Jobs and Economic Development from New Transmission and Generation in Wyoming

Eric Lantz and Suzanne Tegen

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-6A20-50577
March 2011

Contract No. DE-AC36-08GO28308

NATIONAL RENEWABLE ENERGY LABORATORY

Jobs and Economic Development from New Transmission and Generation in Wyoming

Eric Lantz and Suzanne Tegen

Prepared under Task No. WTQ1.1000

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401
303-275-3000 • www.nrel.gov

Technical Report
NREL/TP-6A20-50577
March 2011

Contract No. DE-AC36-08GO28308

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information

P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: mailto:reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/help/ordermethods.aspx

Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721

Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

Acknowledgments

This report was commissioned by the Wyoming Infrastructure Authority (WIA) and jointly funded by the WIA and the U.S. Department of Energy (DOE) State Technical Assistance Program. A special thanks to Loyd Drain, executive director of the WIA, for supporting this work throughout. In addition, the authors would like to thank each of the local, state, and industry representatives who were interviewed for this study or otherwise contributed to the development of the data that were used in this analysis. Thanks also to our colleagues who provided review and comments on earlier drafts of this report including Marshall Goldberg (MRG & Associates), David Taylor (University of Wyoming), Delphine Hou (the Brattle Group), David Kline (NREL), Gail Mosey (NREL), and Lynn Billman (NREL) as well as our NREL technical editor, Mary Lukkonen. Of course any remaining errors or omissions are the sole responsibility of the authors.

Executive Summary

Wyoming is a significant energy exporter, producing nearly 40% of the nation's coal and 10% of the nation's natural gas (EIA 2010a). However, opportunities to add new energy exports in the form of power generation are limited by insufficient transmission capacity. This report is intended to inform policymakers, local government officials, and Wyoming residents about the jobs and economic development activity that could occur should new investments in transmission, wind generation, and natural gas generation in Wyoming move forward. The analysis and results presented here are not a market projection or a forecast. Instead, the report uses a representative deployment scenario and economic modeling tools to estimate the jobs and economic activity likely associated with these projects if or when they are built.

New infrastructure projects considered in this analysis include four high voltage (HV) transmission lines designed for export of electricity out of Wyoming and a network of transmission lines that collect new power generation before export outside the state. The scenario considered here also includes 9 GW of new wind power and 1.8 GW of new natural gas power. This infrastructure is estimated to result in more than $25 billion invested during construction and approximately $380 million invested per year of operations (once all new capacity is in service). The Wyoming share of these investments is estimated at approximately 19%–26% of the total construction investment and 31%–34% of the annual operations period investment. Given today's economic structure, the investments flowing through the Wyoming economy are estimated to support:

- An average (as opposed to peak) of 4,000–5,900 Wyoming jobs per year for 10 years from construction-related activities; 8,000–14,000 Wyoming jobs annually during peak construction activity
- Wages and benefits to Wyoming workers averaging $200 million–$330 million per year during the 10-year construction period
- 2,300–2,600 Wyoming jobs during the operational period of the infrastructure lifecycle (at least 20 years, based on typical financing for new wind power projects)
- Wages and benefits ranging from $100 million–$120 million per year during operations
- Economic activity (output) of $1.2 billion in 2016 and $1.4 billion in 2019 (during peak construction) and $380 million per year during operations-only years
- Total Wyoming economic output on the order of $12 billion–$15 billion (construction plus 20 years of operations); this represents approximately 30% of the total potential economic activity associated with these projects.

Whether this economic potential is ultimately realized or not will depend on a variety of factors. Demand for Wyoming wind energy is critical, but the development of the new transmission infrastructure to export the Wyoming wind and natural gas generation across the West is also important. In addition, should the deployment scenario presented here become a reality, an array of factors will influence whether Wyoming will ultimately capture this level of economic activity. Parallel deployment of wind, transmission, and natural gas generation could limit Wyoming's ability to contribute local goods and services to these projects at the level they have

been able to for individual projects in the past and reduce the Wyoming specific economic activity estimated here. Alternatively, the development of a Wyoming labor force that can support this type of infrastructure development, along with a modest amount of Wyoming manufacturing capacity to support these types of projects, could greatly increase the economic activity occurring in Wyoming from these projects.

Table of Contents

List of Figures

List of Tables

Introduction

Wyoming produces nearly 40% of the nation's coal and approximately 10% of the nation's natural gas (EIA 2010a). At the end of 2010 Wyoming was ranked 13th in installed wind power capacity (AWEA 2011), and in 2009 the state generated the equivalent of 6.7% of its electricity consumption from wind energy (Wiser and Bolinger 2010). Wyoming's fossil resources remain abundant with coal reserves second only to Montana and dry natural gas reserves second only to Texas (EIA 2010a). The state also has excellent developable wind resources: over 500 GW of potential wind power with an estimated capacity factor of 30% or greater and over 260 GW of wind with an estimated capacity factor of 40% or greater (WPA 2010).[1] From an energy resource standpoint, Wyoming is well positioned to continue supplying large amounts of energy to other regions of the country.

In addition, many states in the West and around the country have instituted renewable portfolio standards (RPS) requiring utilities to obtain a specific percentage of their electricity from renewable energy resources. Because wind energy is among the lowest cost renewable energy resources, demand for wind energy has increased as states have passed increasingly aggressive RPS goals. Moreover, the excellent wind resources of Wyoming suggest that exporting wind energy from Wyoming to load centers in the Southwest and West may be a viable solution for state RPS goals.

Historically, decades of infrastructure development—including electricity transmission, rail lines, pipelines, and power generation—have provided the ability to distribute Wyoming's abundant energy resources to other parts of the country and provide economic development and revenue to Wyoming residents and communities. However, Wyoming's existing infrastructure is nearing capacity, and without new infrastructure, further development and export of Wyoming's energy resources could be compromised (Black and Veatch 2009; State of Wyoming 2004; WGA 2006). While new infrastructure investments are important for all types of Wyoming energy resources, they are especially critical for wind energy. Unlike coal or natural gas, which can be stored, exported as a raw material over rail lines and pipelines, or moved as electrons over long-distance transmission lines, the only option for wind energy today is to be transported over transmission

Basic Wyoming Economic & Demographic Statistics

Wyoming's population is estimated at approximately 544,000 (U.S. Census Bureau 2010). As of June 2010, the Wyoming labor force was estimated to be 292,000 and unemployment was estimated at 6.8% or approximately 20,000 workers. Wyoming's construction workforce was estimated at approximately 20,000 workers in June of 2010—down 16% from June 2009. Approximately 30% of the state's total labor force and 20% of the state's construction labor force are located in the metropolitan areas of Casper and Cheyenne (BLS 2011).

Wyoming's 2009 gross domestic product (GDP) was estimated at approximately $32 billion and while growth overall between 2008 and 2009 was up 5.4%, construction sector GDP grew by 0.6% (BEA 2010).

[1] These data apply standard industry exclusions for slope, protected land, wetlands, and other areas unlikely to be developed; they do not include other broad-based state specific exclusions (e.g., sage grouse core areas). Typical average capacity factors in the U.S. fleet today are 30%–35% (Wiser and Bolinger 2010). Capacity estimates are based on an 80 m hub height.

lines. And those transmission lines must extend all the way to the high value wind resource areas, which are typically in remote areas away from load centers (WGA 2009). New transmission lines could also support continued or expanded exports of Wyoming natural gas generation or advanced coal technologies.

Despite the need for new infrastructure, these projects are sometimes controversial. New transmission, rail, and pipelines all require long-distance right-of-ways or easements and affect many landowners across the state. In addition, opinions vary regarding the need or desire for Wyoming to continue to develop both conventional and renewable energy resources that serve out-of-state demand. This report is intended to inform policymakers, local government officials, and Wyoming residents about the jobs and economic development activity that could occur should investments in new transmission, wind generation, and natural gas generation in Wyoming move forward.

Methodology

Background

Economic development activity is typically estimated using input-output (I/O) models. I/O models apply historical relationships between demand (i.e., specific expenditures within a given sector) and the resulting economic activity to estimate how new expenditures will affect economic development metrics including jobs, earnings (wages and employer paid benefits), and output, a general measure of economic activity.[2] Many I/O models are static—they measure inter-industry relationships for a given time period—and linear—they assume that any change in demand, regardless of magnitude, has the same proportional result.[3] However, the inter-industry relationships utilized in I/O modeling tend to change gradually over a long period of time, and I/O modeling is a widely used and robust methodology for measuring economic development activity.

This analysis relies on the suite of NREL I/O models known as the Jobs and Economic Development Impacts (JEDI) models: JEDI Wind, JEDI Natural Gas, and JEDI Transmission models were used in this analysis.[4] Economic activity in I/O models is typically assessed in three categories. NREL's JEDI models classify the first category of results—on-site labor and professional services results—as dollars spent on labor from companies engaged in development and on-site construction and operation of power generation and transmission. These results include labor only—no materials.[5] Companies or businesses that fall into this category of results include project developers, environmental and permitting consultants, road builders, concrete-pouring companies, construction companies, tower erection crews, crane operators, and operations and maintenance (O&M) personnel.

The second category of JEDI results—local revenues, equipment and supply chain results—occurs in supporting industries. These results are driven by the increase in demand for goods and services from direct on-site project spending. Businesses and companies included in the second tier of economic activity include construction material and component suppliers, analysts and attorneys who assess project feasibility and negotiate contract agreements, banks financing the projects, all equipment manufacturers (e.g., blade manufacturers), and manufacturers of replacement and repair parts.

Induced results are driven by reinvestment and spending of earnings by direct and indirect beneficiaries. Induced results are often associated with increased business at local restaurants,

---

[2] Output is defined more broadly than other metrics of economic activity including value added or GDP; output is the sum value of all goods and services at all stages of production (i.e., as a raw material and as a finished product). Value added refers only to the market value of the final product.

[3] Some I/O models include features that account for magnitude of demand and economies of scale. Some also include a full suite of dynamic features, which account for pricing variability and labor cost variability among other factors.

