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AGRIBUSINESS AND APPLIED ECONOMICS REPORT 779 SEPTEMBER 2017

Wind Energy Industry's Contribution
TO THE NORTH DAKOTA ECONOMY IN 2016

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USND
Utility Shareholders of North Dakota

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Acknowledgments

Special thanks are extended to Carlee McLeod, President, Utility Shareholders of North Dakota, for project leadership, guidance and for assisting and coordinating data collection. Financial support for this project was provided through a grant from the North Dakota Utility Shareholders.

This study was based on actual expenditure data (annual audits) provided by wind energy generation enterprises, actual wind generation capacity as reported by the North Dakota Public Service Commission and actual tax collections as reported by the North Dakota Office of the State Tax Commissioner. Thanks are extended to the following individuals for their assistance in collecting and assembling the requested information. This effort would not have been possible without their participation.

Kathryn Strombeck and Dustin Bakken – North Dakota Office of State Tax Commissioner
Jerry Lein – North Dakota Public Service Commission
Robert Harms—The Harms Group
Peter Doherty – Xcel Energy
Todd Simmons – Minnesota Power
Julie Voeck – NextEra Energy Resources, LLC
Sean O'Leary—LM Wind Power Blades (ND), Inc.
Lori Hannesson – Dakota Turbines.

The authors assume responsibility for any errors of omission, logic, or otherwise. Any opinions, finding, and conclusions expressed in this publication are those of the authors and do not necessary reflect the view of the Department of Agribusiness and Applied Economics, North Dakota State University, or the study sponsors.

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Executive Summary

Energy is one of the North Dakota's most important industries. While production of fossil fuels, namely coal extraction and conversion and oil and gas production are the predominant influences in the energy industry in North Dakota, renewable energy, which includes wind energy and ethanol production have grown substantially in recent years. The wind energy industry in North Dakota has grown from a few small turbines with 4.4 megawatts (MW) production capacity in 2002 to maximum production capacity of nearly 3,000 MW of electricity in 2016. The objective of this study was to estimate the contribution the wind energy industry makes to the North Dakota economy.

An economic contribution assessment measures the changes in economic variables that result from in-state expenditures by a given industry. This economic contribution analysis measures the economic activity generated in the state's economy from the wind energy industry. Economic effects for both construction and operations are categorized into direct and secondary effects. North Dakota's wind energy industry includes those complexes, facilities and enterprises related to the production of electricity from wind turbines and the manufacture of wind turbine components.

There are 29 commercial wind farms in North Dakota (North Dakota Public Service Commission 2017). Commercial scale wind farms in North Dakota range from 30 to 100 turbines with generation capacity of 50 to 200 MW. Wind generation capacity in North Dakota grew from less than 100 megawatts in 2005 to nearly 3,000 megawatts in 2016. The percentage of electricity generated by wind power has increased from nearly zero percent in 2003 to 17.5 percent in 2015. Preliminary estimates from U.S. Energy Information Administration (2017) indicate that 21.5 percent of net electricity was generated by wind power in 2016. While the percentage of electricity produced from coal has declined from around 95 percent in the mid-2000s, to 21.5 percent in 2016, generation capacity and kilowatt hours produced has remained about the same. Wind generation has provided much of the additional generation capacity and production in recent years.

The wind energy industry was estimated to have injected $67 million into the state's economy in 2016. Operational expenditures represent direct economic effects and are annual and reoccurring as long as the wind energy site remains operational. In-state expenditures in *the Retail Trade* sector were $23.3 million, $18.7 million in the *Households* sector, and $10.9 million in the *Professional and Social Services* sector. Expenditures in the *Households* sector represent personal income and consists of wages and salaries and lease payments to land owners. Payment to the *Government* sector totaled $5.5 million and represent actual property taxes paid. Payment to the *Government* sector for property taxes were not estimated based on survey data. Taxes paid by the industry were requested from and provided by the North Dakota Office of the Tax Commissioner. Operations expenditures do not include one-time construction expenditures for the development and construction of wind generation capacity or activities related to wind energy manufacturing. Construction and manufacturing activities will be presented separately.

The total business activity generated in North Dakota by the wind energy industry was estimated to be $174.6 million in 2016. This level of economic activity produced $57.1 million of state-wide personal income (*Households* sector) in 2016. Business activity in the *Retail Trade* sector totaled $55.2 million. Of the $174.8 million of business activity from wind farm operations, $107.6 million were secondary impacts resulting from the economic activity created as expenditures for operations flow through the economy. The total economic contribution of the wind energy industry in 2016 is nearly double the $98.7 million estimated in 2011 (Coon et al. 2012c). The percentage increase in business activity parallels the growth in generation capacity.

While operations activities associated with the wind energy industry are not labor intensive, the wind energy industry in North Dakota supports 136 full time equivalent jobs. In addition to direct industry employment, industry expenditures create business activity which supports secondary, or indirect and induced jobs. The business activity from the wind energy industry supports 364 secondary jobs.

In addition to jobs related to wind energy operations, in 2016, two firms were engaged in the manufacture of components for the wind energy industry in the state. In 2015, the state's large-scale manufacturer employed 567 full-time equivalent employees, by January 2017, employed had increased to 1,013. While North Dakota's small wind turbine manufacturer only employs 17 full time equivalents, it is in rural North Dakota where employment opportunities can be limited, especially good paying jobs in the manufacturing sector. Total economic impacts (direct plus secondary impacts) from manufacturing activities are estimated to be $119 million in 2016. Impacts are considered annual and reoccurring as long as operations continue at a similar level.

Total in-state construction expenditures for wind farms were presented as the summation of outlays for each of the industry components to avoid disclosure of confidential information due to the small number of firms with construction activities in certain years. Construction of wind farms has not been consistent over the 2002 to 2016 period. There were no construction expenditures in 2004, 2013, and 2014 as no new facilities were built. Peak construction years were 2008 and 2009 with $950 million and $814 million of in-state construction expenditures, respectively. In-state construction expenditures exceeded $100 million in 2003, 2007, 2010, 2012, and 2016. When viewed collectively over the past 15 years, the wind energy industry has made in-state construction expenditures of $2.8 billion as the industry has expanded in the state.

Average land lease payments per turbine were estimated to be $9,394 which is consistent with individuals familiar with the industry that estimated that average lease payments would generally range from $8,000 to $10,000 per turbine (Bakken, 2017, Harms, 2017). Total payments to landowners were estimated to be $14.4 million in 2016. Land lease payments are annual payments to landowners that will reoccur for the lifetime of the turbine. These separate estimates of lease payments to landowners should not be added to estimates of industry direct expenditures to the *Households* sector. Those payments were included in the estimate of industry total (direct and secondary) contribution. Estimate of payments to landowners for land leases is for illustrative purposes.

Wind energy represents another element of the state's energy complex that creates jobs and uses the export of electricity to create additional business activity in the state. Wind generating capacity and output has continued to expand for over a decade in North Dakota. The North Dakota Public Service Commission reported than an additional 400 megawatts of capacity are likely to be constructed over the next two years demonstrating the value that wind energy interests have on locating their operations in the state.

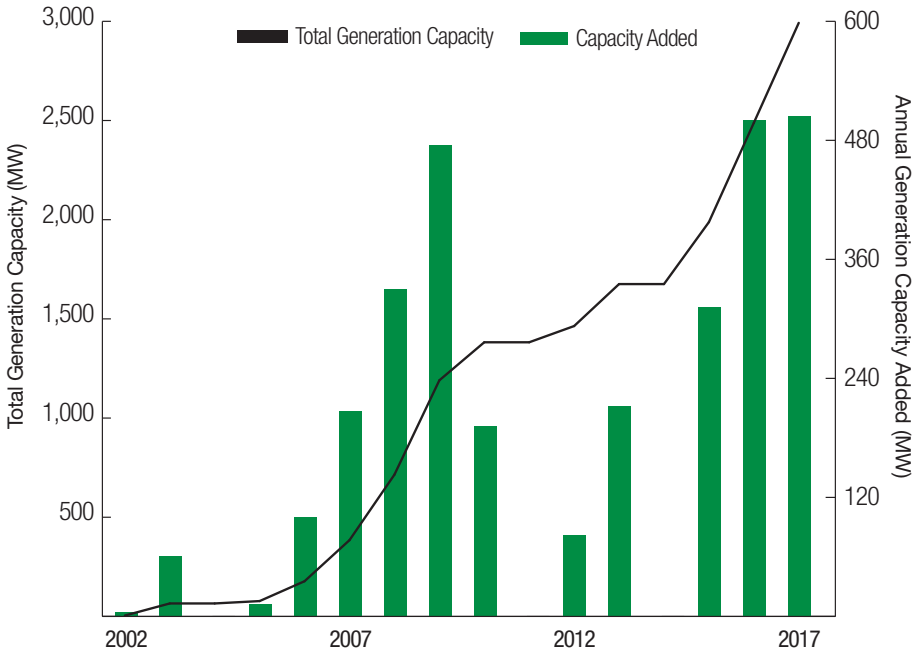
Wind energy provides positive economic impacts

Wind energy affects the North Dakota economy through the manufacture, construction and operation of wind farms.

