



The Statewide Economic Impact of Wind Energy Development in Oklahoma: An Input-Output Analysis by Parts Examination

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Executive Summary

Wind energy is no longer “alternative” energy. It has become a mainstream, reliable, and cost-effective source of energy for the people of Oklahoma.

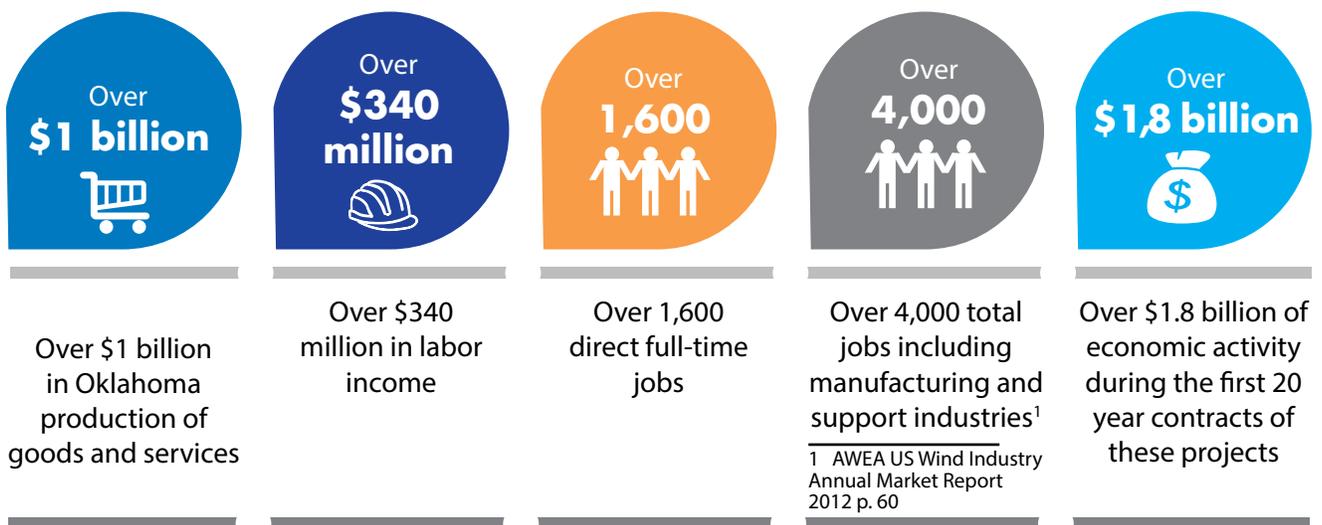
As Oklahoma Governor Mary Fallin’s administration pursues a systems approach to energy production and consumption, wind energy will continue to grow as a key source of electricity generation, complementing the state’s natural gas-fired, coal-fired, and hydro-electric generation fleets. Because of Oklahoma’s outstanding wind resources and the state’s commitment to developing diversified energy

resources, the state has attracted robust investments in wind energy. Developers constructed 26 wind energy facilities in the state between 2003 and 2012, and in this report we have analyzed investment data, revenues paid to local landowners, ad valorem tax base increases, employment data, and developer expenditure data for these wind energy projects.

Using this data, we have calculated the contributed economic impacts of wind energy in Oklahoma during development, construction, and operational phases.

Some of our key findings are:

