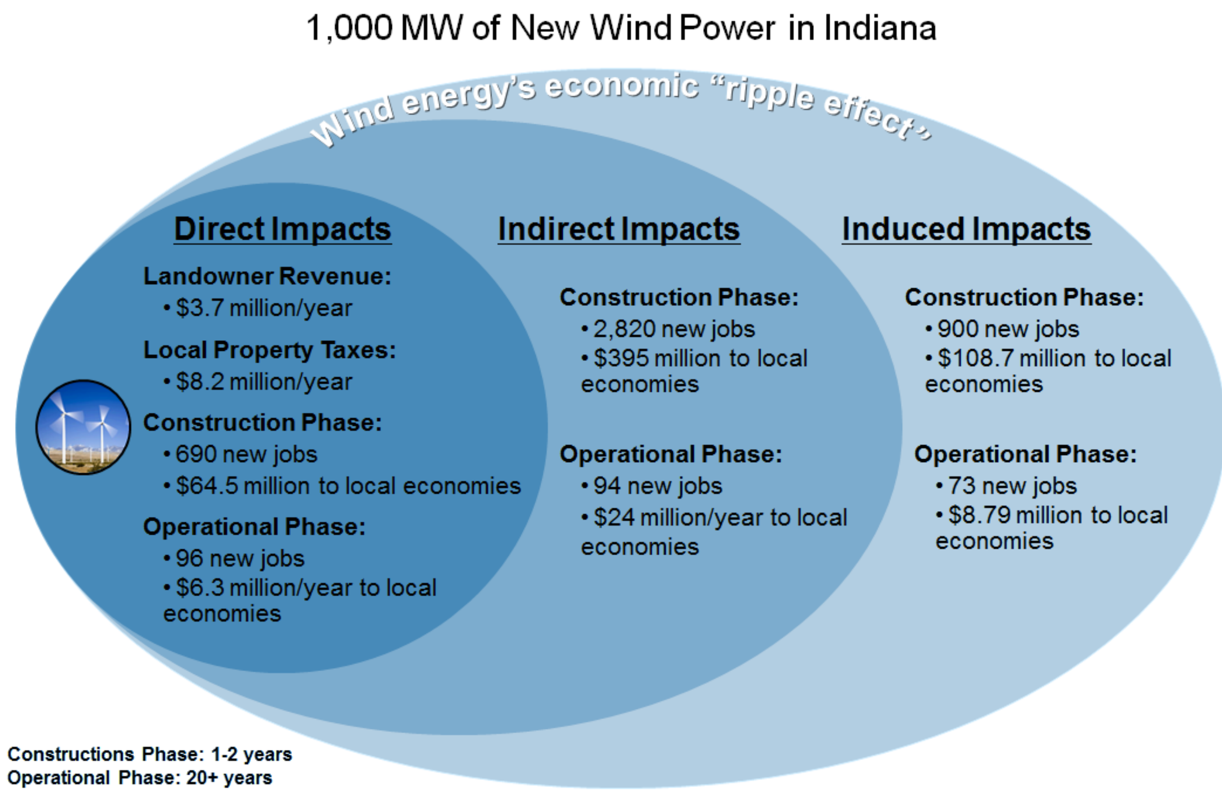


Figure 7. Economic ripple effect from 1,000 MW of wind energy in Indiana

Table 6. Indiana Summary Economic Impacts from 1,000 MW of Wind Energy Development

During construction periods	Supported approximately 4,400 FTE jobs in Indiana and approximately $570 million in economic activity for the state
During operating periods	Annually supports approximately 260 Indiana jobs Annually supports nearly $40 million in gross economic activity in the state Generates more than $8 million in annual property taxes Generates nearly $4 million annually in income for Indiana landowners who lease their land for wind energy projects

Results are provided in 2010 real dollars

3.1 Construction Phase

A typical construction period for a wind power plant lasts between 6 and 12 months. During that period, local project expenditures support a wide range of economic activity. These expenditures include compensating the laborers, administrative staff, engineers, and managers who directly work on the project as well as expenditures made in local establishments such as hotels or restaurants. Developers spent more than $2.5 billion to construct the seven wind-powered electricity generation facilities examined in this report, an average of approximately $1,900/kW. About $553 million of this, or 22%, was spent in Indiana.