STUDY ASSESSES WIND ENERGY CONTRIBUTIONS

- Energy is one of North Dakota's most important industries with renewable energy, including wind, growing substantially in recent years.
- The Department of Agribusiness and Applied Economics recently conducted a study to estimate the contribution that the wind energy industry makes to the North Dakota economy.
- The study concluded that wind energy resulted in a number of positive economic impacts. Data was collected in 2016.

Annual and Total Wind Generation Capacity, North Dakota



Much of North Dakota's wind capacity was built from 2006 to 2010 when approximately 1,300 megawatts came on-line. More recently, 1,370 MW have come online since 2015.

At a glance – North Dakota Wind Energy

- North Dakota is ranked sixth in U.S. wind generation potential
- 29 wind farms
- More than 1,500 wind turbines
- Total generation capacity of nearly 3,000 megawatts, up from nearly zero in 2002
- Electricity generated from wind up from nearly zero percent in 2003 to 21.5 percent in 2016 (preliminary estimates from U.S. Energy Information Administration)

Benefits of wind energy in North Dakota

Approximately
$170 million
economic impact, 2016

Approximately
500
jobs, 2016

$2.8 billion
total construction expenditures

$7.7 million
property taxes, 2016

$119 million
manufacturing activities, 2016

Wind Energy Industry's Contribution to the North Dakota Economy in 2016

Randal C. Coon, Nancy M. Hodur, and Dean A. Bangsund[1]

Introduction

Energy is one of North Dakota's most important industries. While production of fossil fuels, namely coal extraction and conversion and oil and gas production are the predominant influences in the energy industry in North Dakota, renewable energy, which includes wind energy and ethanol production have grown substantially in recent years. The wind energy industry in North Dakota has grown from a few small turbines with 4.4 megawatts (MW) production capacity in 2002 to maximum production capacity of nearly 3,000 MW of electricity in 2016. In addition to the various benefits of renewable energy, the wind energy industry acts to diversify and expand North Dakota's energy industry and economy. The objective of this study was to estimate the contribution the wind energy industry makes to the North Dakota economy.

Methods

An economic contribution assessment measures changes in economic variables that result from in-state expenditures by a given industry. This approach is frequently used to estimate the impact of the construction and operations of a new business or industry, the economic footprint of basic sector industries, or predicting the implications of a change in public policy (Bangsund et al. 2012, Hodur et al. 2006, Leistritz and Coon 2008).

This economic contribution analysis measures the economic activity generated in the state's economy from the operation and maintenance of wind-generated activity and related wind energy manufacturing enterprises. North Dakota's wind energy industry includes those complexes, facilities and enterprises related to the production of electricity from wind turbines and the manufacture of wind turbine components.

Economic effects for both construction and operations are categorized into direct and secondary effects. Direct effects are defined as the original expenditures made by the industry to purchase goods and services from in-state entities. Direct effects are often referred to as first-round effects. Secondary impacts, often referred to as the multiplier effect, are a result of subsequent rounds of spending and re-spending in the economy from the initial or first round dollars. The multiplier effect is based on linkages among sectors of an economy (Schaffer et al. 2004).

[1] The authors are Research Specialist, Department of Agribusiness and Applied Economics, Director, Center for Social Research, and Research Scientist, Department of Agribusiness and Applied Economics, respectively, North Dakota State University, Fargo.

Input-output analysis is a common tool used to measure economic linkages. This methodology measures the business volume created as an original dollar (direct expenditure) works its way through the North Dakota economy before it leaves the state's economy to acquire a good or service not provided by in-state sources.

North Dakota Input-Output Model

The North Dakota Input-Output Model consists of interdependence coefficients, or multipliers, that measure the level of business activity generated in each economic sector from an additional dollar of expenditures in a given sector. A sector is a group of similar economic units, e.g., the firms engaged in retail trade make up the Retail Trade Sector. For a complete description of the North Dakota Input-Output Model, see Coon et al. (1989). The model generates levels of business activity (direct and secondary) for each economic sector and the sum is an estimate of the total economic contribution (direct and secondary impacts) from the spending and re-spending of the original dollars added to the economic unit (Coon et al. 1989; Coon et al. 2012b). Historic relationships are used to estimate selected tax revenues and secondary employment. All economic indicators are presented as current year or nominal dollars (i.e., in terms of the purchasing power of the dollar in each respective year).

For this analysis, the model was used to estimate these changes for operations of wind farms in the state. The sum of business activity generated by the direct impacts are used to estimate secondary employment and tax revenues. Procedures used in this analysis are similar to those used to estimate the impact of other facilities and activities (Leistritz and Coon 2008, Coon and Leistritz 2007). Empirical testing has confirmed the model's accuracy in estimating changes in levels of economic activity in North Dakota over the period 1958-2014. Estimates of statewide personal income from the model averaged within 10 percent of comparable values reported by the U.S. Bureau of Economic Analysis 2016.

Capital Outlays for Construction

Data obtained from this study were combined with information from a 2012 assessment of the renewable energy industries in the state (Coon et al. 2012c). The combined information represents a time series of in-state construction expenditures from 2002 through 2016. In-state construction expenditures were estimated on a per megawatt basis to avoid disclosure of any in-state capital outlays for individual firms. Estimated per megawatt construction cost were applied to the capacity added each year.

Annual wind farm construction expenditures were based on a one-year construction period. Construction expenditures were allocated to calendar years based on start dates and completion dates for various projects. Construction start and completion dates and expenditures were obtained from survey and secondary data. Construction costs were allocated to the year the facility became operational, unless the facility became operational very early in the year, in which case, construction costs were assigned to the previous year. For example, if a wind farm became operational in January of 2010, construction expenditures

were allocated to 2009, or if a wind farm became operational in July of 2010, half of the expenditures were allocated to 2009 and the other half to 2010.

All construction expenditures were reported in current year dollars (i.e., dollars in terms of their purchasing power in each respective year—dollars not corrected for inflation). Capital outlays reported represent only in-state expenditures. Total industry investment was higher due to expenditures made to out of state entities. Total cost of construction is not reported in this study. The potential one-time secondary impacts of wind farm construction were not estimated.

In-state Expenditures for Wind Farm Operations

Operational expenditures are defined as the expenses firms incur to manage, operate, and maintain a facility or activity, excluding capital outlays for new construction or plant expansion. Expenditures for operations produce annual economic impacts because spending to support operations re-occur each year a plant, facility, or activity is operational. In-state expenditures were collected for wind farm operations in 2016.

A list of firms operating wind farms was provided by the North Dakota Utility Shareholders. Following similar methods as the previous study (Coon et al 2012c), firms were surveyed to collect expenditure data for annual operations. Firms were first contacted by the study sponsor to advise them of the study and to elicit their participation and subsequently contacted by the research team. Estimates of industry expenditures for annual operations were based on data collected from firms that own and operate wind farms in the state.

A similar questionnaire as the previous study was developed to reflect the specific characteristics of the industry (Appendix A). Firms were asked to provide estimates of in-state expenditures for operations in North Dakota and to omit expenditures to out-of-state entities.

Wind energy centers in North Dakota are owned and operated by only a few firms. All wind farms were contacted, and while not all firms responded to the request for data, survey data collected from participating firms represented approximately 80 percent of the wind generation capacity in North Dakota. In order to avoid underestimating the economic effects of wind farm operations, operating expenses of non-responding wind farms were estimated. Using expenditure data from similar-sized wind farms, average expenditures per megawatt were estimated and used as a proxy for operating expenditures at wind farms that did not participate in the survey.