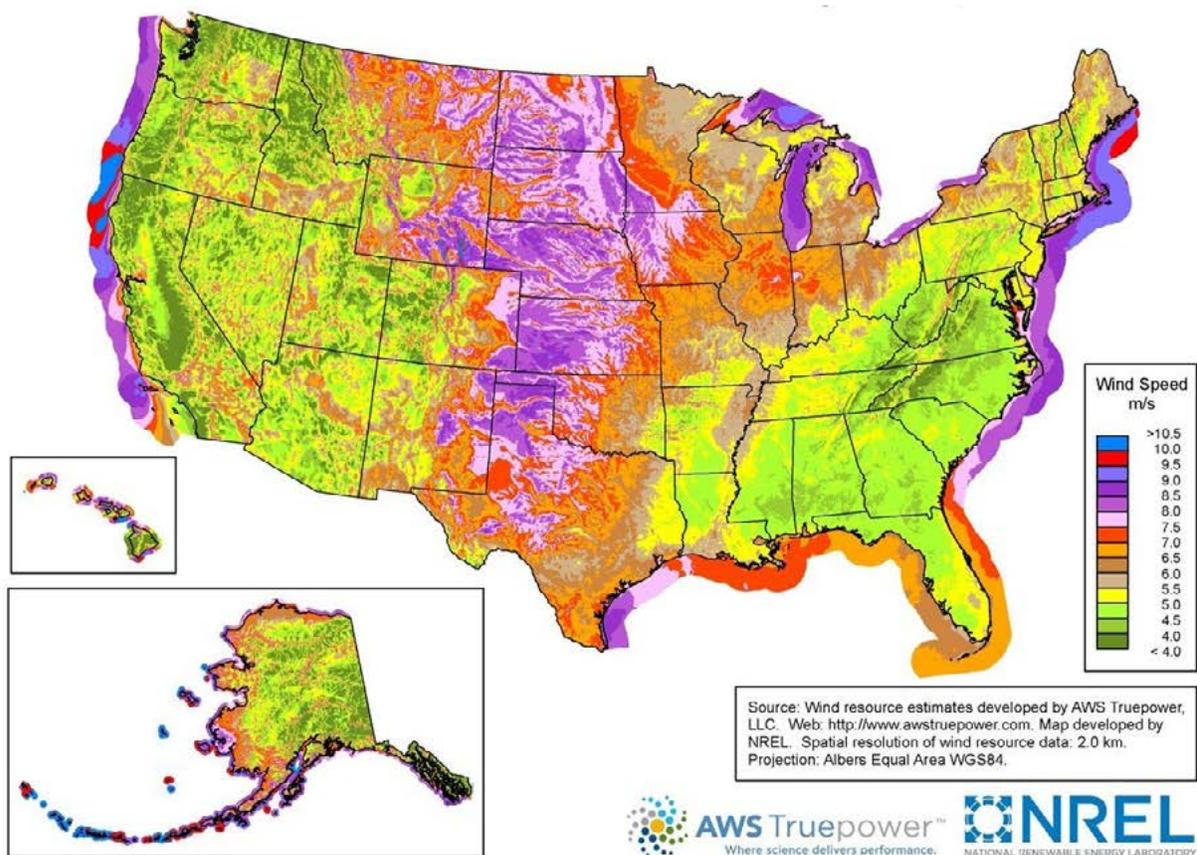
- Wind farm developers invested more than \$6 billion during the development and construction of wind farms during the wind industry's first decade in Oklahoma.
- The property improvements made by developers created a tax base that will provide over \$42 million in property taxes annually to Oklahoma municipalities and school districts following the property tax abatement period.
- These projects provide more than \$22 million annually in payments to local landowners and approximately \$15 million in direct wages to local workers.
- When analyzed in the context of the Oklahoma economy, and accounting for spillover (multiplier) impacts, we estimate that wind energy project construction and operating activities during the period from 2003 – 2012 supported the following:



Introduction

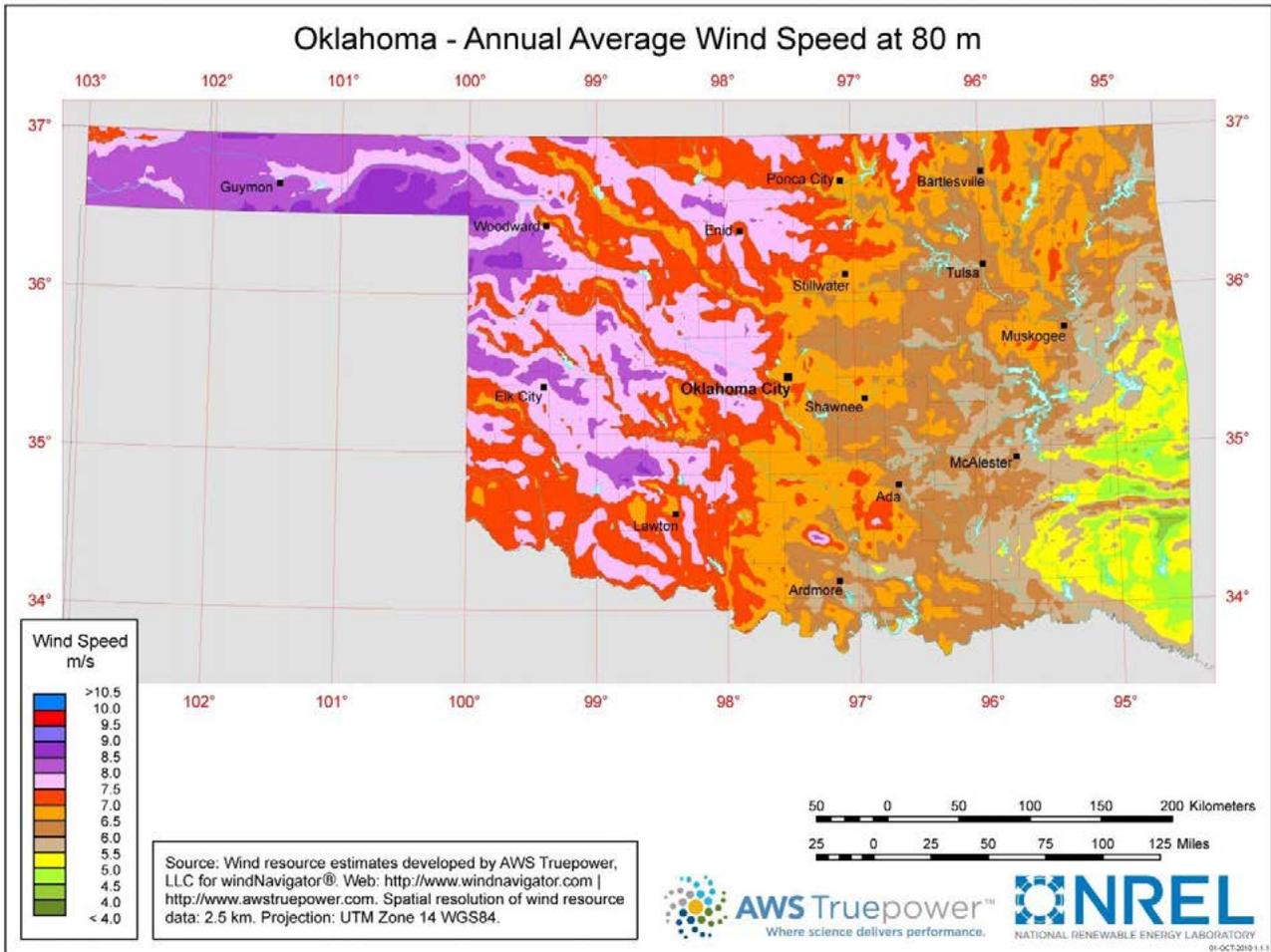
As the public has begun to call for reliable, inexpensive, American-made sources of energy, wind energy has emerged as a viable, pollution-free complement to traditional energy sources. This is especially true in