[4] NREL's JEDI models are publicly available spreadsheet tools that apply state-specific IMPLAN year 2008 multipliers. NREL's JEDI Transmission model has recently been developed; as the current draft model contains some proprietary information specific to Wyoming and Rocky Mountain West, it has not yet been released to the public. The JEDI analysis tools were developed by NREL in conjunction with MRG & Associates. For more information on the JEDI tools, see http://www.nrel.gov/analysis/jedi/.

[5] This category is narrower than typical direct economic impacts as it focuses exclusively on on-site labor expenditures.

hotels, and retail establishments but also include child care providers and any other entity affected by increased economic activity and spending occurring at the first two tiers.

JEDI model results are displayed in two different time periods: construction and operations. Construction-period results are inherently short term. Jobs are defined as full-time equivalents (FTE), or 2,080-hour units of labor (one construction period job equates to one full-time job for 1 year).[6] Equipment manufacturing jobs, such as tower manufacturing, are included in construction-period jobs as it is ultimately new construction that drives equipment manufacturing. All employment related to the construction of the project is reported in FTE. Operations-period results are long term, for the life of the project, and are reported as annual jobs and economic activity, which continue to accrue throughout the operating life of the facility.

JEDI results are not intended to be a precise forecast; they are an estimate of potential activity resulting from a specific set of projects and scenarios. In addition, JEDI results presuppose that projects are financially viable and can be justified independent of their economic development value. Results generated by the JEDI models are gross (not net) results. They do not consider potential increases or decreases in electricity rates resulting from investments in new infrastructure, nor do they consider whether the respective projects displace economic activity elsewhere.[7] JEDI model categories and default information are based on real-world projects. NREL analysts perform interviews with project owners, developers, engineering and design firms, construction firms, and others to align model inputs and the corresponding results with reality, as closely as possible. Of course, individual projects will have varying results depending on a wide variety of factors including project location and topography, available local labor, available local goods and services, and commodity prices at the time of construction. All results in this report are in 2010 dollars.

Analysis-specific Methodology

This analysis quantifies the Wyoming-specific jobs and economic development activity associated with new wind generation, natural gas generation, and new high voltage (HV) transmission lines constructed in Wyoming. In order to quantify only economic activity that is specific to Wyoming, total project construction and operations expenditures are adjusted based on that portion of the expenditure that is likely to be spent in Wyoming. The Wyoming share of any given expenditure can be thought of or labeled as the Wyoming local share, the percentage of goods and services procured in Wyoming, or the Wyoming purchase coefficient. The analysis conducted here is based on a hypothetical deployment scenario and assumes capital and operating costs in line with those observed in the industry today. While there is some debate regarding the trajectory of future costs,[8] this analysis relies on constant cost inputs throughout the development period; detailed cost projections into the future were beyond the scope of this study.

---

[6] Although the JEDI model is based on IMPLAN, which does not explicitly distinguish full- and part-time jobs, JEDI results are converted to FTE using supplementary conversion data provided by IMPLAN.

[7] In theory, exports of Wyoming power to other parts of the West may offset potential economic activity in the localities that, instead of developing their own resources, will purchase Wyoming energy resources.

[8] Various industry representatives interviewed for this report argued that costs could increase or decrease into the future. In the wind space, for example, falling turbine prices observed today suggest costs may decline within the development period considered here; at the same time, increasing commodity prices (as has been observed in the recent past) or a shift to second tier project sites could put upward pressure on costs.

There are some expenditures associated with these projects that are only indirectly captured by this analysis. For example, lodging and food expenditures from out-of-state workers along with sales and hotel tax payments from purchases by out-of-state workers are only captured by inclusion in the miscellaneous expenditure line item.[9] In addition, there are intangible effects from these projects that are also not captured, including improvements to transmission and grid reliability, reductions in incremental new emissions and water use from power generation, and electricity price stability resulting from the reduced fuel price risk of wind power.

JEDI model inputs, including project costs and Wyoming local share values, were determined by research, interviews, and conversations with various Wyoming wind, transmission, and natural gas industry stakeholders as well as companies that conduct energy sector and other business (e.g., legal services) in Wyoming. Detailed interviews with leading engineering, design, and construction firms working in the Rocky Mountain region were also utilized. Recent cost estimates were derived from review of various industry and publicly available sources (e.g., EIA 2010b; WECC 2010; Wiser and Bolinger 2010). Costs estimates were subsequently reviewed and adjusted based on input from power generation and transmission developers currently working in Wyoming or the Rocky Mountain region. Wyoming local share values were also generated through interviews with developers operating in Wyoming.

Model inputs are generally grounded in the industry as it stands today. To the extent that significant new development activity attracts new Wyoming businesses and generates new capabilities within existing Wyoming businesses, the results presented here are likely conservative. At the same time, primary data sources often estimate local shares (model inputs) based upon their past experience and current projects. To the extent that significant infrastructure development in Wyoming reduces the availability of Wyoming labor for the whole group of projects below what it is today for individual projects (used as an input in the modeling), the results presented here may be somewhat optimistic. Nevertheless, by speaking with developers, construction companies, county officials, and others, this study relies on the current best available Wyoming-specific information based on real projects. When individuals could not be reached for interviews, researchers performed literature searches including company website data, documentation from the Wyoming Department of Revenue, the Wyoming Department of Industrial Siting and Permitting, the Wyoming Office of State Lands & Investments, and the University of Wyoming Cooperative Extension Service, among others. In some cases, where Wyoming-specific data were not available, the authors relied on representative U.S. data.

Generation and transmission capacity deployments are constant throughout the analysis and referred to as the *deployment scenario*. Primary data collected from the sources noted above were utilized in modeling the jobs and economic development activity resulting from the deployment scenario. The base case economic development results represent today's best available information on project costs and the best available estimates of the Wyoming local share or purchase coefficients. However, as a result of uncertainty in various modeling parameters and given future unknowns, two sensitivities around the base case were also modeled. The results from these two additional sensitivities are labeled the *high case* and *low*

[9] These expenditures are captured indirectly via the JEDI "Miscellaneous" expenditure line item. This line item represents approximately 3%–4% of total wind construction project capital expenditures and includes out-of-state worker per diem expenditures and associated taxes, other labor-related expenditures, and project contingency funds. This analysis assumes 50% of these wind-related expenditures occur in Wyoming.

case. The high case and low case analyses conducted here did not consider changes in the underlying infrastructure deployment or changes in estimated capital and operations-related costs. Wyoming local share values were the only variables adjusted in the high case and low case. Additional details on the parameters and data inputs used in the base case, high case, and low case are included in the description of the analysis and results by infrastructure type.

The Infrastructure Deployment Scenario

The economic development modeling that underlies the results presented here is premised on deployment of new wind generation, natural gas generation, and HV transmission over the 10-year period between 2012 and 2021. The hypothetical deployment scenario applied in this analysis was developed by the Wyoming Infrastructure Authority (WIA) in conjunction with industry stakeholders. Although new Wyoming load growth could result in additional power generation and transmission capacity coming online in the state, this deployment scenario is intended to reflect new generation and transmission developed to serve out-of-state loads. The scenario is grounded in the array of proposed HV transmission and wind generation projects and assumes a nominal amount of natural gas generation is added to assist in utilizing new transmission capacity. While this scenario is intended to represent real market potential, it is not intended to be an explicit market forecast or projection. It was beyond the scope of this analysis to conduct technical analyses of existing transmission capacity and reliability and to assess the natural gas firming and balancing needs of adding new wind generation. Whether this specific scenario is ultimately brought to fruition will depend on an array of market, policy, and other variables.

The deployment scenario applied in this analysis assumes development of two interstate 500 kV high voltage direct current (HVDC) transmission lines, each with the capacity to move 3,000 MW of power, and two interstate 500 kV high voltage alternating current (HVAC) transmission lines, each with the capacity to move 1,500 MW of power. This new transmission infrastructure is expected to be capable of exporting up to 9,000 MW of new Wyoming power generation. The scenario applied in this analysis assumes 9,000 MW of new wind generation and 1,800 MW of new natural gas generation will be built. Natural gas generation is assumed to be used during periods of low wind speeds to maximize the value of the transmission capacity.[10] Depending on wind energy capacity factors and system-wide operations, some capacity on this set of transmission lines could potentially be used to export additional Wyoming electricity generation. However, detailed system and operational analysis was not within the scope of this study, and hence actual utilization of the new transmission lines by the wind and natural gas capacity included in this specific scenario was not evaluated. A transmission collector system, a network of lower capacity transmission lines that bring electricity from multiple projects to a centralized point before it is exported out of state, consisting of a network of 230 kV HVAC transmission lines and associated substations is also included. Figure 1 illustrates the deployment of this infrastructure over time. Table 1 summarizes the assumed total expenditures associated with each of these infrastructure development types.

[10] There is no explicit assumption that the natural gas generation will serve in a direct balancing manner for variable output wind energy. It is expected to be dispatched and exported as transmission capacity is available.