Lease Payments

Expenditures for land lease payments are made directly to hundreds of landowners in the state. While, payments for land leases were included in the estimate of industry expenditures to the *Households* sector, other payments to households such as salaries and wages for industry employees were also included. Given that the industry makes substantial land lease payment

directly to landowners, those payments were also estimated and reported separately. These separate estimates of lease payments to landowners should not be added to estimates of industry direct expenditures to the *Households* sectors. Data collected from the survey of wind energy firms included payments for land leases and land lease payments are included in the estimate of industry total (direct and secondary) contribution. Estimates of payments to landowners for land leases is for illustrative purposes.

Survey data and generation capacity from participating wind energy firms was used to extrapolate total statewide land lease payments to landowners. Lease payments per turbine were calculated using survey data and the number of permitted turbines as of January 2017 (North Dakota Public Service Commission, 2017). Permitted projects that were scheduled for completion and operations in early 2017 were included. Estimates were based on 1,528 permitted turbines with generation capacity of 2,990.6 MW (North Dakota Public Service, 2017). Survey data on lease payments was representative of 1,053 turbines, or 69 percent of the total number of turbines in North Dakota. Responding firms reported payments to landowners for land leases. Lease payments and the number of turbines for participating firms were summed and used to estimate average lease payments per turbine. Average lease payments per turbine of participating firms were applied to total number of turbines permitted in 2016 to estimate total lease payments made to landowners in North Dakota.

In recent years, the structure of land lease payments has begun to change and evolve. In the early years of wind energy development, land lease payments were largely based on the physical footprint of the turbine and payments based on the number of turbines. More recently land lease payments are based not only on the number of turbines, but also electricity generated (Harms, 2017). At least one wind development project in the state negotiated lease payments with all landowners in the project area, not only with landowners with a turbine located on their property (Bakken, 2017). While the terms of leases vary, data was not available to refine estimates beyond a calculation of average payments per turbine. Given that most leases have historically been based on payments per turbine, it is not likely additional data would substantially refine the estimate of statewide payments to landowners in North Dakota for land lease payments.

Wind Energy Manufacturing

Manufacturing firms related to wind energy were identified. Both firms were contacted and a questionnaire similar to the questionnaire distributed to wind generation firms was developed. Both firms responded to the request for information on in-state expenditures related to business operations. However, because there are only two firms, direct expenditures will not be reported to maintain confidentiality of proprietary financial information. Expenditures were allocated to the appropriate sectors of the North Dakota Input-Output model and total impact (direct plus secondary) were calculated and will be reported. Reporting only total impacts protects proprietary direct expenditure data as it is impossible to reverse engineer total impacts without knowledge of the direct impacts. A brief description of wind

energy manufacturing and other non-propriety indicators such as employment are reported in the results section.

Wind Generation Capacity and Production

There are 29 commercial wind farms in North Dakota (North Dakota Public Service Commission 2017). Commercial scale wind farms in North Dakota currently range from 30 to 100 turbines with generation capacity of 50 to 200 MW (data not shown). Statewide there are 1,526 commercial scale turbines with total generation capacity of 2,992.2 megawatts (Table 1, Figure 1). Most of the wind farms built in recent years have generation capacity of 100 to 200 megawatts of power. Seventeen of the 29 commercial wind farms have generation capacity of over 100 megawatts. Much of the state's current capacity was built from 2006 to 2010 when 1,304.6 MW came on-line (Table 1, Figure 1). Since 2015, 1,317 MW has come on line. While the industry has grown substantially in recent years, North Dakota has considerable potential for future growth and expansion. North Dakota's wind energy 'potential' has been rated at just over 770,000 MW by the National Renewable Energy Laboratory (2011), placing North Dakota 6th among states in wind generation potential. Annual and total wind turbine generation capacity is detailed in Table 1. Figure 2 details the location of the state's commercial wind farms. Wind farms are widely distributed across the state.

Table 1. Annual and Total Wind Turbine Electric Generating Capacity, North Dakota, 2002-2017

	Annual Change		
Year	Number of Turbines	Capacity	Total Generation Capacity[1]
		----------megawatts----------	
2002	4	4.4	4.4
2003	41	61.0	65.4
2004	0		65.4
2005	18	12.0	77.4
2006	55	100.1	177.5
2007	138	207.0	384.5
2008	219	330.0	714.5
2009	289	475.6	1190.1
2010	120	191.9	1,382.0
2011	0	0.0	1,382.0
2012	33	81.8	1,463.8
2013	71	211.6	1,675.4
2014	0	0.0	1,675.4
2015	107	312.3	1,987.7
2016	262	500.5	2,488.2
2017[2]	250	504.0	2,992.2
Projects likely to proceed		450.0	

Source: North Dakota Public Service Commission (2017).
[1]Includes some small non-commercial generation capacity of less than 2 megawatts.
[2]As of April 2, 2017

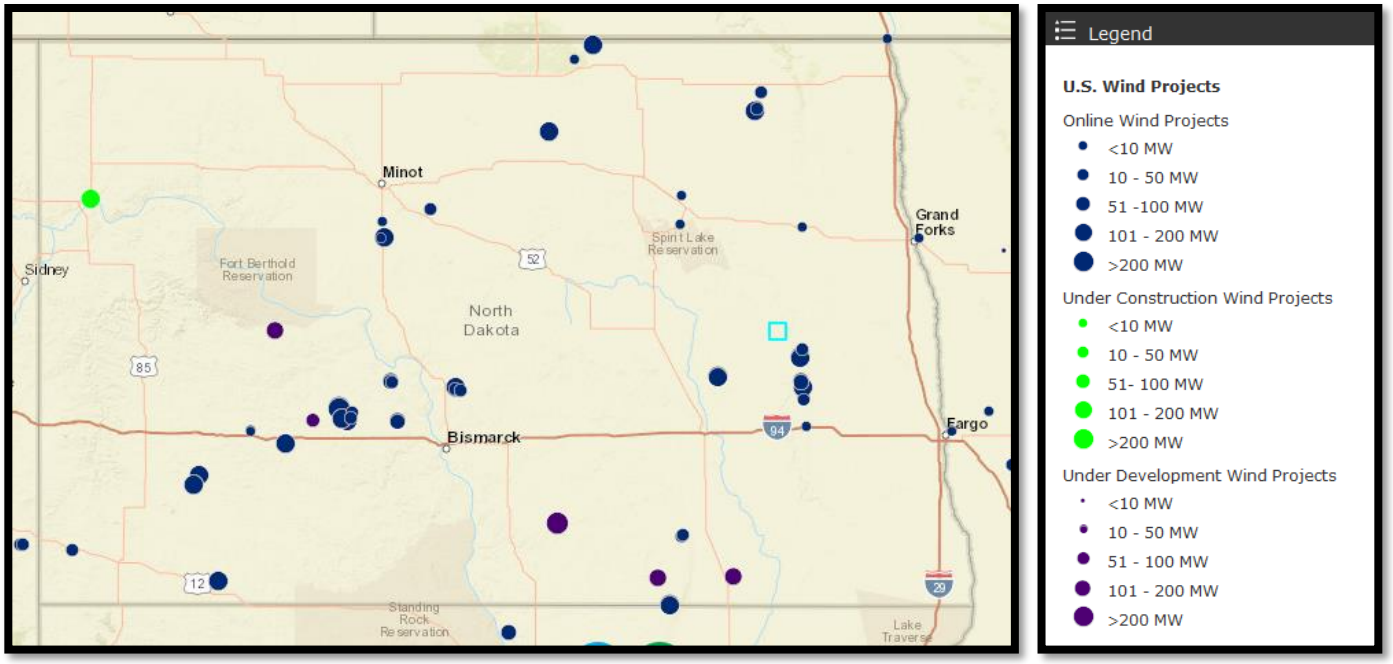


Figure 1. Commercial Wind Farms, North Dakota, 2017
Source: American Wind Energy Association, http://gis.awea.org/arcgisportal/apps/MapSeries/index.html?appid=663f1edd000d4b9b8e8177a5b62be7a2