Oklahoma where the state looks to a combination of locally produced Oklahoma natural gas and Oklahoma wind energy to provide cleaner, domestic alternatives for future energy production.



Oklahoma is located in the heart of America's "Wind Corridor" and, according to the National Renewable Energy Laboratory (NREL), is blessed with some of the nation's most valuable wind energy resources.

Like other more familiar energy types, the presence of these resources represents an economic opportunity for individual landowners, local communities, and the State of Oklahoma.



Since the settlement of the state, Oklahomans have lived with the wind, and relied on the wind as one of their earliest forms of energy. Today, they are embracing wind as an energy source for their future, as Oklahomans know that the development of the state's wind resources benefits their state. Indeed, when polled in 2009, 72% of Oklahomans indicated a willingness to pay more for electricity generated by wind power². In the course of this study, utilities have reported that they have purchased additional wind power in response to requests by their customers.

According to the America Wind Energy Association (AWEA) wind power accounted for 3.5% of the total energy produced for U.S. consumption in 2012, and that amount continues to grow. AWEA indicates that the installed U.S. wind energy capacity grew by over 16% in 2011, and 28% in 2012 with continued growth

2 "Oklahomans United in Support of Wind Power", Sooner Survey, Vol. 19 Number 3, Cole, Hargrave, and Snodgrass, October 2009.

predicted well into the future³. In fact, wind energy was the top source for new generation in 2012, with a new record of 13,124 MW installed across the United States, with Oklahoma ranked #4 in the list of top states for new capacity installations⁴.

AWEA also reports that Oklahoma is the 6th largest producer of wind energy within the U.S. and enjoys the 8th highest in percentage of wind energy electricity usage, meeting 10.5% of the state's total electricity needs in 2012. With installations throughout Oklahoma, the total installed capacity was 3,373 megawatts (MW) at the end of 2012, with continued growth expected as new capacity is installed in the coming years.

3 See AWEA U.S. Wind Energy First Quarter 2012 Market Report and the AWEA Oklahoma Wind Energy Fact Sheet for the 3rd quarter of 2012 for more information.

4 American Wind Energy Association. (2013). Wind energy top source for new generation in 2012 [Press release]. Retrieved from <http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=4744>

The purpose of this study is to quantify the statewide economic links between the installed wind energy base and the broader economy. Like most development, wind energy projects progress in three phases: pre-construction development; construction; and ongoing operations. The economic impacts of the

phases detailed in this report reflect the first 10 years (2003 – 2012) of industry development in Oklahoma. Note that for purposes of this report, pre-construction development expenditures are combined with construction expenditures.