Other states and countries realized much of the economic benefit related to the manufacturing of wind components in the six largest Indiana projects; this is not accounted for in this report. Vestas accounted for the majority of manufacturing, with its turbines 37% of the projects' nameplate capacities. General Electric (GE) produced nearly as much with 32%. REPower, Suzlon, Clipper, and Acciona were all utilized, and each account for less than 10% of total capacity. Developers spent approximately $1.8 billion on this equipment.

The ability of producers to source goods or services from within the state plays a significant role in local content percentages. Developers are not obligated to purchase goods from in-state suppliers, and in the first 1,000 MW built in Indiana, there were no in-state options for major turbine and tower equipment. However, producers in this study had the option of purchasing wind-specific components and materials from 14 manufacturing facilities throughout Indiana.

Since the construction of the wind power generation facilities included in this report, new manufacturing facilities have been built in Indiana. Manufacturer Brevini constructed a $62 million gearbox manufacturing plant in Muncie.

3.1.1 Gross Output

Project expenditures supported approximately $570 million of gross economic output in Indiana. Gross output includes local expenditures as well as wages and salaries earned. As shown in Figure 8, most of this output, $400 million, is related to supplying construction materials, equipment, business to business services, and other goods or services that fall within the Turbine and Supply Chain Impacts category.

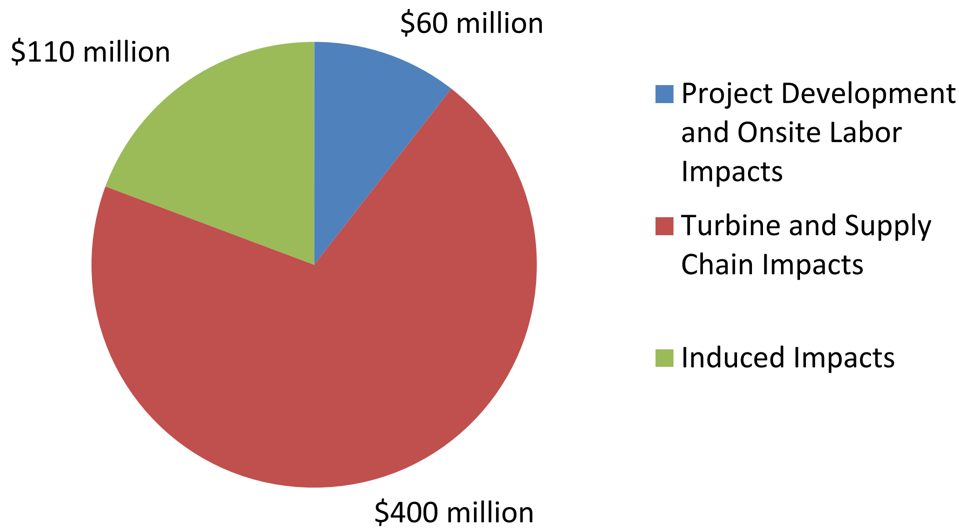


Figure 8. Gross economic output impacts from construction of 1,000 MW of wind projects

3.1.2 Jobs and Earnings

For the seven wind farms analyzed, 50% to 75% of construction workers were Indiana residents. According to our interviews with developers, some contracts required that a percentage of workers be hired from the area in which the wind project was developed. Certain specialized positions related to the electrical collection system and project management required labor outsourcing from other states or countries.

This research suggests that 1,000 MW of Indiana wind power development supports approximately 4,400 FTE jobs (Table 6). Of these, nearly 690 are onsite workers who are directly involved in a project's development. More than 2,800 workers - the majority - are supply chain workers or contractors. These can include manufacturing workers, construction subcontractors, or white collar contractors such as accountants or lawyers. These onsite workers, contractors, or other supply chain workers support another 900 FTE induced jobs with the expenditures that they make within Indiana (e.g., they stay at hotels and eat at restaurants near the project, increasing the need for work in those industries).