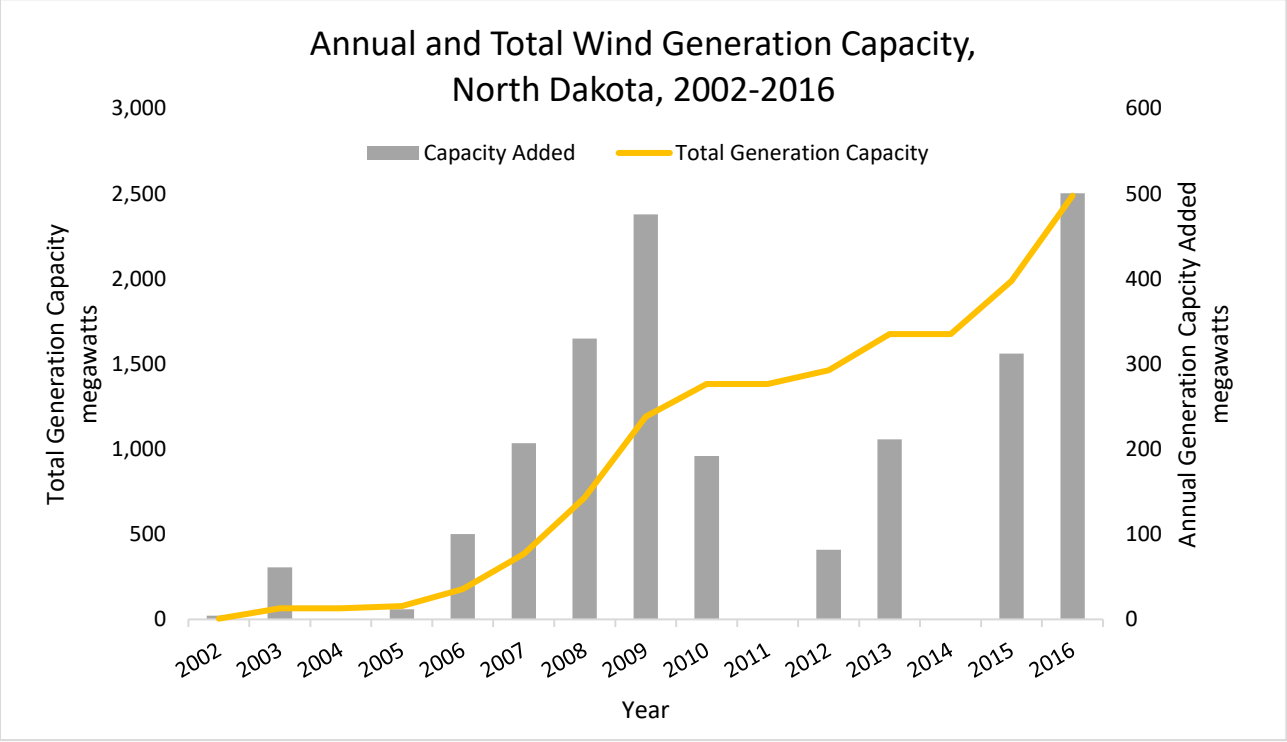


Figure 2. Annual and Total Wind Generation Capacity, North Dakota, 2002-2017.
Source: North Dakota Public Service Commission (2017).

Energy generation capacity is measured as the maximum potential capacity, and does not necessarily represent actual electricity output. Among North Dakota's key electricity generating sectors, coal has the largest generation capacity of 4,214 megawatts. Generation capacity from coal has remained relatively unchanged since the industry was developed in the 1970s and 1980s. In 2000, electricity generation capacity from coal was 4,127 and in 2015 was 4,214, a 2 percent increase.

Wind generation capacity is measured assuming turbines operate at nameplate capacity. Using those metrics, wind generation capacity in North Dakota grew from less than 100 megawatts in 2005 to over 2,200 megawatts in 2015 (Figure 2). Over the same period, electricity generation capacity from natural gas also grew going from nearly zero generation capacity in 2012 to 328 megawatts in 2015. Data to make comparisons among the major electricity generating sectors in North Dakota was only available through 2015; however, data specific to wind generation in North Dakota shows that capacity has expanded to nearly 3,000 megawatts in 2017 (Figure 2, Appendix Table 1).

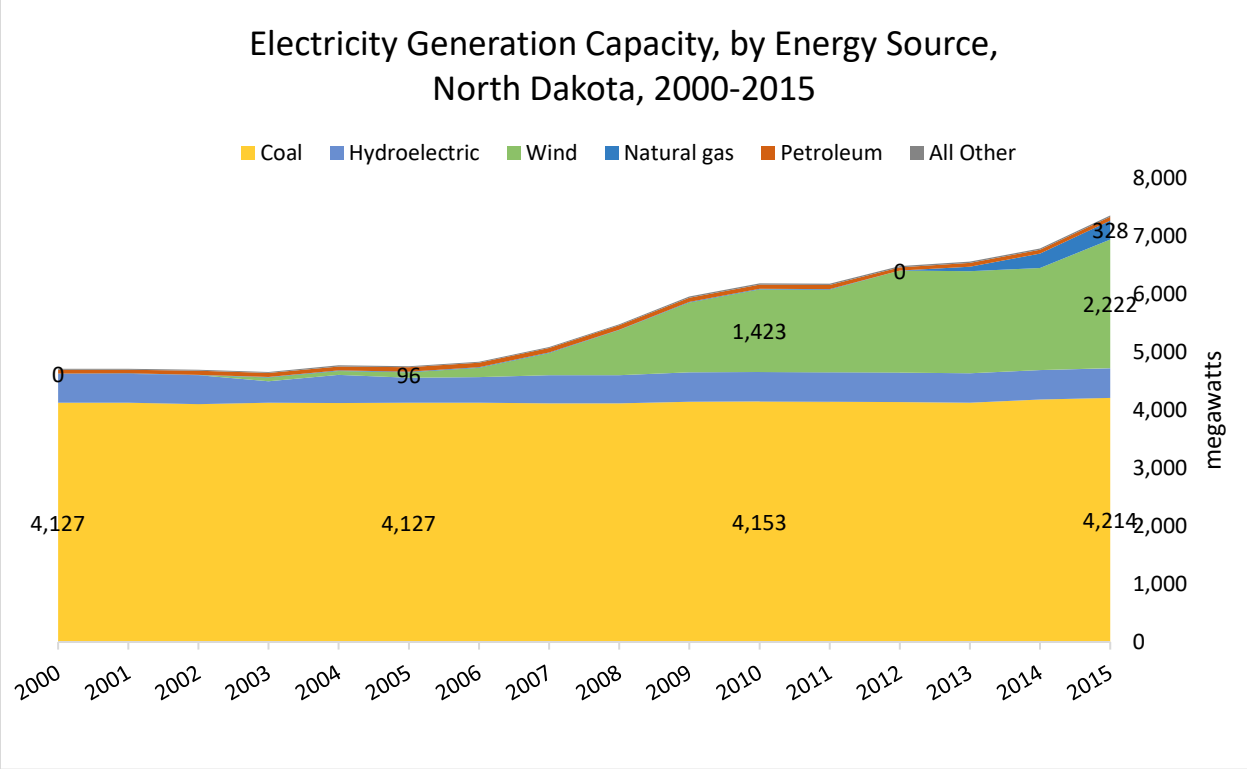


Figure 3. Electricity Generation Capacity, by Source, North Dakota, 2000-2015
Source: Energy Information Agency, https://www.eia.gov/electricity/data/state/

Another metric to describe industry capacity is to examine actual megawatt hours of electricity produced. Coal is the dominant electricity source, generating 71 percent of all megawatt hours of electricity produced in North Dakota in 2016. Total megawatt hours

generated from coal has remained relatively constant in the last 15 years, ranging from 29,069 megawatt hours in 2000 to 27,734 in 2015 with average annual production over the same period of 28,689 MWH. Total megawatt hours generated by coal declined by 4 percent since 2000. While total production of electricity from coal has remained relatively unchanged, the percentage of electricity produced from coal has declined since the mid-2000s. In 2007, 93 percent of the kilowatt hours produced were generated from coal compared to 75 percent in 2016 (Table 3, Appendix Table 2). While the percentage of electricity produced from coal has declined, generation capacity and kilowatt hours produced has remained about the same.

Electricity generated from wind has increased from zero in 2002 to 6,505 MWH in 2015. The percentage of electricity produced in North Dakota from wind over the same period has increased from zero percent in 2003 to 17.5 percent in 2015. Preliminary estimates from U.S. Energy Information Administration (2017) indicate that wind was responsible for 21.5 percent of North Dakota's net electricity generation in 2016 (Figure 3, Appendix Table 2). Wind generation has provided much of the additional generation capacity and production in recent years. Megawatt hours of electricity generated from natural gas has also increased. While total megawatt hours of electricity generated from natural gas is relatively small, production has increased substantially in recent years, from 16 MWH in 2010 to 711 MWH in 2015.