QUICK FACTS 2012

OKLAHOMA WIND ENERGY

- 1** Oklahoma Gas and Electric (OG&E) is one of the top 10 investor-owned utilities in the US in terms of wind energy use.
 - 2** Western Farmers is one of the top 5 electric cooperative in the US in terms of wind energy use.
 - 3** Oklahoma is number 6 in the nation in wind energy capacity.
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Background

In 2011, Governor Mary Fallin published the first energy plan for the State of Oklahoma. The plan discussed the state's existing energy needs and the diversity of its available energy supply. It then presented a roadmap to a future comprehensive energy infrastructure that relies on a broad assortment of energy resources.

The plan identified key strategic objectives including supporting the Oklahoma economy through the use of Oklahoma resources, the development of industries that create Oklahoma jobs, the generation of surplus energy for export, and the reduction of environmental damage by shifting more of the state's power production to cleaner sources such as natural gas and wind.

In May 2010, Oklahoma House Bill 3028 established a renewable energy goal for Oklahoma electricity generation of 15% to be met by 2015. The U.S. Energy Information Administration reports that Oklahoma ranked 7th in the nation in net electricity generation from wind in 2011 and that wind provided 7.1% of Oklahoma's net generation⁵.

According to Oklahoma Energy Secretary C. Michael Ming in late 2012, the state had nearly already met its 15% renewable goal 3 years ahead of schedule, largely through wind generation⁶.



“Oklahoma will exceed its 15% renewable capacity target this year

- **3 years ahead of schedule**
- **Wind capacity alone essentially satisfies this goal”**

C. Michael Ming,
Former Oklahoma Secretary of Energy

⁵ Oklahoma State Profile and Energy Estimates, <http://www.eia.gov/state/?sid=OK>

⁶ Partnering in the Portfolio of the Future, Presentation to the American Wind Energy Association Wind Energy Summit in Houston Texas, December 5, 2012.

Wind's First Decade



"We saw the benefit of further diversification of our generation mix and the known pricing of wind energy,"

Steven Fate,
*Public Service Company
of Oklahoma*

Wind energy has been an important economic development engine in rural Oklahoma since its arrival in 2003. During the first 10 years of wind energy development in Oklahoma, the industry spent more than \$6 billion on land, equipment, fees, and construction while developing the first 26 operational facilities.

In 2003, Oklahoma's first two wind farms were constructed and brought into operation. The Oklahoma Wind Energy Center north of Woodward and the first phase of Blue Canyon Wind Farm near Lawton have now been providing clean, renewable energy to Oklahoma utilities for more than a decade.

From 2003 to 2007, wind farm development advanced slowly in Oklahoma, but by 2008, utilities were increasingly recognizing the benefits of wind power including an emission-free, fixed-price component to their generation mix.

In light of current and anticipated future restrictions on air and water emissions and a growing focus on conserving water, the state's major utilities have recognized the environmental challenges their coal-burning facilities face and have increased their demand for wind energy since 2008. Federal Clean Air Act regulations will be implemented in the coming years that will most likely add costs to the operation of coal-fired generation facilities. This anticipated expense, necessitated by changes in the regulatory environment, makes coal generation's future uncertain.

Developers more than doubled the number of installed wind farms to 11 facilities at the end of 2009. Rapid growth continued through 2012 as 26 facilities were online by the end of December of that year. According to the Oklahoma Department of Commerce, more installations are expected to come online in the next few years. This increase in wind generation capacity provides distributors with a low marginal cost option to complement existing generation facilities as the state moves to the energy "systems" approach detailed in The Governor's Energy Plan.

How does Google power its data centers?



“...we locate our data centers where they can be most efficient, and we often buy renewable energy from where it's most efficiently produced.”

<http://www.google.com/about/datacenters/faq/index.html>

Utilities have additionally recognized the benefit that wind energy can bring to their consumers and shareholders by offering a long-term fixed price contract for up to twenty years. There is no potential fluctuation in fuel price, which protects ratepayers from the volatility inherent in global fuel prices.

In 2011, wind energy even attracted renewable energy champion Google to Oklahoma. Google located one of its data centers in Pryor and immediately signed a contract for wind power with the Minco II wind farm in Grady and Caddo Counties and later inked a contract with GRDA for power generated by the new Canadian Hills facility in Canadian County⁷. Currently, wind farms are located in 15 Oklahoma counties from northwest to southwest and central to north central Oklahoma⁸.