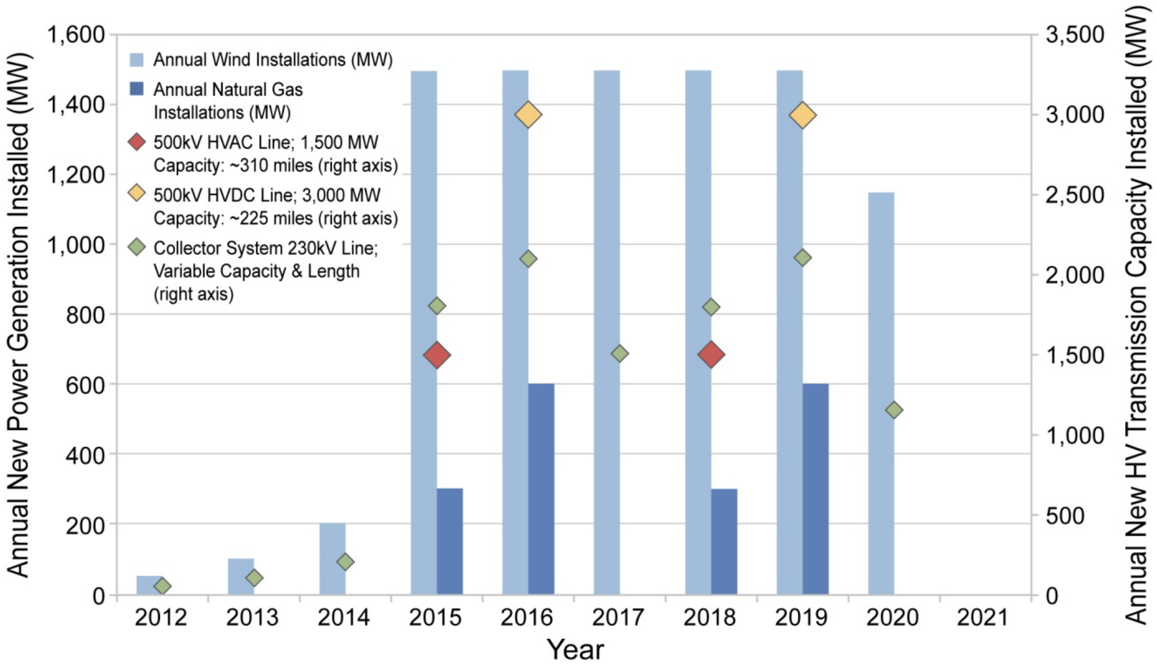

Figure 1. Deployment scenario for new wind generation, natural gas generation, and transmission capacity in Wyoming

Table 1. Summary of Infrastructure and Associated Expenditures for Equipment Installed in Wyoming

Infrastructure Type	Units Installed	Installed Cost	Direct Annual Operating Expenditures
Wind Generation	9,000 MW	$18 billion	$225 million
Natural Gas Generation	1,800 MW	$2.3 billion	$42 million**
500 kV HVDC Transmission Line	2	$2.2 billion	$60 million
500 kV HVAC Transmission Line	2	$1.3 billion	$35 million
230 kV HVAC Collector System	multiple*	$660 million	$17 million

*Various lines and substations associated with a basic collector system.
** Excludes fuel costs.

Total Jobs and Economic Development Activity

The base case Wyoming jobs and economic development activity during the 10-year construction period is summarized in Table 2. The base case estimates that construction of the new infrastructure will support on average 4,700 Wyoming full-time jobs each year for a period of 10 years. Average on-site construction-sector employment for the 10-year construction period is estimated to be more than 2,100 jobs each year. Compared with today's Wyoming construction sector, which employs about 22,000 full- and part-time workers (BLS 2011), on-site construction employment averages roughly 10% of the state's construction labor force. [11,12] Average annual Wyoming earnings generated from constructing these infrastructure projects during this time period are estimated to be on the order of $260 million.[13] Wyoming economic output resulting from the construction period would average $510 million per year over the full 10-year deployment period.

Table 2. Construction Period Employment and Economic Activity

(Average Annual Results for 10 Years)

	Jobs	Wages ($Million)	Output ($Million)
Project Development and On-site Labor	2,100	$140	$160
Equipment and Supply Chain Activity	2,000	$93	$280
Induced Activity	620	$22	$76
Total	**4,700**	**$ 260**	**$510**

Note: Totals may not add due to rounding.

Annual base case operations period results are summarized in Table 3. When all construction activities are completed, approximately 2,500 Wyoming long-term jobs are estimated to be supported by operations expenditures from these projects. These 2,500 jobs are estimated to receive more than $110 million in wages annually, and total operations-related output is estimated to be approximately $380 million per year for the life of the combined assets.

[11] BLS (2011) data include full- and part-time jobs and all construction-related labor. Only a subset of that labor force (i.e., heavy commercial, civil, and craft construction labor) would likely be employed by these types of large infrastructure projects. Precise comparison between the results of this study and Wyoming's existing labor force is difficult. This comparison is included only to provide context regarding the general ability of Wyoming to provide labor for these projects.

[12] Based on the primary data provided to NREL for this analysis, peak construction periods could utilize 20%–30% of the states' current construction labor force. In actuality, this level of demand may require Wyoming-based contractors to take on and train additional staff effectively broadening the Wyoming construction labor force. It could also require additional out-of-state labor, diminishing the Wyoming share of peak period jobs and economic development activity.

[13] Earnings include wages as well as employer-paid benefits (e.g., health insurance, and retirement contributions)

Table 3. Operations Period Employment and Economic Activity Upon Full Deployment (Annual for at least 20 Years)

	Jobs	Wages ($Million)	Output ($Million)
On-site Labor	680	$40	$40
Local Revenue and Supply Chain Activity	1,300	$50	$270
Induced Activity	530	$20	$60
Total	**2,500**	**$110**	**$380**

Note: Totals may not add due to rounding.

Total lifetime economic activity can be approximated by combining the construction period results and assuming 20 years of operations, the typical financing period for new wind generation.[14] Given construction-related expenditures and 20 years of operations, total economic activity is estimated to range from $12 billion to $15 billion (based on low and high cases).

Employment results over time are shown in Figure 2. Economic output by year is shown in Figure 3. There are two peak periods of economic activity during the 10-year construction period associated with the construction of the HVDC transmission lines followed by an extended period of reduced activity after all construction activities have ceased. The modest employment result during the years 2012–2014 is due to the extremely limited existing transmission capacity in Wyoming in 2011.[15] Significant deployment of new generation is limited until the new transmission lines begin to come into service in 2015. Peak Wyoming employment occurs in 2015–2016 and again in 2018–2019 where approximately 10,000 jobs and 12,000 jobs are supported by these projects, respectively. During these time periods, economic output peaks at roughly $1.2 billion and $1.4 billion per year, respectively (Figure 3). The two peak periods are the result of significant short-term investment that occurs as new transmission capacity is constructed and then rapidly filled by new generation. Operations-related employment increases gradually throughout the construction period as new transmission and generation come online but levels off once all projects in the deployment scenario are placed in service. Construction-related economic activity ultimately diminishes to zero once the full portfolio of infrastructure considered in this analysis is in service. Should additional transmission capacity be available, additional construction and related activity could result from continued build-out of infrastructure.

[14] New natural gas power generation and transmission assets are expected to have lifetimes on the order of 30–40 years or greater.

[15] It is generally assumed that there is no available transmission capacity for incremental new generation in Wyoming today. However, it is expected that some new wind generation will be built and exported by reducing generation from existing assets. Additional wind or conventional generation could also be built to serve new Wyoming load; however, these results are not captured in this analysis.

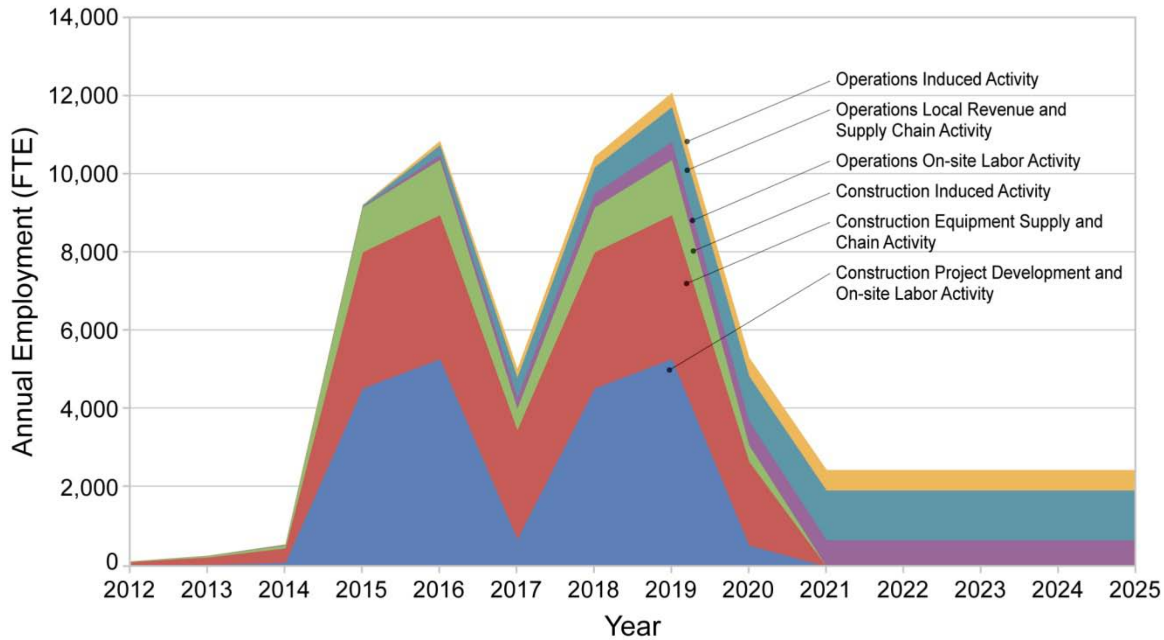

Figure 2. Base case employment in Wyoming from new power sector infrastructure development