Table 7. Estimated Job Impacts from the Wind Plant Construction Phase

	Total Jobs	Jobs Per 1,000 MW	Average Annual Earnings Per Worker
Project Development & Onsite Labor Impacts	930	690	$67,670
Construction & Interconnection Labor Impacts	610	450	$67,120
Construction-Related Services Impacts	320	240	$68,690
Turbine & Supply Chain Impacts	3,770	2,820	$47,990
Induced Impacts	1,200	900	$38,510
Total Impacts	5,900	4,410	$49,150

Note: Totals may not sum due to rounding

Construction-period jobs were relatively well-paid, with this analysis estimating direct onsite employees earning an average of approximately $68,000 annually. Indiana jobs that supply services or materials, turbine and supply chain impacts earned approximately $48,000 annually. Induced jobs earned approximately $39,000.

3.2 Operations & Maintenance

Wind farm operators need to maintain and operate their facilities, which have expected life spans of 20 to 30 years. This includes staffing projects with technicians, administrators, and managers and budgeting for materials, replacement parts, and services as well as required environmental or other reviews. In the case of the seven wind farms analyzed in this report, operators also make lease payments to local landowners and pay property taxes to local governments. Debt and equity payments are outside the scope of this analysis.

Interviews with industry experts and developers revealed that operators spend an average of approximately $44.6 million annually to operate and maintain the seven wind farms. With the exception of spare parts and insurance, most of this is spent in Indiana. Local expenditures total $28.7 million annually, which translates to approximately $21.4 million per 1,000 MW.

3.2.1 Gross Output

The first 1,000 MW of wind in Indiana support approximately $40 million of economic activity, or gross output, annually. The majority of this, $24 million, is through the supply chain, landowner revenue, or business to business services. Onsite labor impacts account for the smallest share, $6 million. Onsite workers such as technicians and managers as well as supply chain workers are estimated to support an additional $9 million in economic activity each year that the wind facilities operate.

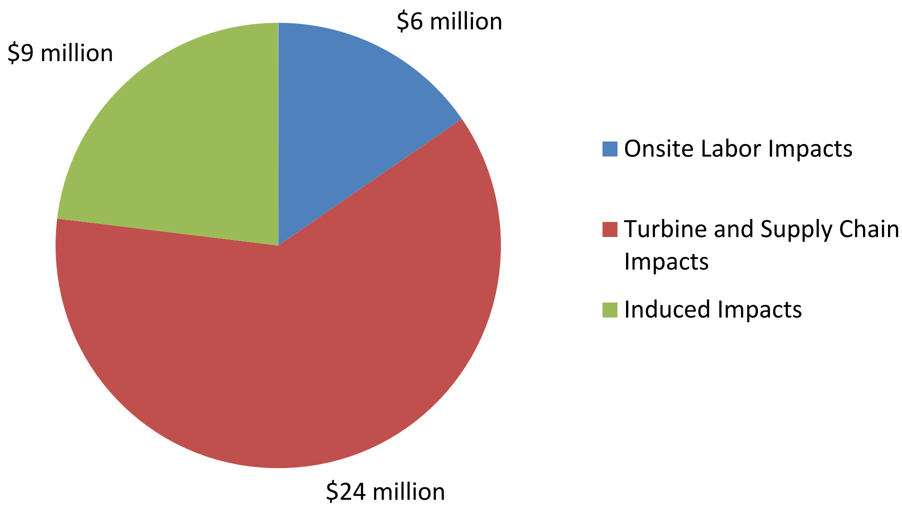


Figure 9. Annual gross economic output impacts from O&M of 1,000 MW of wind

3.2.2 Jobs and Earnings

When the wind farms are operational, they need long-term employees to operate and maintain the facility during their 20- to 30-year expected life spans. These long-term or ongoing positions are positions earning average salaries between $30,000 to more than $90,000 annually. The majority of these positions will be filled by Indiana residents or by people who relocate to Indiana.