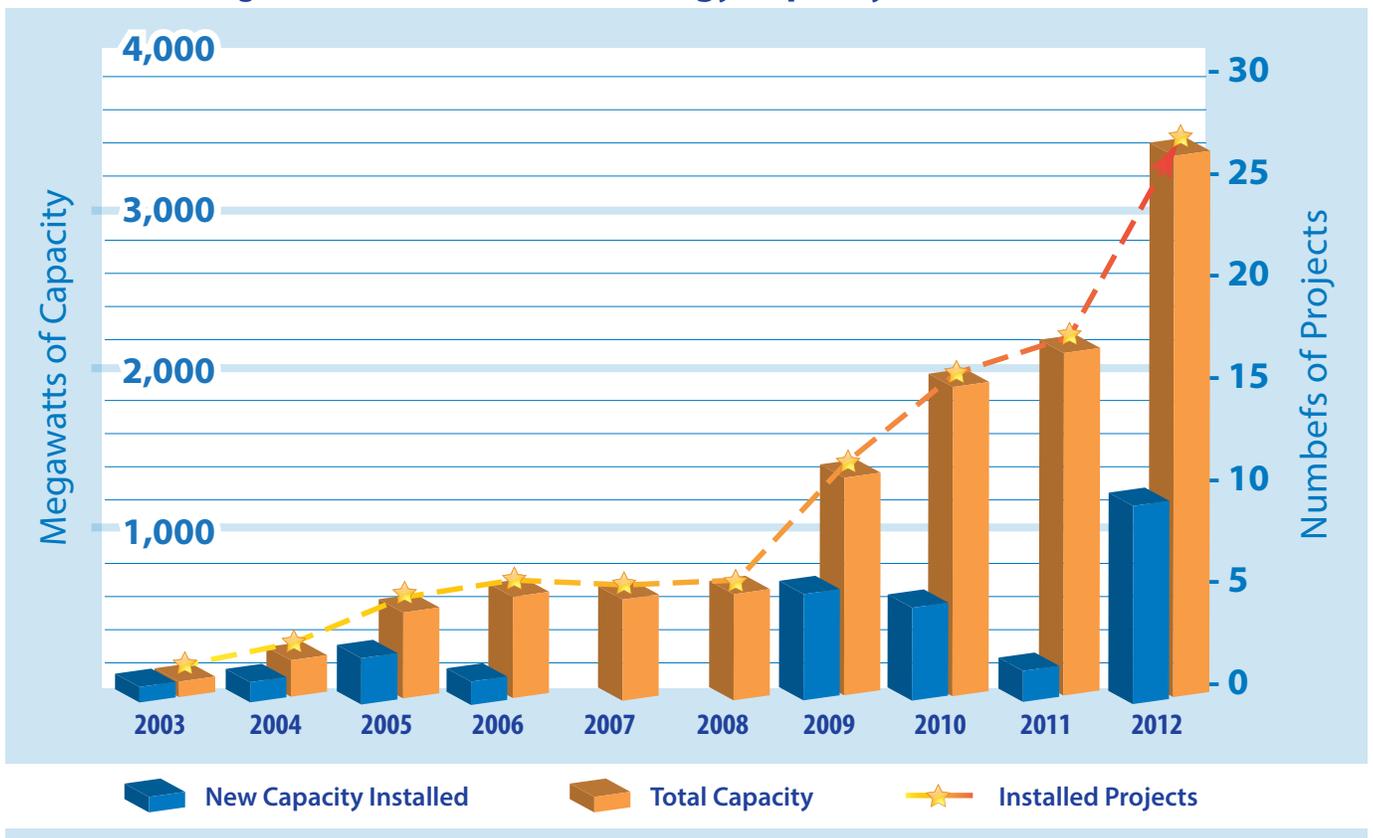
The 26 wind energy facilities now in operation are providing more than 3,000 megawatts (MW) of generating capacity for Oklahoma electric utility providers including Oklahoma Gas & Electric (OG&E), Western Farmers Electric Cooperative (WFEC), Public Service Company of Oklahoma (PSO), the Grand River Dam Authority (GRDA), and the Oklahoma Municipal Power Authority.

⁷ “Google signs wind-power agreement with Oklahoma’s Grand River Dam Authority,” *The Oklahoman*, September 26, 2012.

⁸ Wind farms are currently located in Beckham, Caddo, Canadian, Comanche, Custer, Dewey, Garfield, Grady, Grant, Harper, Kay, Kiowa, Roger Mills, Washita, and Woodward counties.



Figure1: Oklahoma Wind Energy Capacity 2003-2012



Study Data

For this study, we collected both development/construction expenditure data and operational expenditure data from the developers/operators of Oklahoma wind farms. Of the 26 locations included

in this study, we received complete expenditure data for 7 facilities and partial expenditure data for many of the remaining installations.



Incorporating this expenditure data with capacity specifications provided by wind energy producers and the Oklahoma Department of Commerce, we

interpolated complete expenditure data for the remaining facilities. A summary of the collected and interpolated data is given in Table 1 on the next page.