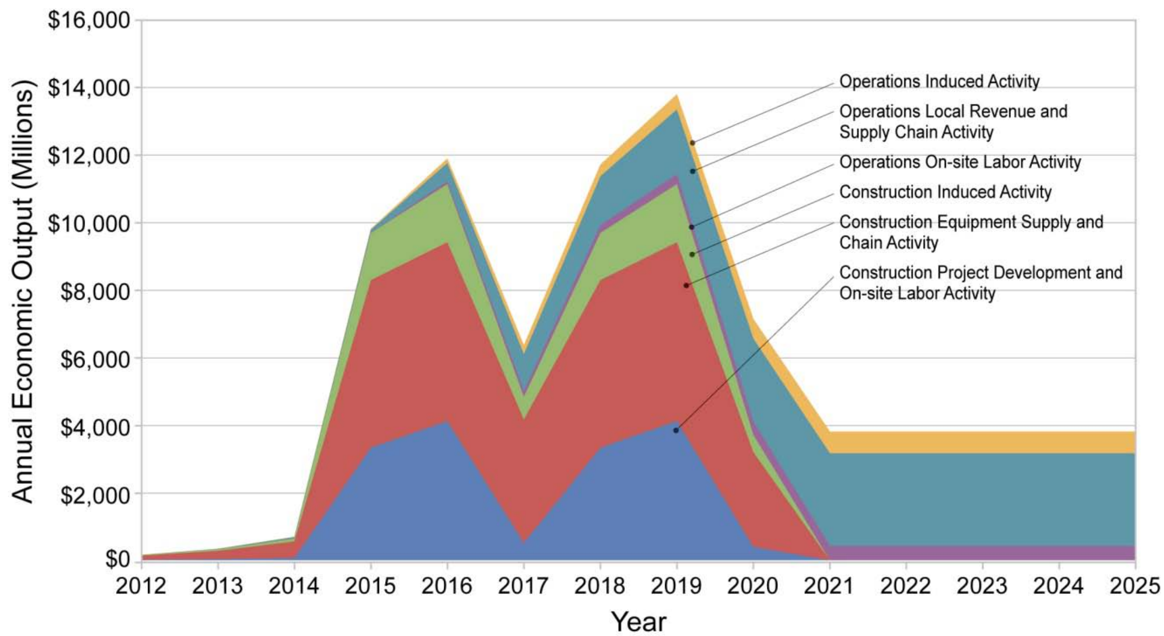

Figure 3. Base case economic activity in Wyoming from new power sector infrastructure development

Employment results in the base case, by infrastructure type, are shown in Figure 4. This figure shows that the wind and transmission projects constitute the largest share of employment and economic activity. Wind accounts for roughly 40%–80% of employment over the construction period (2012–2020) and nearly 70% of employment during operations. New transmission deployment accounts for roughly 15%–50% of employment during construction but only 20% of employment during the operations period. Natural gas generation accounts for 4%–15% of construction period employment and 10% of operations period employment. The distribution of employment by infrastructure type is generally the result of the relative scale of investment between the various infrastructure types; however, the ratio of labor costs to material and equipment costs for each infrastructure type also plays a role. Figure 4 illustrates the result of the very large expenditures that occur over a short period of time typically associated with building new transmission capacity. The relatively constant nature of wind-generation-related employment is the result of the sustained deployment on the order of 1,500 MW per year envisioned in the deployment scenario. To the extent that wind deployment more closely tracks the in-service date of the new transmission lines, the peak (and minimum) jobs and economic activity observed in Figure 3 and Figure 4 would vary accordingly.

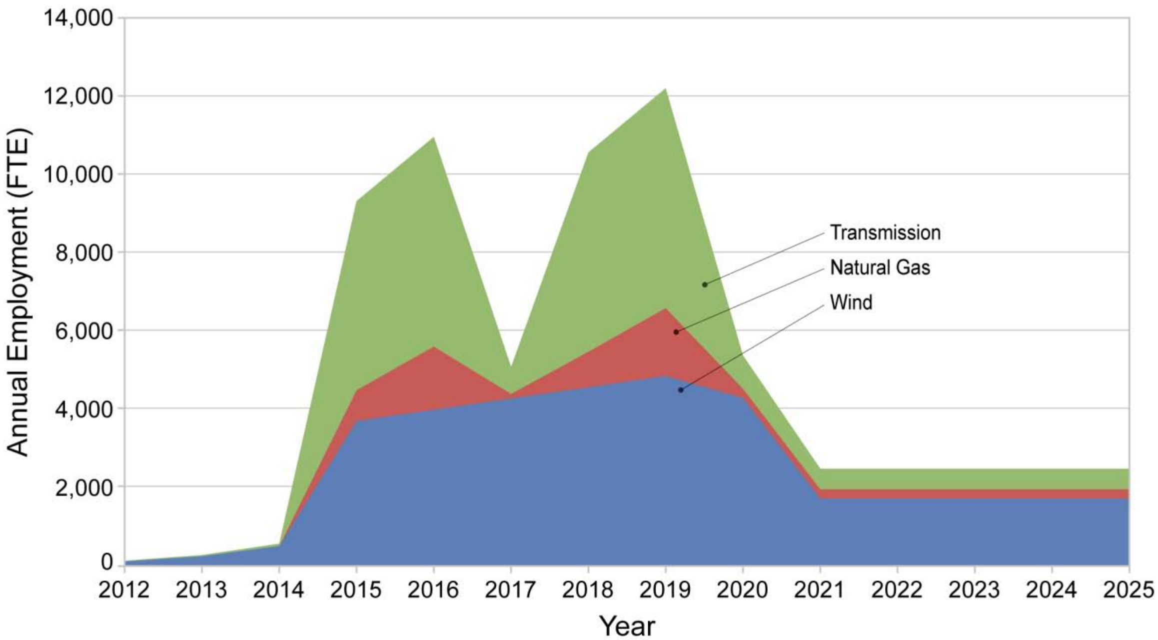

Figure 4. Base case employment by infrastructure type

Figure 5 illustrates the potential magnitude of variation from the base case determined by the high case and low case and resulting from changes in the local share inputs. Assuming the same deployment scenario and equivalent capital and operations expenditures, peak employment could range from approximately 8,000 Wyoming jobs to more than 14,000 Wyoming jobs. Less variability in the operations period employment is observed as a result of greater certainty in the allocation of operations period expenditures between Wyoming-based individuals and businesses and out-of-state individuals and businesses. Greater certainty in the allocation of expenditures to Wyoming during the operations period is the result of the relatively definitive distinction that exists between day-to-day operations of the facilities and periodic specialized maintenance. Day-to-day operations generally employ local individuals and service providers. Specialized maintenance and repair are expected to require out-of-state contractors or service providers.

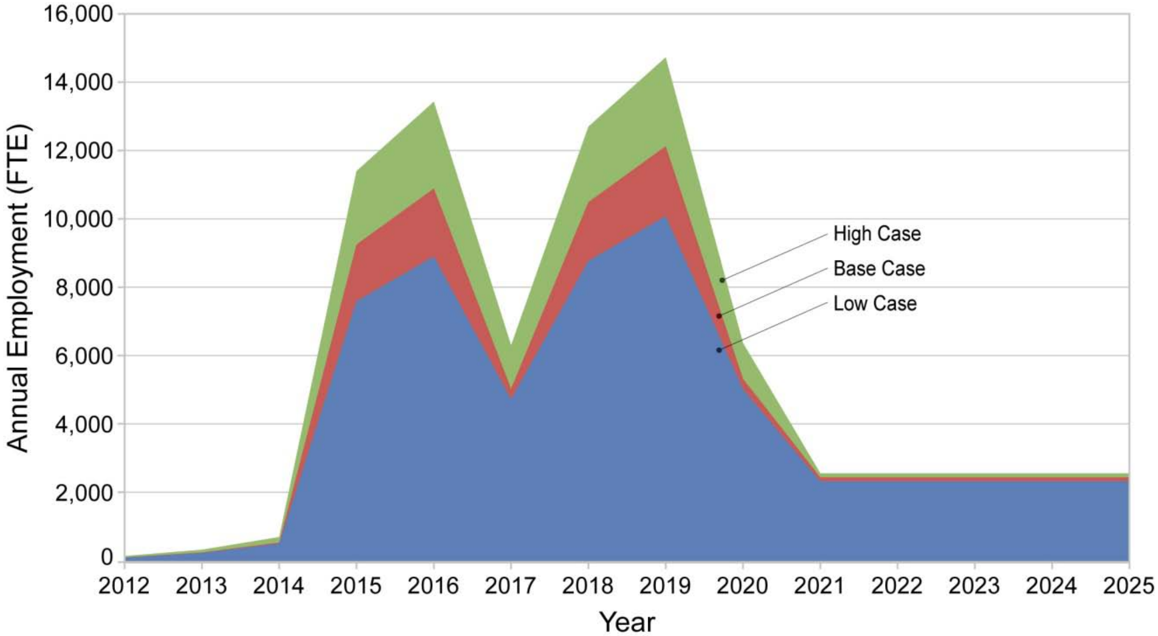

Figure 5. Estimated range of employment based on variability in reliance on Wyoming goods, services, and labor

Direct payments to Wyoming residents and government are often some of the more tangible economic results from these types of projects. Landowner lease or easement payments, local property and sales tax payments, and the Wyoming wind generation tax are forms of direct payments. Although there is some uncertainty with respect to Wyoming's wind generation tax as well as the current sales tax abatement for wind energy equipment, this study utilized existing policy provisions to estimate the direct payments to Wyoming landowners and government.[16] Figure 6 illustrates the flow of direct payments in the form of property and sales tax, Wyoming generation tax, and landowner easement and lease payments.

[16] Because no new construction before 2012 is captured by this analysis, it is assumed that all new wind projects will be subject to state and local sales tax. Wyoming's wind generation tax is assumed to remain at $1/MWh and go into effect after 3 years of project operations (Justia Laws and Regulations 2010).

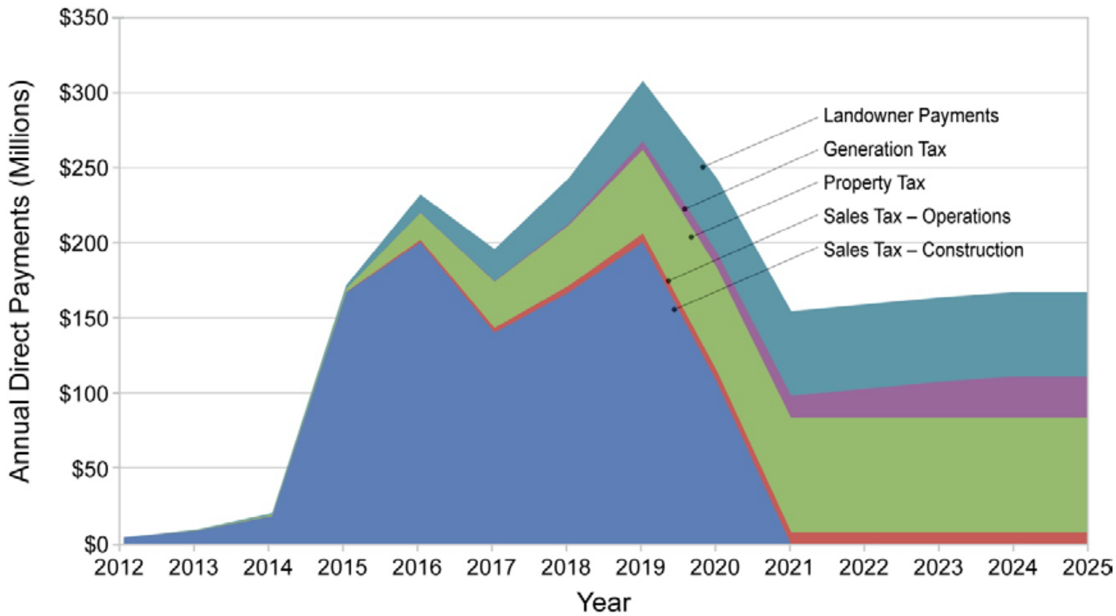

Figure 6. Total direct payments to Wyoming landowners and government

Note: Transmission right-of-way (ROW) payments are included in the landowner payments above as equivalent annual payments and exclude ROW payments on federal land. Property tax estimates are based on the estimated average payment in current dollars.