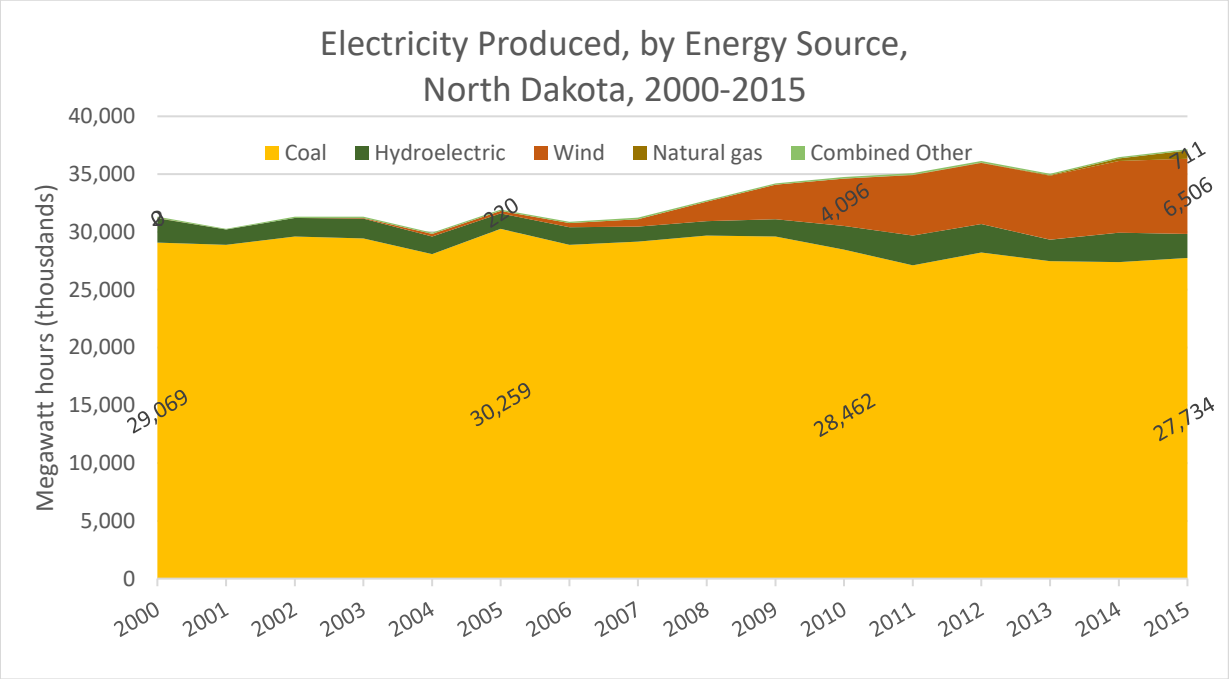


Figure 4. Electricity Produced, by Source, North Dakota, 2000-2015
Source: U.S. Energy Administration Agency, https://www.eia.gov/electricity/data/state/

Results

An economic contribution study estimates the total business activity associated with a given industry or activity within a specified location. A survey of wind energy developers and operators was conducted to obtain information on in-state expenditures, employment, and selected tax liabilities. The survey was successful in collecting expenditure data from firms representing much of the generation capacity in the state.

Operations

The wind energy industry was estimated to have injected $67.2 million into the state's economy in 2016 (Table 2). Operational expenditures represent direct economic effects and are annual and reoccurring as long as the wind energy site remains operational. Operational expenditures for wind farms have grown significantly since 2006, and nearly doubled since 2011 when direct expenditures were estimated to be $31.0 million (Coon et al. 2012c). In-state expenditures in *the Retail Trade* sector were $23.3 million, $18.7 million in the *Households* sector, and $10.9 million in the *Professional and Social Services* sector. Expenditures in the *Households* sector represent personal income and consists of wages and salaries and lease payments to land owners. Payment to the *Government* sector totaled $5.5 million and represent actual property taxes paid. Payment to the *Government* sector for property taxes were not estimated based on survey data. Taxes paid by the industry were requested from and provided by the North Dakota Office of the Tax Commissioner. Operations expenditures do not include one-time construction expenditures for the development and construction of wind generation capacity or activities related to wind energy manufacturing. Construction and manufacturing activities will be presented separately.

Table 2. Estimated In-State Expenditures by North Dakota's Wind Energy Industry for Operational Activities, by Input-Output Model Sectors, 2016

Input-Output Sectors	In-state Expenditures
	----------$000----------
Retail Trade	23,251
Households (personal income)	18,665
Profession and Social Services	10,861
Government	5,516
Business and Personal Services	5,155
Finance, Insurance and Real Estate	1,798
Communications and Public Utilities	1,430
Transportation	544
Wholesale Trade and Manufacturing	--
Total Direct Economic Impacts	67,220

The total business activity generated in North Dakota by the wind energy industry was estimated to be $174.8 million in 2016 (Table 3). Secondary impacts are a result of the spending and respending of dollars associated with operations such as land and lease payment to landowners, wages and salaries for employees and other operations expenditures. Secondary impacts totaled $107.6 million. Secondary impacts were the greatest in the *Households* sector with total economic activity of $57.1 million. Payments in the *Households* sector includes salary and wages for industry employees, lease payments to landowners and other payments that represent personal income. The second highest level of business activity was in the *Retail Trade* sector totaling $55.2 million. Given the high level of direct effects in the *Household* sector substantial secondary effects in the retail trade sector would be expected as households spend salaries and wages, lease payment and other personal income for goods and services. The total economic contribution of the wind energy industry in 2016 is nearly double the $98.7 million estimated in in 2011 (Coon et al. 2012c). The percentage increase in business activity parallels the growth in generation capacity.

Table 3. Estimated Direct, Secondary, and Total Economic Impacts for Operational Activities of North Dakota's Wind Energy Industry, 2016

	Business Volume		
Input-Output Sectors	Direct	Secondary	Total
	----------$000----------		
Households	18,665	38,443	57,108
Retail Trade	23,251	31,963	55,214
Profession and Social Services	10,861	4,095	14,956
Government	5,516	4,764	10,280
Finance, Insurance, and Real Estate	1,798	7,042	8,840
Business and Personal Services	5,155	2,549	7,704
Communications and Public Utilities	1,430	5,490	6,920
Construction	--	3,880	3,880
Wholesale Trade & Miscellaneous Manufacturing	--	2,520	2,520
Transportation	544	630	1,174
Others[1]	--	6,250	6,250
Total Direct and Secondary Economic Impacts	67,220	107,626	174,846

[1] Agriculture (crops and livestock), mining.

While operations activities associated the wind energy industry are not labor intensive, the wind energy industry in North Dakota supports 136 full time equivalent jobs. In addition to direct industry employment, industry expenditures create business activity which supports secondary, or indirect and induced jobs. The business activity from the wind energy industry supports 364 secondary jobs.

Secondary tax revenues generated in North Dakota as a result of direct and secondary expenditures attributed to the industry were estimated to be $7.7 million in 2016. The "other taxes" category (which includes property and unemployment taxes) produced the largest amount of collections in 2016, followed by sales and use taxes.

Table 4. Direct and Secondary Employment and Selected Tax Revenues Associated with Operational Activities of North Dakota's Wind Energy Industry, 2016

Category	Impacts
	----------FTE jobs ----------
Employment	
Direct (within the industry)	136
Secondary (jobs outside of the industry)	364
Tax Revenues	----------$000s----------
Sales and Use	2,556
Personal Income	857
Corporate Income	315
Other[1]	3,974
Total	7,702

[1] Other includes property, unemployment, and miscellaneous taxes.

The wind energy industry in North Dakota has grown substantially from virtually no generation capacity in 2002 to nearly 3,000 megawatts of capacity in 2016. Wind energy generation capacity doubled from 2011 to 2016. Economic effects of wind farm operations were estimated to have direct economic impacts of $67 million and total (direct plus secondary) economic impacts of $174.8 million. Economic effects have paralleled the growth in generation capacity in the state.