**TABLE
1**

OKLAHOMA WIND ENERGY SUMMARY

Operational Wind Farms by year end 2012	26
Installed Capacity (Megawatts)	3,373
Average Facility Size	
Average Project Capacity (Megawatts)	130
Average Turbine Size (Kilowatts)	1,365
Average Number of Turbines	68

CONSTRUCTION SUMMARY*

Construction Expenditures	\$442,283,512.92
Construction Employment	342.34**
Income per job (includes benefits)	\$61,408.68
Land Easements	\$20,536,292.24
Local Fees and Taxes	\$10,251,453.69

OPERATIONS SUMMARY

Local Project Expenditure	\$10,969,920.78
Local Project Employment	252.59
Income per job (includes benefits)	\$59,322.53
Land Royalties	\$22,109,034.09
Local Property Taxes (post abatement)	\$42,671,638.45

* Total development expenditures were estimated to be \$6.156 billion from 2003 – 2012 with \$442 million spent directly within the state on Oklahoma goods, services, and employment.

** Employment estimate is the average level of employment for the final 4 years of the study. Due to the non-linear nature of development within the state, the construction trend of the final four years provided the most reasonable estimate of long-term construction employment.

Oklahoma wind energy projects range in capacity from 40 to 300 megawatts, with the average facility incorporating 68 turbines to produce 130 megawatts of energy.

During the construction phase, developers spent \$6.156 billion, of which \$442 million was spent directly

within the State of Oklahoma. The 26 facilities currently pay over \$22 million annually in royalty payments to Oklahoma landowners, and following the property tax abatement period, these 26 Oklahoma facilities will pay nearly \$43 million in property taxes to fund local schools and other public services.



Impact Methodology

Estimating the economic impact of an established industry expansion is relatively straightforward. Historical data on production processes, compensation, and tax obligations provide a snapshot of the economic flows necessary to generate new production.

For example, new production in the residential construction industry requires predictable purchases of inputs from supporting sectors like wholesale trade, ready-mix concrete manufacturers, and architectural and engineering services. These input purchases, in turn, require each of these sectors to increase purchases of their sector specific inputs. The successive streams of economic activity are known commonly as the multiplier, or spillover, effect. In addition to the direct production of residential construction and the

indirect activity in supporting industries, additional economic activity is induced by household spending of new wages generated by the process. In cases where an industry and its production process are not well established, estimation of aggregate economic activity is more complicated and is established by an “analysis by parts”.

In the case of wind energy development, analysis by parts requires detailed information to be collected from the new industry that reflects the spending pattern on inputs required for new production. This information may include, but would not be limited to, detailed expenditures on land, labor, initial engineering and construction, manufacturing of component parts, tower erection, installation and transmission, maintenance, and tax payments.



From this information, input-output models of an existing economy can estimate the economic activity resulting from a pattern of spending consistent with expanded production within the wind energy industry. In order to ensure that the model results are representative of the true linkages of the industry to the local economy, the true spending patterns required for production were collected directly from one of the study participants.

The most comprehensive estimates of expenditure patterns from wind farm development are found in the Jobs and Economic Development Impact Model (JEDI) developed and maintained by the National Renewable Energy Laboratory⁹. The JEDI model estimates basic patterns of spending (construction, materials purchases, operations, and maintenance) from wind farm summary information. The model then calculates aggregated economic impacts using a library of multipliers purchased from MIG, Inc., formerly the Minnesota IMPLAN Group, Inc.

While the JEDI model provides an impressive first look at economic impacts, improvements to this model can be made by 1) refining JEDI estimates of spending patterns and locations, specifically addressing expenditures dismissed as leakages by JEDI that are in reality local expenditures that should be included in the model, and 2) refining the underlying model of the economy to better reflect underlying linkages, particularly in wind-specific supporting industries, thereby improving the estimates of the underlying multipliers.

With the JEDI model as a baseline, we have constructed a statewide model using Implan multipliers and data (and their linkages) provided by participating firms. We then implemented an analysis-by-parts methodology to estimate the production, employment, payroll, and tax impacts specific to the state of Oklahoma resulting from construction and operation of the current 26 facilities

⁹ <http://www.nrel.gov/analysis/jedi/>



Economic Impacts

Again, for the purpose of this report, economic impacts are categorized into two distinct project phases: Construction (including pre-construction development activity) and Operations. Financial and employment data for both phases used for impact estimation was detailed in Table 1 in the Background section of this report.

Economic impacts are estimated for three categories: output (total production within the state; total expenditure serves as a proxy for output), labor income, and employment. Data was provided by developers and analyzed in conjunction with publicly available data from the Bureau of Economic Analysis, and impacts were estimated using Implan multipliers for the state of Oklahoma¹⁰.