The single largest factor influencing direct payments is the sales tax assessed against new generation and transmission equipment. During the peak construction years of 2016 and 2019, more than $200 million in sales tax is estimated (assumed sales tax rate of 5.32%). However, as new assets are added, property tax and landowner payments become a notable source of direct Wyoming payments.[17] Wyoming's wind generation tax is also a source of direct payments and constitutes about 16% of operations period direct payments.

Summary of Total Results

When considering the high case and low case results, on average, construction of new infrastructure is estimated to support 4,000–5,900 jobs, each earning an average of $54,000 per year in wages and benefits for a period of 10 years; approximately 1,500–2,600 of these jobs are estimated to be in the construction sector. This equates to roughly 10% of Wyoming's current construction labor force. Once all new infrastructure is in service, employment is estimated to be 2,300–2,600 Wyoming jobs earning an average salary and benefits of just over $44,000 per FTE per year with roughly 25% of these jobs in direct O&M of the facilities. Assuming construction and 20 years of operations, the total Wyoming economic output associated with these projects is estimated at $12 billion–$15 billion. This is roughly one-third of the total potential economic output that could theoretically accrue to Wyoming from these projects.[18]

[17] In reality, property tax payments in nominal dollars will be weighted towards the early years of operations and diminish over time as the assets are depreciated. Estimates shown in Figure 6 are based upon the average payment calculated from the NPV (discount rate of 3%) of the lifetime property tax payments.

[18] In today's global economy, it is unreasonable to think that Wyoming could ever capture 100% of the available economic activity from these projects. However, it is possible that Wyoming could capture a larger share than has been estimated here.

Wind Generation

Wind resources in Wyoming are abundant. The state is ranked eighth in the country in total available wind resources (WPA 2010). Figure 7 shows the state's wind power resource (based on an 80 m turbine hub height).

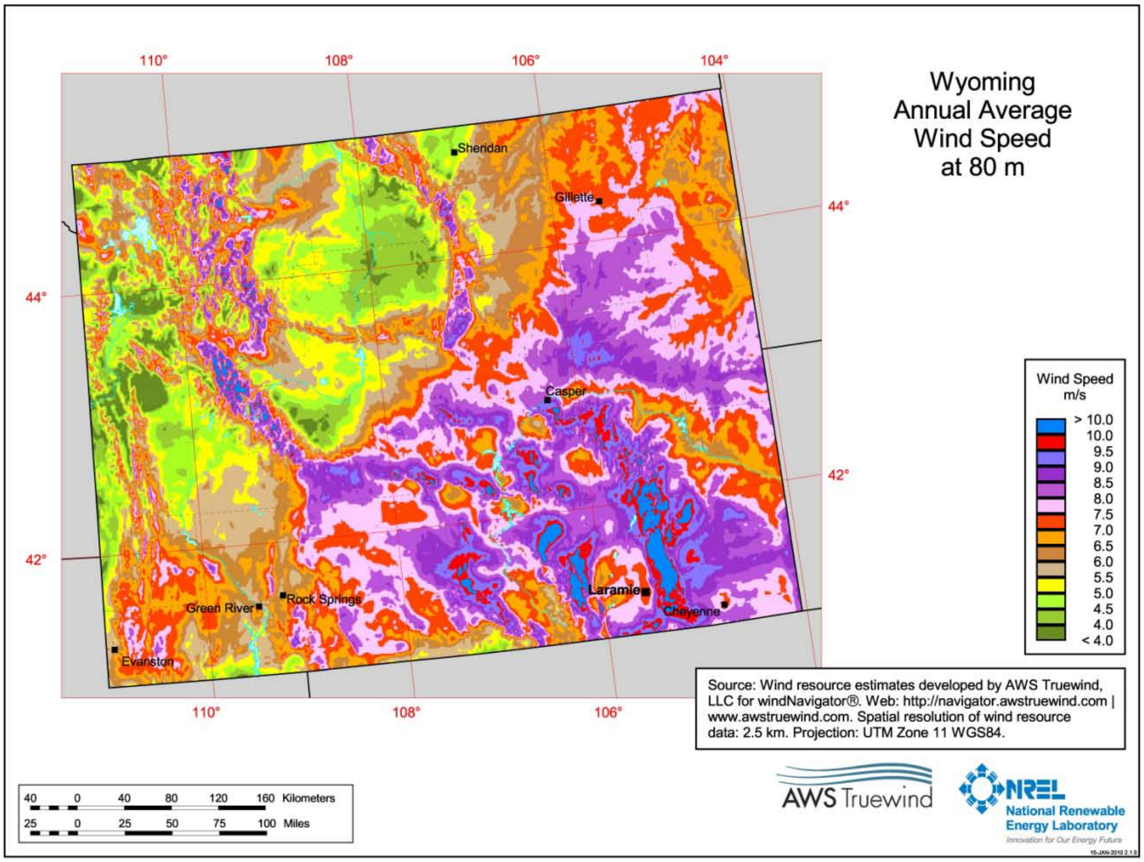

Figure 7. Wyoming wind speed at 80 m

Source: NREL, AWS Truewind 2010

As seen in Figure 8, Wyoming has among the top wind speeds in the nation.

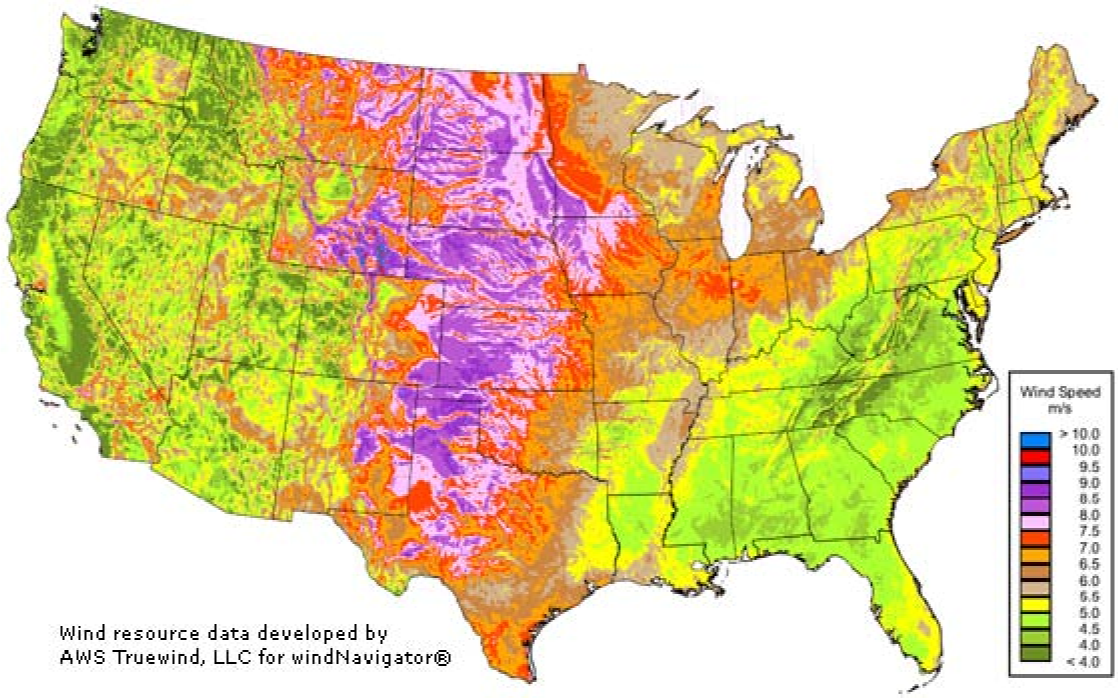

Figure 8. U.S. wind speed map at 80 m

Source: WPA 2010

Figure 9 shows the potential megawatts of rated capacity above a given gross capacity factor (i.e., without losses) at 80 m and 100 m heights above ground.[19] This figure shows the amount of available wind power in Wyoming at given capacity factors. Wyoming alone could provide more than 400 GW of wind power with a 35% capacity factor or greater (WPA 2010). These data apply standard industry exclusions for slope, protected land, wetlands, and other areas unlikely to be developed; they do not include other broad-based state-specific exclusions (e.g., sage grouse core areas). In 2008, the U.S. Department of Energy estimated that it would require approximately 300 GW of wind power to provide 20% of the U.S. electricity consumption from wind power (U.S. DOE 2008). With a relatively small population and a vast wind resource, electricity generated by Wyoming wind would likely serve load centers in nearby states such as Arizona, California, Colorado, Nevada, and Utah. Compared to the rest of the United States and to nearby load centers, Wyoming's wind potential is particularly strong. Figure 10 compares the Wyoming wind resource at specific capacity factor values relative to California's wind resource.

[19] Capacity factor is a measure of energy produced by a given generator relative to its potential at continuous full power. Typical capacity factors for wind generators are 30%–35%, indicating that on average a wind turbine will generate approximately one-third of its rated or maximum generating capacity. Capacity factor is directly affected by the wind resource, which is in turn affected by the tower or hub height (better wind resource exists higher off the ground). Typical hub heights for the wind industry today are 80 m, although turbines have been installed in the United States on towers of 100 m or greater.