Construction

Total in-state construction expenditures for wind farms were presented as the summation of outlays for each of the industry components to avoid disclosure of confidential information due to only a few firms with construction activities in certain years. Construction of wind farms has not been consistent over the 2002 to 2016 period. There were no construction expenditures in 2004, 2013, and 2014 as no new facilities were built. Peak construction years were 2008 and 2009 with $950 million and $814 million of in-state construction expenditures, respectively. In-state construction expenditures exceeded $100 million in 2003, 2007, 2010, 2012, and 2016. When viewed collectively over the past 15 years, the wind energy industry has made $2.8 billion of in-state construction expenditures as the industry has expanded in the state (Table 5, Figure 4).

Table 5. In-State Expenditures for Construction of Wind Energy Facilities, by Economic Sector, 2002 - 2016 (Current Year Dollars)								
	Communications and Public Utilities	Agriculture Processing & Miscellaneous Manufacturing	Retail Trade	Finance, Insurance & Real Estate	Business and Professional Services	Professional and Social Services	Households	Total
Year	----------$000s----------							
2002	4	1,499	97	20	312	6	74	2,012
2003	208	77,372	4,985	1,039	16,097	311	3,843	103,855
2004	--	--	--	--	--	--	--	--
2005	166	61,754	3,979	829	12,848	249	3,067	82,892
2006	169	62,800	4,046	843	13,066	253	3,119	84,296
2007	292	108,853	7,013	1,461	22,647	438	5,406	146,110
2008	1,900	707,792	45,603	9,500	147,259	2,850	35,152	950,056
2009	1,628	606,592	39,082	8,142	126,204	2,443	30,126	814,217
2010	374	139,325	8,977	1,870	28,987	561	6,920	187,014
2011	39	14,613	942	196	3,040	59	726	19,615
2012	416	154,804	9,974	2,078	32,208	623	7,688	207,791
2013	--	--	--	--	--	--	--	--
2014	--	--	--	--	--	--	--	--
2015	127	25,486	3,313	680	10,195	255	2,421	42,477
2016	649	129,806	16,875	3,461	51,922	1,298	12,332	216,343
Total	5,972	2,090,696	144,886	30,119	464,785	9,346	110,874	2,856,678

Sources: Coon et al. 2012c, Unpublished industry data.

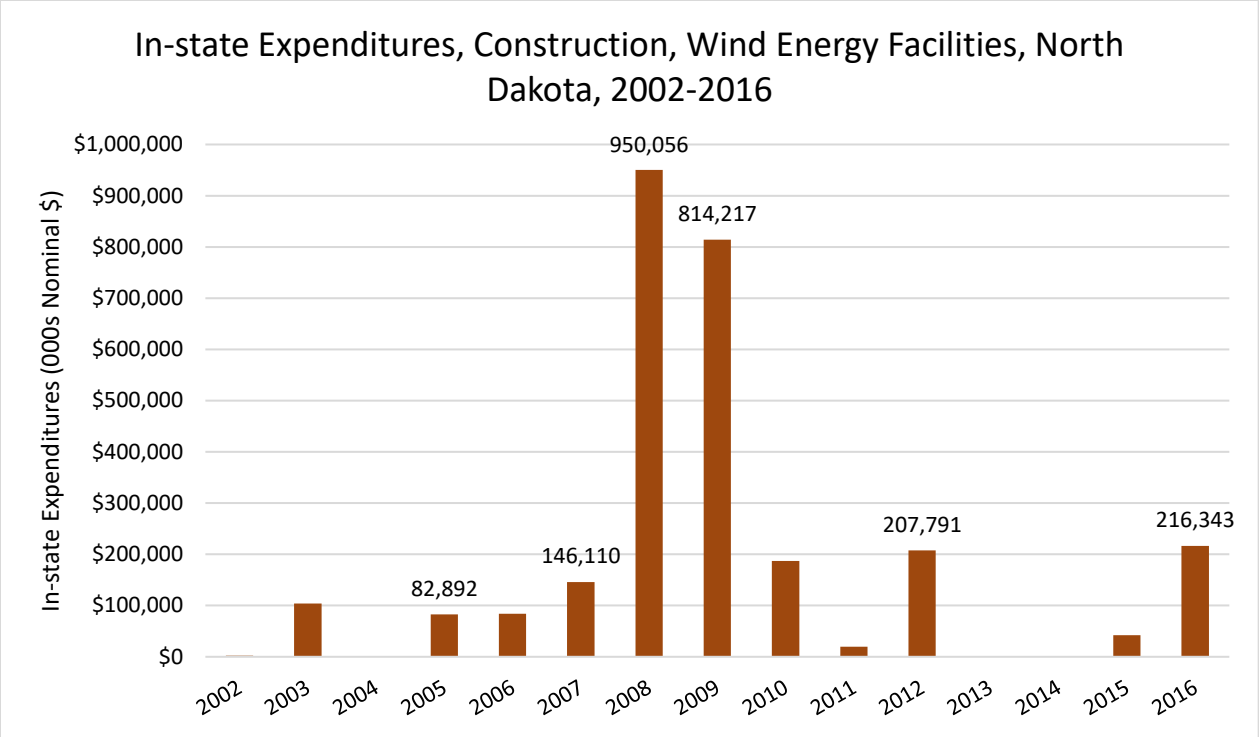


Figure 5. In-state Construction Expenditures, Wind Energy Facilities, North Dakota, 2002 through 2016
Sources: Coon et al. 2012c, Unpublished industry data.

Land Lease Payments

Average land lease payments per turbine were estimated to be $9,394 which is consistent with estimates from individuals familiar with the industry that reported average lease payments would generally range from $8,000 to $10,000 per turbine (Bakken, 2017, Harms, 2017). Total payments to landowners were estimated to be $14.4 million in 2016. Land lease payment are annual payments to landowners that will reoccur for the lifetime of the turbine.

Table 6. Land Lease Payments, Wind Energy Industry, North Dakota, 2016	
Average lease payments per Turbine	$9,394
Permitted turbines	1,528
Total payments	$14,353,724

Wind Energy Manufacturing

In 2016, two firms were engaged in the manufacture of components for the wind energy industry in the state. One firm manufactures blades for commercial wind turbines. The other firm manufactures “small wind” turbines for farm and off-grid applications, although in some cases excess electricity generated by microgeneration turbines can be sold back to the power grid. Small wind turbines are generally less than 100 kilowatts. A third manufacturer that

produced towers for wind turbines closed in 2012. The difference in scale between the two manufacturing firms is quite substantial. In 2015, the large-scale manufacturer employed 567 full-time equivalent employees. By January 2017, employment at the large-scale manufacturer had increased to 1,013 full-time equivalent employees. While North Dakota's small wind turbine manufacture employs only 17 full time equivalents, the production facility is in rural North Dakota where there are generally few manufacturing jobs. Total economic impact (direct plus secondary impacts) from manufacturing activities was estimated to be $119 million in 2016. Impacts are considered annual and reoccurring as long as operations continue at a similar level. In-state economic impacts are far less than total expenditures as a majority of the inputs to production, such as fiberglass and polyester resins, are purchased from out of state entities.

Conclusions

Much of North Dakota's economy is directly associated with the use and development of the region's natural resources—oil and gas, coal, agriculture, and tourism are all examples of natural resource-based industries in North Dakota. Wind, while not often mentioned as a natural resource, is being used to produce electricity in the state. Wind generated electricity represents another segment of the state's energy complex.

The purpose of this report was to estimate the economic contribution of wind-generated electricity to the North Dakota economy. Wind energy affects the North Dakota economy through the manufacture, construction, and operation of wind farms. Information on expenditures made in North Dakota for construction and operation of wind farms was collected from firms that own and operate wind farms in North Dakota.

Operation of wind farms was estimated to inject $67.2 million into North Dakota's economy in 2016. Operations expenditures represent direct or first round effects and include wages and salaries, lease payments to landowners, taxes and other expenses associated with wind farm operations. Operational expenditures were estimated to generate $107.6 million of additional business activity (secondary effects) as those first-round effects worked through the economy. Combining the first round of spending with the subsequent additional rounds of re-spending indicates that total economic contribution (direct plus secondary) from the operation of wind farms was $174.8 million in 2016. The manufacture of components for the wind energy industry supports 1,020 full time equivalent jobs. The industry supports 500 jobs in the state, of which, 136 were directly employed by the industry. Wind-generated electricity make $5.5 million in property tax payments and was estimated to generate $7.7 million in state and local government revenues in 2016.