¹⁰ Implan is a national vendor of economic multipliers. Refer to the Minnesota Implan Group and www.implan.com for additional information. When necessary, multipliers are adjusted to reflect local knowledge of economic conditions.

Development and Construction

The decision to develop a wind energy facility is a complex amalgam of science, technology, and economics. Prior to any decision to proceed with wind farm development, each developer reviews available maps of wind activity, available electricity grid connectivity, and land use and land ownership characteristics to identify potential sites for construction. Once this initial phase of analysis complete, and if it is found to be acceptable, the developer begins leasing land from local landowners and installs meteorological towers on-site to analyze actual wind patterns and wind activity at the site.

The developer then brings together a team including environmental consultants, transmission engineers, construction engineers, meteorologists, and lawyers to assess the environmental suitability of the site, the constructability of the site, the nature of wind flows across the land, and any local, state, and/or Federal legal requirements pertaining to the development of a wind farm on the site. This process takes several months, even years. While studies are underway, the developer continues collecting wind data to determine wind speed, variability, turbulence, and the resultant expected power output and appropriate wind turbine and rotor configuration for the specific wind resource.

If the wind energy measurements meet expectations, and the company sees promise that a utility will seek to buy wind energy in the near future, the developer continues to collect wind data, makes land lease payments to the landowners, and attempts to market the potential output of the project to local utilities. Recently, developers have also identified export opportunities and have used available transmission capacity to export Oklahoma wind-generated electricity to other states – primarily eastward into the less windy states of the Southeast, but also north to Nebraska.

Under Federal law, wind farms may sell their output only at the wholesale level, meaning they must sell

to investor owned utilities, cooperatives, municipal electric companies, or Federal power companies. These wholesale electricity buyers occasionally buy wind farms outright or agree to purchase the output of a wind farm through a deal with a single developer; however, in most cases, prospective power purchasers announce a competitive solicitation process known in the industry as a Request for Proposals (RFP).

Utility RFPs are highly competitive and typically receive proposals from numerous developers. In the course of this analysis, we found that there are often more than two dozen projects and proposals submitted as responses to a typical RFP, and in one recent case there were 52 proposals offered in response to a single RFP.

This phenomenon demonstrates the competitive nature of wind energy development, bringing some of the only independent power into the regulated electricity marketplace of the Southwest Power Pool, the Regional Transmission Authority (RTO) of which the Oklahoma transmission system is a part. This results in innovation within the industry and lower prices for consumers.

A long-term power contract is typically required before any bank-financed wind energy project can begin construction. Many development projects make it to the stage of bidding into utility RFPs, but only a small number of projects win contracts. Put differently, many wind farm development projects do not – or have not yet – become operational wind farms. Therefore, economic data reflecting this early phase of development – namely landowner payments, pre-construction engineering, and wind resource assessment expenditures, are likely understated in this report. However, we have excellent data on the construction and operating costs of the development projects that win contracts and become wind farms. The construction costs reported in this analysis include the actual dollars spent in Oklahoma during the development phase of the 26 projects that are currently operational.



Total economic impacts include the direct impacts from developer and operator activities, combined with the multiplier impacts that extend beyond the wind farm facility itself.

For example, the \$6 billion in construction expenditures across the state are estimated to have generated over \$431 million in Oklahoma output (this is the direct contribution to the local economy), and an additional \$509 million in spillover production (the output of firms who directly or indirectly support construction operations), combining to generate

\$941 million in statewide economic output. All other impacts are interpreted analogously.

Table 2 provides impact estimates for the construction of the 26 facilities from 2003 to 2012. The employment numbers represent permanent jobs that arose from the establishment of this new industry in Oklahoma. The direct employment is the average of the last four years of employment capturing the most recent industry trend. All earnings and output estimates are cumulative across years and projects.

TABLE 2 STATEWIDE ECONOMIC IMPACT DURING CONSTRUCTION

	EMPLOYMENT	EARNINGS	OUTPUT
Direct Impact	342	\$102,616,039	\$431,443,558*
Multiplier Impact	221	\$206,311,372	\$509,385,895
Total Impact	563	\$308,927,411	\$940,829,454

* Wind Energy firms spent \$442 million in the state, some of which was counted as indirect expenditure and included in the multiplier impact.



Operations

During their operational life, Oklahoma wind energy facilities are estimated to provide an additional \$92 million in annual economic activity throughout the state. This includes the wind farm operator and technician salaries, payroll and equipment taxes, and annual consumption of each employee. As each wind facility is expected to have a life span of at least 20 years, the first 26 facilities will generate approximately \$1.8 billion in economic activity throughout their useful lives.

Additionally, these facilities will generate \$43 million in property tax revenue annually that will be used by local municipalities and school districts to fund public services. As growth continues to slow in rural areas relative to the urban centers of Oklahoma City and Tulsa, these funds are critical to ensure the continuation of quality services to rural residents.