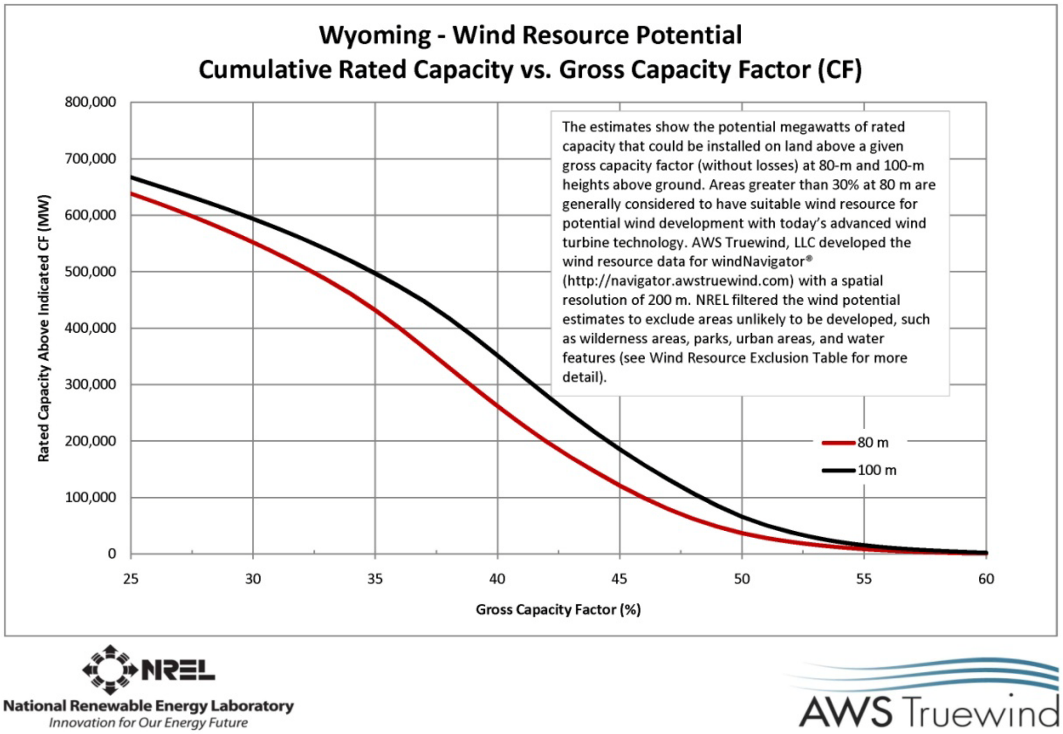

Figure 9. Wyoming wind resource potential

Source: WPA 2010

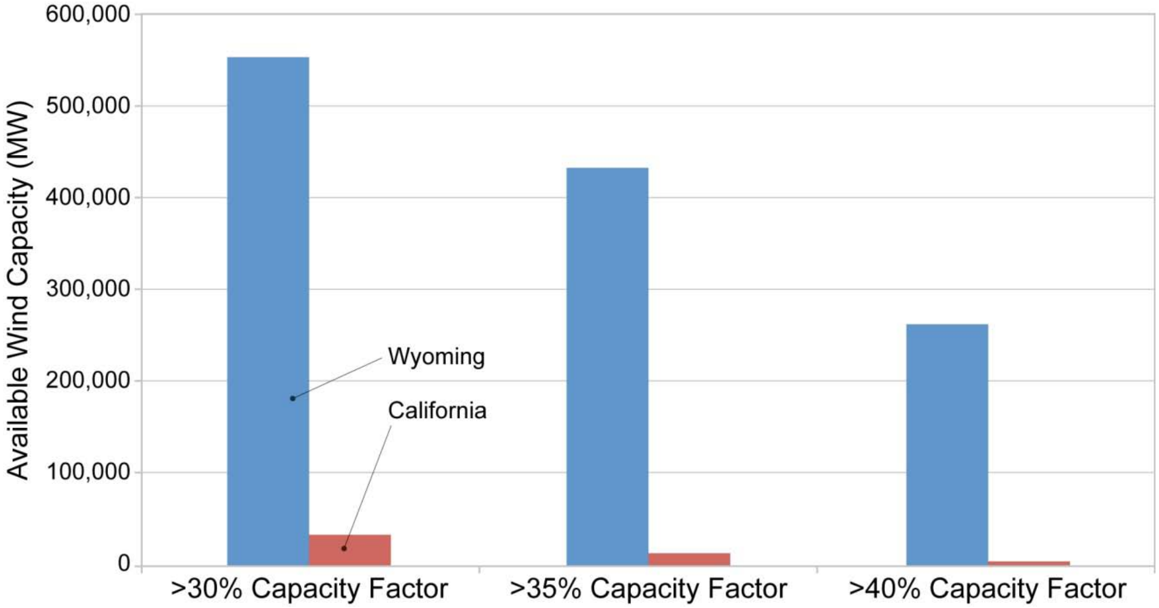

Figure 10. Wyoming wind resource relative to California

Source: WPA 2010

Note: Assumes standard land use, environmental and protected land exclusions, and does not consider state-specific exclusion zones.

As of the end of 2010, current utility-scale Wyoming wind electricity projects include approximately 1,100 MW of wind capacity with a number of projects in various stages of development. Wyoming currently ranks 13th in the country in installed wind capacity (AWEA 2011). Projects range from small (e.g., Medicine Bow, which began in 1996 and is under 10 MW) to what is considered medium to large today (e.g., Wyoming Wind Energy Center at 144 MW and 80 turbines online in 2003).

Modeling Inputs

Given Wyoming's excellent wind resource, the deployment scenario applied here includes 9,000 MW of new wind power for Wyoming's energy portfolio, added between 2012 and 2021. Installations start gradually at 50 MW in 2012 and ramp up to 1,500 MW in years 2015–2019 as new transmission capacity is added; new wind deployment ends by 2020. There are no new projects assumed in or after 2020. However, this is a function of the deployment scenario utilized here. In reality, additional transmission capacity could allow for continued new wind installations. Figure 11 depicts the annual wind installations in Wyoming resulting from the deployment scenario analyzed here.

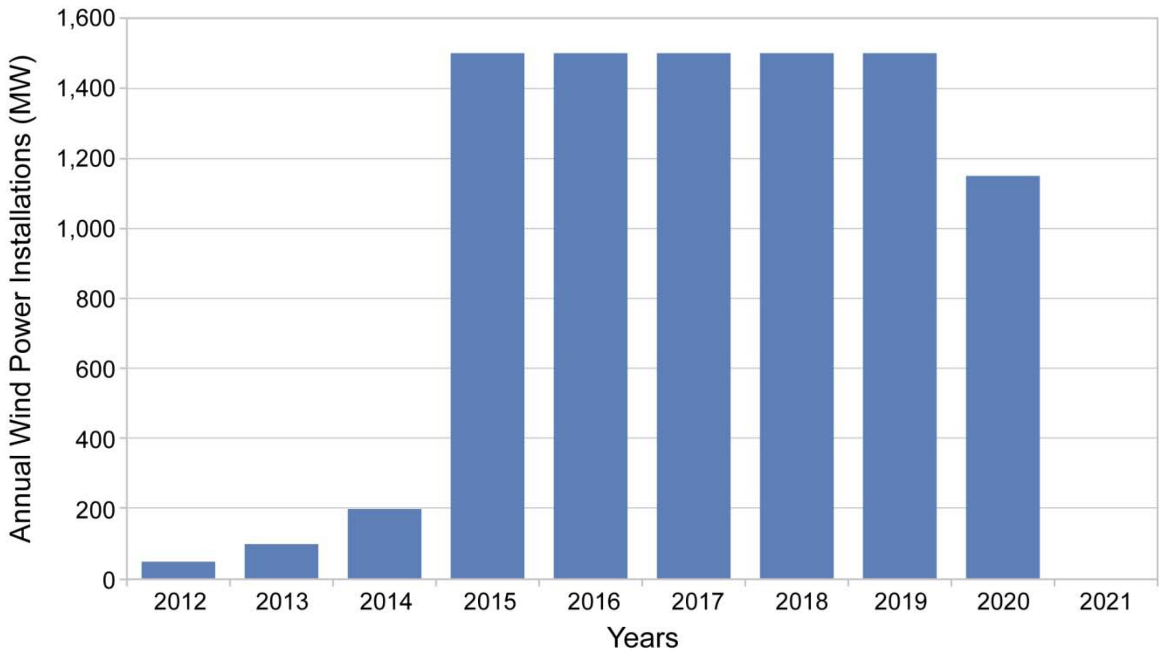

Figure 11. Wyoming wind deployment by year

Installed project cost for wind power is assumed to be $2,000/kW (Table 4). This estimate is grounded in existing U.S. project costs over the time period of 2007–2009 (Wiser and Bolinger 2010) as well as interviews with various wind project developers considering projects in Wyoming.[20] The annual direct O&M cost is estimated to be $25/kW, excluding property taxes and land lease payments (which are reported separately). In calculating the Wyoming wind generation tax, the capacity factor is assumed to be 35%.

Table 4. High Level Wind Power Inputs

Installed Cost	Annual O&M Cost	Land Lease ($/MW)*	Property Tax ($/MW)*
$2,000/kW	$25/kW	$6,025	$6,080

*Represents the average payment in current dollars; calculated from the NPV (3% discount rate) of future land lease and property tax payments

Land lease payments are assumed to be an average of $6,025/MW/year (over the 20-year operating life of a wind project).[21] This means that a landowner with a 2 MW wind turbine on his or her land would earn approximately $12,050/year. In addition, these landowners can continue to use virtually all of the land they lease for grazing or crops. Land area covered by

[20] Although it is possible that installed wind energy costs could decline over time, this analysis assumes constant costs into the future. In actuality, wind energy technology faces a variety of upward and downward price pressures, each of which were discussed in NREL interviews with industry representatives. Although costs appear to be declining today, in the recent past costs have in fact escalated dramatically. It was beyond the scope of this analysis to conduct a detailed cost projection for wind and the other infrastructure technologies analyzed here.
[21] The land lease payment assumptions were calculated from data provided by the Wyoming State Lands office (Threewitt 2010) and verified by a representative from a Wyoming landowners association. For additional information on Wyoming landowner lease payments, see Parady et al. (2009).

modern wind power facilities is typically estimated to be 5 MW/km^2. However, only a small percentage (2%–5%) of this land is used for the actual turbine and access roads. The remaining land can still be used for grazing, ranching, or its original purpose prior to the wind installation. Figure 12 shows the land utilized directly by temporary and permanent structures.