The wind energy industry makes substantial payments to landowners in North Dakota. While payment to landowners were included in the estimate of the industry economic contribution, other payments to households such as salaries and wages for industry employees were also included. Because the wind energy industry makes substantial payment to landowners, land lease payments were estimated separately for illustrative purposes. Lease payments to landowners was estimated to be $14.4 million in 2016. Average lease payments

were estimated to be $9,300 per turbine. Lease payment are annual payments for the lifetime of the project.

Wind energy has made substantial outlays for the development of wind farms in the state. From 2002 through 2016, expenditures made to entities in the state for construction of wind farms totaled $2.8 billion. The $2.8 billion represents just the portion of construction costs captured in the North Dakota economy, and does not represent total capital expenditures for those wind farms. Many of the inputs to construction are purchased out-of-state. The industry has made a substantial capital investment in the state.

Two firms in the state manufacture components for the wind energy industry. Because there are only two wind energy manufacturing firms in the state, only the total (direct plus secondary) economic contribution from manufacture activities could be reported. Reporting direct or first round effects impacts would reveal confidential proprietary information. Total economic contribution (direct plus secondary) associated with wind energy manufacturing activities was estimated to be $119 million in 2016. Employment associated with the larger of the two firms is substantial. In 2015, the large-scale manufacturer employed 567 full-time equivalent employees. By January 2017, employment had increased to 1,013 full time equivalent employees. While North Dakota's smaller manufacturing firm employs only 17 full time equivalents, the production facility is in rural North Dakota where there are generally few manufacturing jobs. Impacts are considered annual and reoccurring as long as operations continue at a similar level.

Wind energy generation capacity and production has increased substantially in a relatively short period of time. Wind energy generation capacity has grown to nearly 3,000 megawatts since 2005 when the state's wind energy generation capacity was only 65 megawatts. Electricity produced from wind has increased from roughly zero percent in 2003 to 17.5 percent in 2015. Wind generation has provided much of the additional generation capacity and production in the state in recent years. There has also been an increase in generation capacity and production from natural gas, albeit electricity produced from natural gas represents a very small percentage of total production. Electricity produced from coal has remained relatively unchanged.

Wind energy represents another element of the state's energy complex that creates jobs and uses the export of electricity to create additional business activity in the state. Wind generating capacity and output has continued to expand for over a decade in North Dakota. The North Dakota Public Service Commission indicates an additional 400 megawatts of capacity is likely to be constructed over the next two years demonstrating the value that wind energy interests have on locating those activities in the state.

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Appendix A

Instructions for Utility Shareholders of North Dakota Assessment of the Wind Energy Industry

WIND ENERGY GENERATION

Data provided from this survey will be used to estimate the economic contribution of the wind energy industry to the economy of North Dakota. All the information you provide will be kept strictly confidential. The following general instructions are suggested for completing the questionnaire.

1. Please use information for the most recent fiscal year, preferably, FY 2016.
2. Information should be recorded in dollar terms.
3. **ONLY** include expenditures made in North Dakota, or to North Dakota entities on this questionnaire.
4. Do not include expenditures for inputs/services purchased this year for next year's production.
5. When exact information is not available, your best estimate is adequate.
6. Definitions for selected expenditure items and their corresponding Standard Industrial Classification (SIC) code listing are included to help in determining allocation of expenditures.
7. Please complete the survey and email to nancy.hodur@ndsu.edu or mail the questionnaire to the address below.
8. If you have questions, please contact:

Dean Bangsund (701-231-7471)
d.bangsund@ndsu.edu

Dr. Nancy Hodur (701-231-7357)
nancy.hodur@ndsu.edu

Randy Coon (701-231-1018)
randy.coon@ndsu.edu

Mailing Address
Dr. Nancy Hodur
Richard H. Barry Hall
Dept # 7610, PO Box 6050
North Dakota State University
Fargo, ND 58108-6050

DEFINITIONS FOR EXPENDITURE CATEGORIES

The following definitions are derived from Standard Industrial Classification Manual (SIC codes) and have been provided to assist in allocating expenses into common categories. If needed, please refer to the following web site for additional examples of the expenses included in each category: http://www.osha.gov/pls/imis/sic_manual.html Each category has several Major Group numbers, which contain additional detail on the type of activities in each category.

Construction: Includes expenses for construction projects, such as construction (including new work, additions, alterations, remodeling, and repairs) of residential, industrial, public, office, warehouse, and other buildings and structures. (Major Groups 15, 16, and 17)

Transportation: Includes expenses for railroad, motor freight, water transportation, air transportation, and other transportation to include packing and crating services, and rental of transportation equipment. (Major Groups 40, 41, 42, 43, 44, 45, 46, and 47)

Communications: Includes expenditures for telephone, telegraph, radio, television, satellite services, Internet transactions, and other communication services. (Major Group 48)

Public Utilities: Includes expenses for natural gas, electricity, water supply, and sanitary (sewer & garbage) services. (Major Group 49)

Manufacturing: Includes expenses for on-site fabrication of processing components, contract manufacturing for items used in processing operations, and the rebuilding of machinery and equipment at the plant. (Major Groups 20 through 39, with emphasis on 35-39)

Wholesale Trade: Expenses paid to establishments primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, or professional users; or to other wholesalers, or acting as agents in buying merchandise for or selling merchandise to such persons or companies. (Major Groups 50 and 51)

Retail Trade: Includes expenses for building materials, hardware, food, general merchandise, office supplies, automobile fuel, computers, eating and drinking establishments, work uniforms, and most other business and office-related supplies. (Major Groups 52, 53, 54, 55, 56, 57, 58, and 59)

Finance, Insurance, and Real Estate: Includes expenses for loan service, interest on loans, investment counseling, insurance, real estate transactions, brokerage fees, and any other financial service expenditures. (Major Groups 60, 61, 62, 63, 64, 65, 66, and 67)

Business and Personal Services: Examples of business and personal services include expenses for advertising, collection services, photocopying/duplication/printing services, equipment rental, computer services, computer software, security services, tax preparation, automotive/equipment/miscellaneous repairs, entertainment, janitorial services, and overnight lodging. (Major Groups 70, 72, 73, 75, 76, 78, 79, and 87)

Professional and Social Services: Includes expenses for health/pharmaceutical, medical, legal, educational, research and development, child care, vocational training, and other professional services. (Major Groups 80, 81, 82, 83, 84, 86, 88, and 89)

WIND ENERGY GENERATION

EXPENDITURES QUESTIONNAIRE

Company: _____ Location:

Contact Person: _____ Phone: _____

Email:

I. **Expenditures made in FY 2016**

Expenditure Categories	**Estimated Annual Expenditure in North Dakota**
	----------$----------
Wages and salaries	
Benefits	
Construction	
Site and equipment maintenance	
Transportation	
Communications	
Public utilities: Electricity	
Natural Gas	
Water	
Garbage/Waste Disposal	
Miscellaneous manufacturing	
Wholesale trade	
Retail trade	
Finance	
Insurance	
Real estate	
Business and personal services	
Professional and social services	
Other Expenses	

Items for Which Expenditures were Made	Estimated Annual Expenditure In North Dakota
	----------$----------
Government (taxes paid in ND)	
Property taxes	
Sales and use taxes	
Unemployment	
Other taxes (please specify)	

II. Total annual revenue: $ _____

III. Number of employees in full-time equivalents: _____ FTEs

IV. For each wind farm operated, in what year did the wind farm construction begin?
_____

(If your firm operates more than one wind farm, please see Attachment A.)

V. What was the construction cost for the wind farm(s)? $ _____
(North Dakota expenditures only.)

VI. In what year did the wind farm(s) become operational? _____

VII. Has the wind farm expanded since it became operational? YES NO

If yes, please provide some additional information regarding the expansion(s).

In what year(s) did expansion occur? _____

How many wind turbines were added? _____

How much generating capacity was added? _____MW

How many FTE employees were added? _____

What were the construction costs for the expansion? $_____

Attachment A.

For those entities that operate multiple wind energy sites in North Dakota, please provide the following information:

Wind Energy Sites in North Dakota (Name)	Location (County)	Construction Start (Year)	Commercial Operations (Date)

Comments: _____

_____

_____

_____

Thank you very much for completing this questionnaire. This assessment would not be possible without your input.

Instructions for Utility Shareholders of North Dakota Assessment of the Wind Energy Industry

WIND ENERGY MANUFACTURING

Data provided from this survey will be used to estimate the contribution the renewable industry makes to the economy of North Dakota. All the information you provide will be kept strictly confidential. The following general instructions are suggested for completing the questionnaire.