Table 8. Estimated Annual Ongoing Jobs and Earnings from O&M

	Total Jobs	Jobs Per 1,000 MW	Average Annual Earnings
Onsite Labor Impacts	130	100	$65,640
Local Revenue & Supply Chain Impacts	130	90	$43,550
Induced Impacts	100	70	$38,520
Total Impacts	350	260	$50,210

Note: Totals may not sum due to rounding

This research shows that 1,000 MW of wind energy capacity in the State of Indiana support approximately 260 permanent jobs with a total annual payroll of $13 million. Of these jobs, 100 are onsite positions directly involved with maintaining wind farms, including technicians, supervisors, and administrative workers. Nearly as many – 90 jobs – are indirectly involved with the plant's operation. These can include contractual services, manufacturing of replacement parts, and jobs arising due to revenue or returns realized locally (i.e., landowner payments) from the plant's operation. Expenditures made by the 190 onsite and offsite workers support an additional 70 long-term jobs in industries that provide local services or products.

Case Study: An Interdisciplinary Focus at St. Joseph's College

Indiana's wind farms have also touched St. Joseph's College, located in nearby Jasper County. A Catholic liberal arts college named among the best Midwestern colleges by the Princeton Review, St. Joseph's received a land grant of more than 7,600 acres in 2010 from the trust of Juanita Waugh; the $40-million gift is the largest in the school's history.

Waugh's farm, located in White County, had been in her family for generations. At the time of her death, she had 19 operational wind turbines on the property, and Meadow Lake Wind Farm planned to construct an additional 13. Once the turbines are operating, St. Joseph's College will be the largest private landowner with the most wind turbines east of the Mississippi River, according to Connie Neininger, executive director of White County's economic development department. Having the wind farms on the property will facilitate the college's ability to sustain Waugh's stipulation that the land remain undeveloped.

Although St. Joseph's has 501(c)(3) status, which would allow the school to claim an exemption from property taxes, the college will continue paying taxes on the land.

"We made a conscious decision not to take that much acreage off the tax rolls. White County is a small, rural county, and highly dependent on tax income – just like Jasper County. Using our tax-exempt status wouldn't be the neighborly thing to do," said Sandy McMullen, St. Joseph's grants and contracts director.

While the transfer deed allows use of land for educational purposes, it prohibits sale of the farm real estate and stipulates establishment of a conservation easement. To achieve this latter, the school envisions taking advantage of an unusual-shaped piece of non-arable land located near the major highway running through Jasper, White, and Benton Counties. This section of property also happens to overlook the wind farms of Benton and White Counties, which are of significant interest to tourists. College officials are in the preliminary stages of developing a plan to build a center focused on sustainability, with wind and other renewable energy being a significant highlight. Not only will this serve to educate St. Joseph's students and public visitors, but also among the benefits is higher visibility – literally and figuratively – for the college.

Stewardship of the land and care of the poor and vulnerable is both a collective and educational ethic for St. Joseph's College and its faculty and students – in part this ethos and the academics led Waugh to donate the land to the college.

"This focus is a key aspect of Catholic social teaching and includes social justice and the environment, including considering issues such as the effects of climate change on people and places. Sustainability – which includes considering wind and other renewable energy – as a curricular focus achieves this end, bridging across all of the college's disciplines," explained Lana Zimmer, an associate professor at St. Joseph's College.

In the spirit of sharing the beneficence of Waugh's donation and achieving one of the school's strategic goals, St. Joseph's is collaborating with other educational institutions, including Ivy Tech (see case study on Page 3). St. Joseph's is also developing closer associations with nearby Catholic colleges – including Calumet College, which is a sister institution in Whiting, Indiana, and Ancilla College, a Catholic institution in Donaldson, Indiana – with a focus on each college's approach to sustainability curriculum and projects related to this focus.