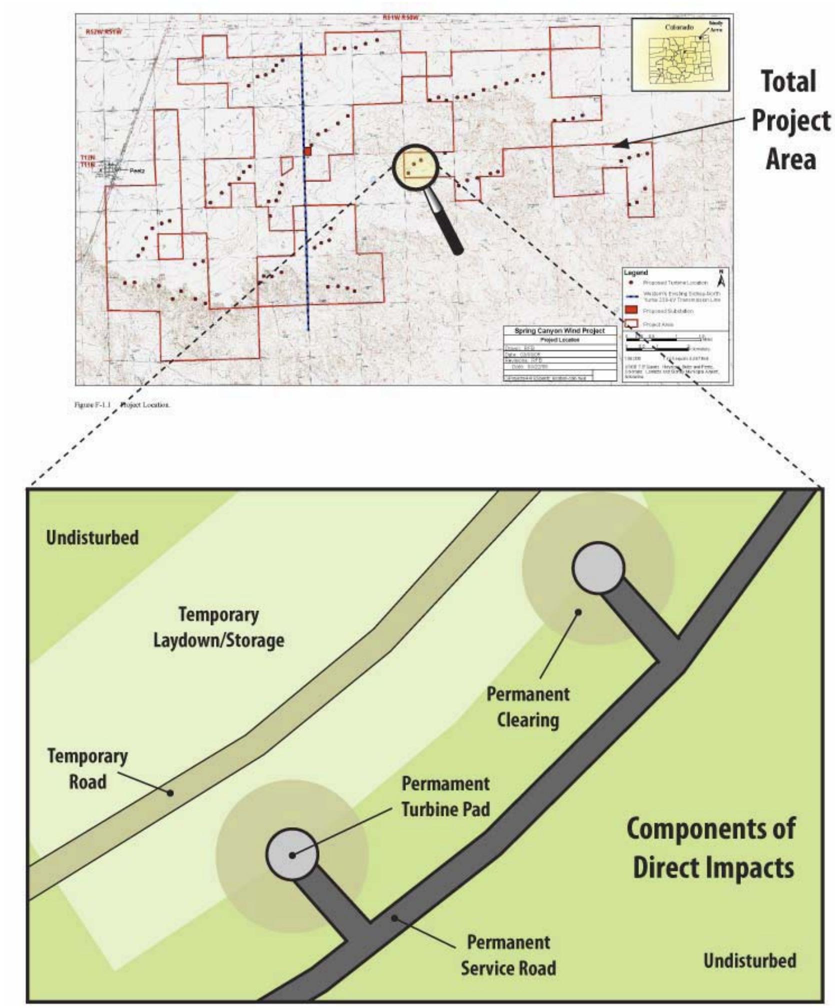

Figure 12. Illustration of total and direct wind project area (temporary and permanent)

Source: Denholm et al. 2009

There are three categories of tax that affect wind farm operations: sales tax, property tax, and generation tax. All assumptions for this work are based on existing policy as of January 1, 2011. Equipment and materials purchased for use in the construction and ongoing maintenance of the wind farms is subject to state and local sales tax of 5.32% (average Wyoming combined state and local sales tax rate; WY DOR 2010). Based on the estimated average property tax payment over a 20-year project life, the property tax estimate used in these calculations is \$6,080/MW/year.[22] The State of Wyoming also taxes the generation of wind electricity.

[22] Property tax estimates applied in this analysis assume property tax is calculated via the installed cost less depreciation methodology. Specific methods used to estimate property tax were derived from conversations with the Wyoming Department of Revenue Property Tax Division (Felton 2010).

Currently, in the beginning of 2011, the generation tax is $1/MWh starting after the third year the wind project is in operation (Justia Laws and Regulations 2010). For example, if a project is constructed in 2012 and begins operations in 2013, its owner will start paying the generation tax in 2016.

Based on interviews with project developers and engineering and construction firms, inputs for the base case, high case, and low case sensitivities were determined (Table 5). For the high case, it was assumed that 50% of the towers for new Wyoming wind farms could come from a manufacturer based in Wyoming. As of January 2011, there are no tower manufacturers in the state. However, if there were to be a market for several thousand megawatts of wind and if other conditions favored that decision, it is not unreasonable to think that a wind turbine tower manufacturer could open a facility within the state.[23] In addition, 75% of the labor for wind turbine erection is assumed to be based in the state, instead of 20% in the base case. There is currently one Wyoming company providing wind turbine erection services. This company could not currently handle 1,500 MW/year. But similar to the tower manufacturing potential, if there were a significant increase in demand for new wind installations, the company could hire additional workers to accommodate the large worker demand, or competing companies could be inspired to locate in Wyoming. It was also assumed after conversations with developers that 20% of the construction management team (as opposed to 10%) comes from within Wyoming for the high case. For the low case, it was assumed that no construction management personnel (instead of 10% in the base case) are based in Wyoming. Legal services were assumed to be primarily provided in-house by the out-of-state developer, so that only 20% (as opposed to 70% in the base case) of legal services labor comes from Wyoming firms. Table 5 lists the full array of modeling inputs used for Wyoming wind projects in the base case, high case, and low case.

[23] On February 15, 2011, Worthington Steel and Gestamp announced a joint venture to construct a $40 million turbine tower manufacturing facility in Cheyenne with construction commencing in the spring of 2011. In addition, in discussions with the Wyoming Business Council, there are other generation-related manufacturers that have shown an interest in siting facilities in Wyoming.

Table 5. Wind Power Project Cost Allocation and Percentage of Goods, Services, and Labor Procured in Wyoming

Construction Costs	Cost Breakdown by Parameter	Base Case	High Case	Low Case
Turbine Nacelle & Drivetrain	43%	0%	0%	0%
Blades	10%	0%	0%	0%
Towers	11%	0%	50%	0%
Transportation	8%	0%	0%	0%
General Site Materials	10%	70%	70%	70%
Transformers	1%	0%	0%	0%
Electrical Equipment	1%	20%	20%	20%
HV Line Extensions	2%	10%	10%	10%
Foundation Labor	< 1%	30%	30%	30%
Turbine Erection	1%	20%	75%	20%
Electrical Craft Labor	1%	30%	30%	30%
Management/Supervision	< 1%	10%	20%	0%
Miscellaneous	4%	50%	50%	50%
Substation/Interconnection Materials	1%	10%	10%	10%
Substation/Interconnection Labor	< 1%	40%	40%	40%
Engineering	1%	10%	10%	10%
Legal Services	1%	70%	70%	20%
Land Easements	< 1%	100%	100%	100%
Site Certificate/Permitting	< 1%	70%	70%	70%
Sales Tax	5%	100%	100%	100%
Total	**100%**	**16%***	**22%***	**15%***

Operations & Maintenance Costs	Cost Breakdown by Parameter	Base Case	High	Low
Field Salaries	9%	100%	**Unchanged**	
Administrative Staff	1%	100%		
Management	2%	100%		
Vehicles	2%	100%		
Site Maintenance/ Miscellaneous Services	1%	80%		
Fees, Permits, Licenses	0%	100%		
Utilities	2%	100%		
Insurance	16%	0%		
Fuel (Motor Vehicle Gasoline)	1%	100%		
Consumables/Tools	5%	100%		
Replacement Parts	48%	2%		
Sales Tax	3%	100%		
Other Taxes/Payments	11%	100%		
Total O&M Cost	**100%**	**37%***		

*Percent of the total category of expenditures procured in Wyoming.

Wind Generation Results

The total investment in new wind construction and installations is an estimated $18 billion. Applying the local spending coefficients noted in Table 5, approximately 15%–22% (based on high and low cases) would be spent within the Wyoming economy; this translates to $2.7 billion–$4.0 billion. The base case construction spending in Wyoming is $2.9 billion during the construction phase. Annual operating expenses from the new wind farms are estimated to be $260 million/year, of which approximately $96 million would be spent in Wyoming (37%). These results include the specific parameters from Table 5 (construction and operations period cost allocations) and do not include electricity sales revenues or debt service requirements.

Table 6 shows the construction period and annual operations period results from the base case. Figure 15 explores the high case and low case sensitivities.

Table 6. Construction and Operation Periods Economic Activity from 9,000 MW of New Wind Generation

Construction Period (Average Annual for 10 Years)	Jobs	Wages ($Million)	Output ($Million)
Project Development and On-site Labor	230	$14	$19
Equipment and Supply Chain Activity	1,600	$77	$210
Induced Activity	300	$11	$37
Total	**2,200**	**$100**	**$270**
Operations Period (Average Annual for 20 Years)	**Jobs**	**Wages ($Million)**	**Output ($Million)**
On-site Labor	470	$27	$27
Local Revenue and Supply Chain Activity	860	$35	$220
Induced Activity	400	$14	$48
Total	**1,700**	**$76**	**$290**

Note: Totals may not add due to rounding.

Table 6 indicates that 10 years of wind construction-related activities are likely to support an average of 2,200 Wyoming jobs each year and bring over $100 million in wages and benefits to Wyoming workers each year. Operations period economic activity is estimated to support approximately $76 million/year in wages and benefits to Wyoming residents and generate Wyoming economic output on the order of $290 million/year once all 9,000 MW of new wind is completed. Figure 13 depicts the number of Wyoming jobs from wind deployment in the base case from 2012–2025. From Figure 13, it is clear that construction project development and on-site labor activity is a relatively small proportion of the total Wyoming employment resulting from wind deployments. This is a result of the capital- and material-intensive nature of wind projects. Only about 6% of total wind project costs is labor, a subset of which flows through the Wyoming economy.