1. Please use information for the most recent fiscal year, preferably FY 2016.

2. Information should be recorded in dollar terms.

3. **ONLY** include expenditures made in North Dakota, or to North Dakota entities on this questionnaire.

4. Do not include expenditures for inputs/services purchased this year for next year's production.

5. When exact information is not available, your best estimate is adequate.

6. Definitions for selected expenditure items and their corresponding Standard Industrial Classification (SIC) code listing are included to help in determining allocation of expenditures.

7. Please complete the survey and email to nancy.hodur@ndsu.edu or mail the questionnaire to the address below.

8. If you have questions, please contact:

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DEFINITIONS FOR EXPENDITURE CATEGORIES

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Construction: Includes expenses for construction projects, such as construction (including new work, additions, alterations, remodeling, and repairs) of residential, industrial, public, office, warehouse, and other buildings and structures. (Major Groups 15, 16, and 17)

Transportation: Includes expenses for railroad, motor freight, water transportation, air transportation, and other transportation to include packing and crating services, and rental of transportation equipment. (Major Groups 40, 41, 42, 43, 44, 45, 46, and 47)

Communications: Includes expenditures for telephone, telegraph, radio, television, satellite services, Internet transactions, and other communication services. (Major Group 48)

Public Utilities: Includes expenses for natural gas, electricity, water supply, and sanitary (sewer & garbage) services. (Major Group 49)

Manufacturing: Includes expenses for on-site fabrication of processing components, contract manufacturing for items used in processing operations, and the rebuilding of machinery and equipment at the plant. (Major Groups 20 through 39, with emphasis on 35-39)

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Retail Trade: Includes expenses for building materials, hardware, food, general merchandise, office supplies, automobile fuel, computers, eating and drinking establishments, work uniforms, and most other business and office-related supplies. (Major Groups 52, 53, 54, 55, 56, 57, 58, and 59)

Finance, Insurance, and Real Estate: Includes expenses for loan service, interest on loans, investment counseling, insurance, real estate transactions, brokerage fees, and any other financial service expenditures. (Major Groups 60, 61, 62, 63, 64, 65, 66, and 67)

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Professional and Social Services: Includes expenses for health/pharmaceutical, medical, legal, educational, research and development, child care, vocational training, and other professional services. (Major Groups 80, 81, 82, 83, 84, 86, 88, and 89)

WIND ENERGY EQUIPMENT MANUFACTURING

EXPENDITURES QUESTIONNAIRE

Company: _____ Location:

Contact Person: _____ Phone: _____

Email:

I. E**xpenditures made in FY 2015**

Expenditure Categories	**Estimated Annual Expenditure in North Dakota**
	----------$----------
Wages and salaries	
Benefits	
Construction	
Plant maintenance and overhaul	
Transportation	
Communications	
Public utilities: Electricity	
Natural Gas	
Water	
Garbage/Waste Disposal	
Miscellaneous manufacturing	
Wholesale trade	
Retail trade	
Finance	
Insurance	
Real estate	
Business and personal services	
Professional and social services	
Other Expenses	

Items for Which Expenditures were Made	Estimated Annual Expenditure in North Dakota
	----------$----------
Government (taxes paid in ND)	
Property taxes	
Sales and use taxes	
Unemployment	
Other taxes (please specify)	

II. Total annual revenue: $

III. Number of employees in full-time equivalents:

IV. What year did manufacturing renewable energy equipment begin? _____

V. Has manufacturing capacity been increased since operations began?

(Yes/No) = _____

If yes, please provide some additional information on your expansion(s)

What year(s) did the increase occur? _____

How much was capacity increased? _____%

How many FTE employees were added? _____

Were shifts added, plant expanded, or both? _____

What were the construction costs? $_____

Comments: _____

_____

_____

Thank you very much for completing this questionnaire. This assessment would not be possible without your input.

Appendix B

Appendix Table B-1. Electricity Generation Capacity, by Energy Source, North Dakota, 2000-2015

	2000	2001	2002	2003	2004	2005
Source:	----------megawatts----------					
Coal	4,127	4,128	4,105	4,129	4,126	4,127
Hydroelectric	497	497	497	371	485	432
Natural gas	10	10	10	10	10	10
Other	0	0	0	0	0	0
Other biomass	9	10	10	10	10	10
Other gas	7	8	8	8	8	8
Petroleum	66	64	69	70	71	75
Wind	0	0	0	64	64	96
Other	82	82	87	88	89	93
Total	4,716	4,717	4,699	4,662	4,774	4,758
	2006	**2007**	**2008**	**2009**	**2010**	**2011**
Source:						
Coal	4,127	4,119	4,119	4,148	4,153	4,147
Hydroelectric	443	486	486	508	508	508
Natural gas	10	10	10	10	10	10
Other	0	0	0	5	5	5
Other biomass	10	10	10	10	10	10
Other gas	8	8	8	8	8	8
Petroleum	77	75	75	71	71	72
Wind	164	383	776	1,202	1,423	1,423
Other	95	93	93	94	94	95
Total	4,839	5,091	5,484	5,962	6,188	6,183
	2012	**2013**	**2014**	**2015**		
Source	----------megawatts----------					
Coal	4,141	4,128	4,185	4,214		
Hydroelectric	508	510	510	510		
Natural gas	0	80	248	328		
Other	5	5	5	5		
Other biomass	10	10	10	10		
Other gas	8	8	8	8		
Petroleum	59	65	65	65		
Wind	1,759	1,759	1,759	2,222		
Other	82	88	88	88		
Total	6,490	6,565	6,790	7,362		

Other biomass includes agricultural byproducts, landfill gas, biogenic municipal solid waste, other biomass (solid, liquid and gas) and sludge waste. Other gases includes blast furnace gas, and other manufactured and waste gases derived from fossil fuels. Other includes non-biogenic municipal solid waste, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, waste heat and miscellaneous technologies.
Source: U.S. Energy Information Administration, Form EIA-860, "Annual Electric Generator Report."

Appendix Table B-2. Electricity Produced, by Energy Source, North Dakota, 2000-2015

	2000	2001	2002	2003	2004	2005
Source:	----------kilowatt hours----------					
Coal	29,069,203	28,877,175	29,611,524	29,427,311	28,064,224	30,258,759
Hydro-electric	2,122,561	1,332,076	1,592,616	1,723,904	1,545,864	1,341,824
Wind	0	0	0	58,878	214,523	220,345
Natural gas	2,087	2,536	8,042	9,446	9,044	8,012
Other[1]	117,345	55,551	94,130	102,590	102,451	103,676
Total	31,311,196	30,267,338	31,306,312	31,322,129	29,936,106	31,932,616
	2006	**2007**	**2008**	**2009**	**2010**	**2011**
Source:	----------kilowatt hours----------					
Coal	28,878,991	29,163,553	29,672,230	29,606,966	28,462,040	27,108,926
Hydro-electric	1,521,034	1,305,393	1,252,790	1,475,251	2,042,118	2,580,042
Wind	369,485	620,772	1,693,458	2,997,530	4,095,641	5,235,590
Natural gas	7,065	16,574	-51	16,606	16,353	19,902
Other[1]	104,562	117,813	116,152	100,114	123,390	135,440
Total	30,881,137	31,224,105	32,734,579	34,196,467	34,739,542	35,079,900
	2012	**2013**	**2014**	**2015**		
Source:	----------kilowatt hours----------					
Coal	28,214,364	27,477,822	27,394,068	27,734,413		
Hydro-electric	2,477,230	1,852,421	2,531,360	2,094,168		
Wind	5,274,509	5,518,958	6,202,412	6,505,704		
Natural gas	21,697	54,195	234,315	711,044		
Other[1]	137,358	118,277	100,352	111,284		
Total	35,021,673		36,462,507	37,156,613		

Other[1]: Other: Other biomass (agricultural byproducts, landfill gas, biogenic municipal solid waste, and sludge waste), Other gases blast furnace gas, and other manufactured and waste gases derived from fossil fuels), Other non-biogenic municipal solid waste, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels, waste heat and miscellaneous technologies), petroleum.
Note: Totals may not equal sum of components because of independent rounding.
Source: U.S. Energy Information Administration, Form EIA-923, "Power Plant Operations Report" and predecessor forms.