4 Conclusion

NREL research has expanded knowledge of Indiana's wind resource and shown far greater potential for wind-generated electricity than was thought in previous years. The development of wind-powered electricity generation infrastructure has the potential to support millions of dollars of economic activity in Indiana, both from construction and operation of facilities. Current development of manufacturing facilities in Indiana enhances the state's ability to capture economic activity from the wind power supply chain as well.

Wind energy manufacturing is the largest economic development driver in the wind industry. It has the potential to provide significantly more jobs and associated economic impacts compared to other wind activities. Supporting local ownership of manufacturing facilities, as well as use of local labor and materials, can provide further opportunities for Indiana's economic diversification and economic growth.

This analysis estimates that the construction of the first 1,000 MW of wind in Indiana supported $570 million in in-state gross economic activity and more than 4,400 jobs. The O&M of the facilities supports approximately $40 million in economic activity annually, as well as an estimated 260 Indiana jobs. These estimates are based on project expenditures and local content assumptions provided by the developers and operators and assume 20% of construction expenditures are made in Indiana and 40% of O&M expenditures are in-state.

The burgeoning wind sector also stimulates a secondary supply chain ripple effect as wind industry participants (developers, service providers, manufacturers, etc.) start up or relocate to the state. While outside the scope of this analysis, this second wave carries with it additional economic impacts associated with training workers, exporting goods outside of the state, fostering research and development, and developing leading-edge technologies and capabilities.

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Appendix: Cost and Local Content Estimates

Tables A.1 and A.2 contain total cost and local (Indiana) content estimates used in JEDI modeling for all projects. These are aggregated across all projects modeled in this analysis to avoid disclosing details of individual projects. Table A.1 contains one-time cost and local content estimates for the construction of wind plants while Table A.2 contains ongoing cost and local content estimates for the O&M phase.

Table A.1. Construction Cost Totals and Local Purchases across All Projects

Construction Costs	Totals	Percent Local
Equipment		
Turbines	$1,116,749,925	0
Blades	$261,446,471	0
Towers	$289,458,593	0
Transportation	$162,259,682	0
Equipment total	$1,829,914,670	
Balance of plant		
Materials		
Construction (concrete rebar, equip, roads & site prep)	$230,239,052	83%
Transformer	$22,910,078	72%
Electrical (drop cable, wire)	$27,452,990	84%
HV line extension	$50,147,453	81%
Materials subtotal	$330,749,573	
Labor		
Foundation	$11,591,563	62%
Erection	$13,129,090	60%
Electrical	$19,133,038	60%
Management/supervision	$9,928,169	52%
Misc.	$105,695,781	57%
Labor subtotal	$159,477,641	
Development/other costs		
HV sub/Interconnection		
Materials	$55,450,786	40%
Labor	$16,985,669	37%
Engineering	$46,078,648	59%
Legal services	$18,964,203	86%
Land easements	0	
Site certificate	$29,169,183	90%
Development/other subtotal	$166,648,489	
Balance of plant total	$656,875,703	
Total project costs	$2,486,790,373	

Table A.2 O&M Cost Totals and Local Content Purchases across All Projects

	Totals	Percent Local
Personnel		
Field salaries	$6,706,392	100%
Administrative	$654,216	100%
Management	$1,294,859	100%
Labor/personnel subtotal	$8,655,466	
Materials & services		
Vehicles	$617,731	95%
Misc. services	$240,915	85%
Fees, permits, licenses	$120,458	95%
Misc. materials	$481,830	95%
Insurance	$3,083,181	28%
Fuel (motor vehicle gasoline)	$240,915	95%
Tools & misc. supplies	$1,565,950	95%
Spare parts inventory	$13,722,907	2%
Materials & services subtotal	$20,073,887	
Debt payment (average annual)	$288,467,683	0%
Equity payment - individuals	$0	
Equity payment - corporate	$85,545,589	0%
Property taxes	$10,927,737	100%
Land lease	$4,958,800	100%
Total annual O&M costs	$418,629,163	