TABLE 3 ANNUAL STATEWIDE ECONOMIC IMPACT DURING OPERATION

	EMPLOYMENT	EARNINGS	OUTPUT
Direct Impact	253	\$14,984,412	\$29,946,670
Multiplier Impact	493	\$22,155,162	\$62,042,709
Total Impact	746	\$37,139,574	\$91,989,379

Additional Economic Considerations

For consumers, the long-term price stability of Oklahoma wind energy contracts help ensure that Oklahoma energy is affordable for the businesses, industries, and residents of the state. Many wind contracts designate stable prices for up to 20 years, nicely complementing shorter-term natural gas contracts. Bolinger (2013)¹¹ found that wind energy contracts provide a vital hedge against long-run natural gas price fluctuations, even given the low cost of natural gas today.

Additionally, the Levelized Cost of Energy (LCOE)¹² for wind energy is 87% of that of coal generation and slightly less than Advanced Combined Cycle (ADVCC) natural gas generated energy. With the development of shale gas resources, low natural gas prices make ADVCC plants attractive alternatives to large-scale coal power generation. Even still, lower wind LCOE make it the perfect complement to natural gas, as firms see it as the best hedge against long-term natural gas price fluctuations.

According to Bolinger, firms, including Google, are looking to lock in energy prices for up to 20 years citing wind as the natural, cost competitive source given the long run nature of wind contracts. With the availability but potential long-run price uncertainty of natural gas and the price stability afforded by wind, the diversity of Oklahoma's energy generation profile will ensure lower cost, consistent power is available to consumers and firms for years to come.

11 Bolinger, Mark (2013). "Revisiting the Long Term Hedge Value of Wind Power in an Era of Low Natural Gas Prices," Lawrence Berkeley National Laboratory working paper LB-NL-6103E.

12 Levelized Cost of Energy (LCOE) is a metric used by the US Department of Energy to assess the cost of energy generation across a variety of sources including coal, natural gas, wind, solar, and hydrothermal. LCOE includes the installed capital cost, the annual operating expenses, and the total costs of financing considering the amount of energy generated annually.



Conclusion

The State of Oklahoma possesses a considerable wind resource that is already being tapped by developers across the state. The benefits of private wind energy development accrue beyond lower energy prices to consumers, and wind development in Oklahoma has demonstrated measureable economic benefits both directly to the communities where wind farms operated and throughout the state.

Recognizing the importance Oklahoma's diverse energy economy has played in the state, and continuing the state's heritage as an energy leader, the governor's Energy Plan calls for a systems-approach to energy production with both a focus on natural gas and a movement toward more advanced renewable energy sources. Wind energy is one such resource, and a resource for which Oklahoma is particularly suited.

Furthermore, during the economic downturn that followed the financial crisis of 2008, Oklahoma fared better than most states, largely based on the strength of Oklahoma's energy sector which provided much needed stability for the state, local governments, and residents. Wind energy development contributed to that economic stability.

Wind energy development in Oklahoma has led to the establishment of 26 operational wind farms, with many more in development. These 26 farms represent more than 3,000 megawatts of electricity generation capacity and an investment of more than \$6 billion into the Oklahoma economy. The wind energy facilities constructed in Oklahoma over the past 10 years already fulfill the plan's targeted 15% renewable goal and continued growth is expected in the future. This growth will continue to add jobs, capital investment, and activity to our economy.

The future is bright for wind energy in Oklahoma. Technological advancements in wind energy technology continue to lower the price of wind-generated electricity. As new EPA regulations on coal are implemented in the coming years, costs

for conventional energy sources will rise, causing the state to rely even more heavily on natural gas and renewables to meet energy needs. Oklahoma's abundant natural gas may continue to provide the lion's share of electricity generation in the state, but wind will continue to grow because of its low cost, its lack of adverse impacts on air quality, its lack of water use, and its beneficial economic development effects.



Photo Credits

Pages 1,3,12,14,15,19, 21 - Blue Canyon Wind Farm, Photo courtesy of EDP Renewables.

Page 11 - *The Keenan II Wind Farm, operational since December 2010, is located 12 miles southwest of Woodward. Photo courtesy of Competitive Power Ventures (CPV).*

Page 16 - Novus Wind I south of Guymon, Oklahoma, Photo Courtesy of Novus Wind Power.

Page 18 - Photo courtesy of Enel Green Power, © 2013 Tim Nauman Photography.

Page 20 - Courtesy of Tradewind Energy.

The logo consists of the letters 'EIG' in a white, serif font, centered within a dark blue square. A thin white horizontal line is positioned directly below the letters.

EIG

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