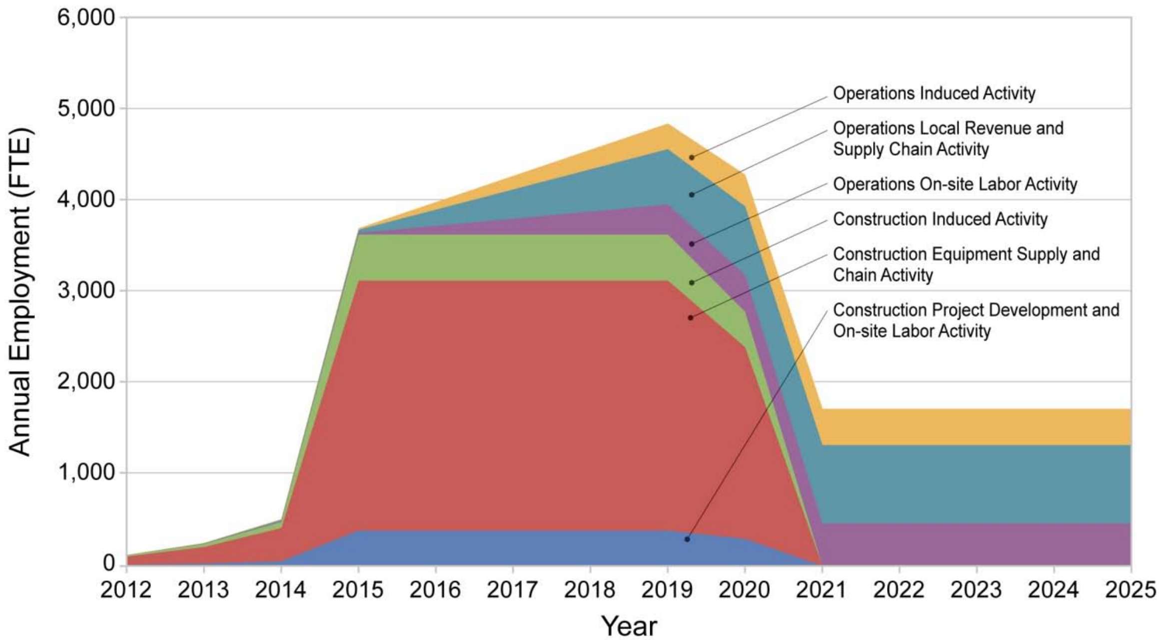

Figure 13. Wyoming employment from 9,000 MW of new wind power (base case)

Another way of viewing the economic activity from 9,000 MW of wind is depicted in Figure 14. This chart shows the economic activity in terms of economic output in Wyoming over the years 2012–2025. The economic output trends are similar to the ones shown in the employment chart in Figure 13 but illustrate the level of economic activity in dollars rather than employment.

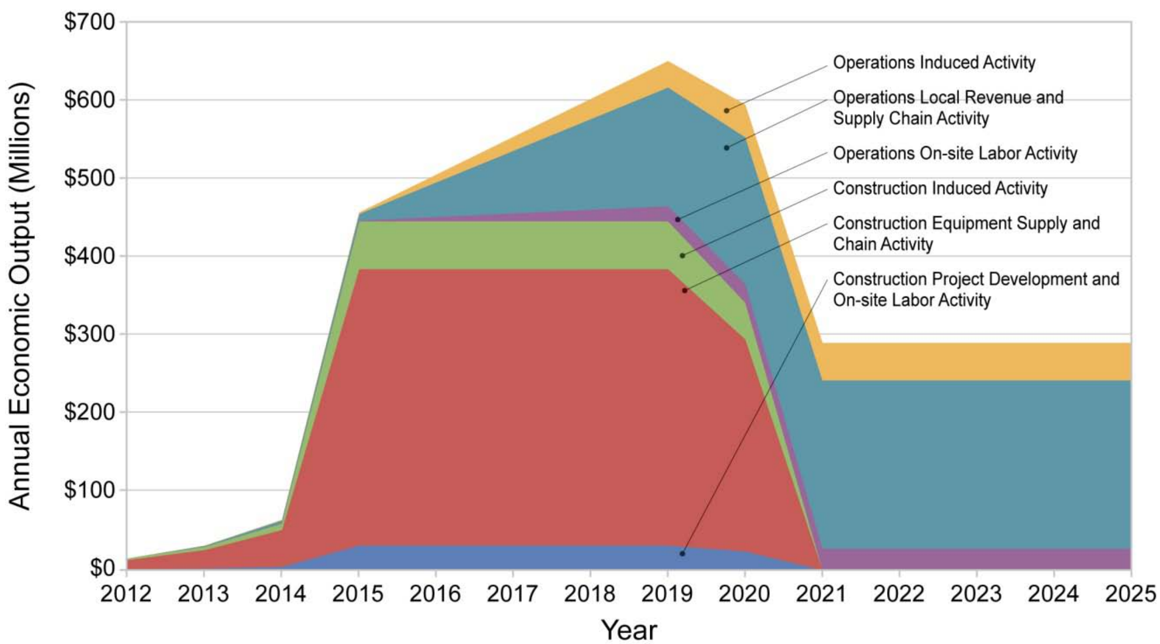

Figure 14. Economic activity from 9,000 MW of new wind power (base case)

Figure 15 shows the difference in employment from wind in the base case, high case, and low case. Generally these differences would be most important to individuals involved in the supply chain and construction of the wind farms. As shown in Figure 15, the number of jobs in the high case is approximately 900 FTE above the base case in some years, and much of this increase is driven by the utilization of Wyoming-based wind turbine towers included in the high case. In a state where the entire workforce is less than 300,000 (BLS 2011), this modest development of supply chain capabilities would be a notable boost to the workforce. Variability in economic development activity from wind all occur during the construction phases of the wind projects, so the long-term jobs are not increased or decreased (see years 2021–2025 for operations-only jobs). Uncertainty about Wyoming's future workforce led the authors to incorporate higher or lower percentages of local share values for the supply chain and for construction labor modeling inputs. However, based on the interviews used in developing the high case and low case, the operations period inputs were comparatively certain, thus they remain unchanged from the base case.

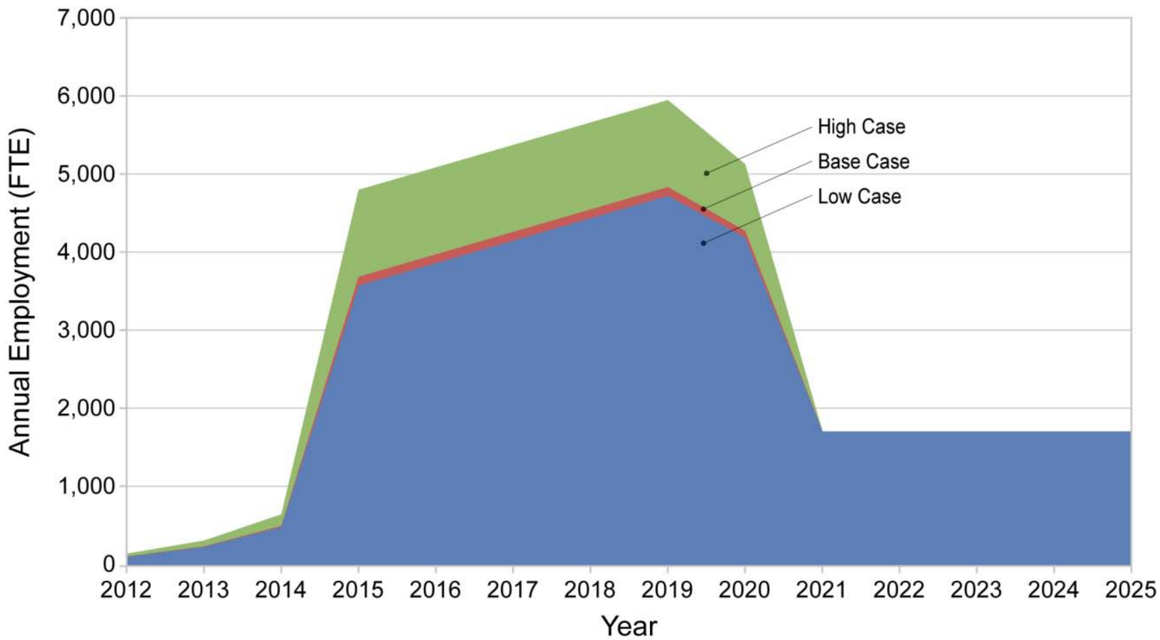

Figure 15. Estimated employment from wind installation in Wyoming—Three sensitivities

Land lease payments are typically negotiated between landowners (in some cases, groups of landowners join together to form landowner associations) and project owners. Estimates of land lease payments applied here are based on interviews with the Wyoming Office of Lands & Investments (Threewitt 2010) as well as Wyoming landowner associations. The estimated annual average payment to landowners is approximately $54 million from 9,000 MW of new wind in Wyoming.

For the purpose of this analysis, tax rates and policy are assumed to remain consistent with existing policy. In fact, taxes will change over time; legislation was already proposed this past session that would have altered the future wind energy tax scheme. However, it is impossible to know exactly what form future tax schemes will take. Based on existing tax policy, sales tax during construction (on equipment and materials purchases) is estimated to be approximately $830 million for 9,000 MW of new wind (assuming the statewide average 5.32% sales tax rate). Sales tax, from the full fleet of wind generation during the operations period, is estimated to be $7.6 million annually. Property taxes on 9,000 MW of new wind generation are estimated to result in an annual average payment from project owners to the State of Wyoming of approximately $55 million. The Wyoming wind generation tax, which is currently $1/MWh and goes into effect after the third year of operations of a wind project (Justia Laws and Regulations 2004), is estimated to provide an additional $28 million to the State once the full 9,000 MW of wind is subject to the tax. Figure 16 illustrates these payments and their variability over time.

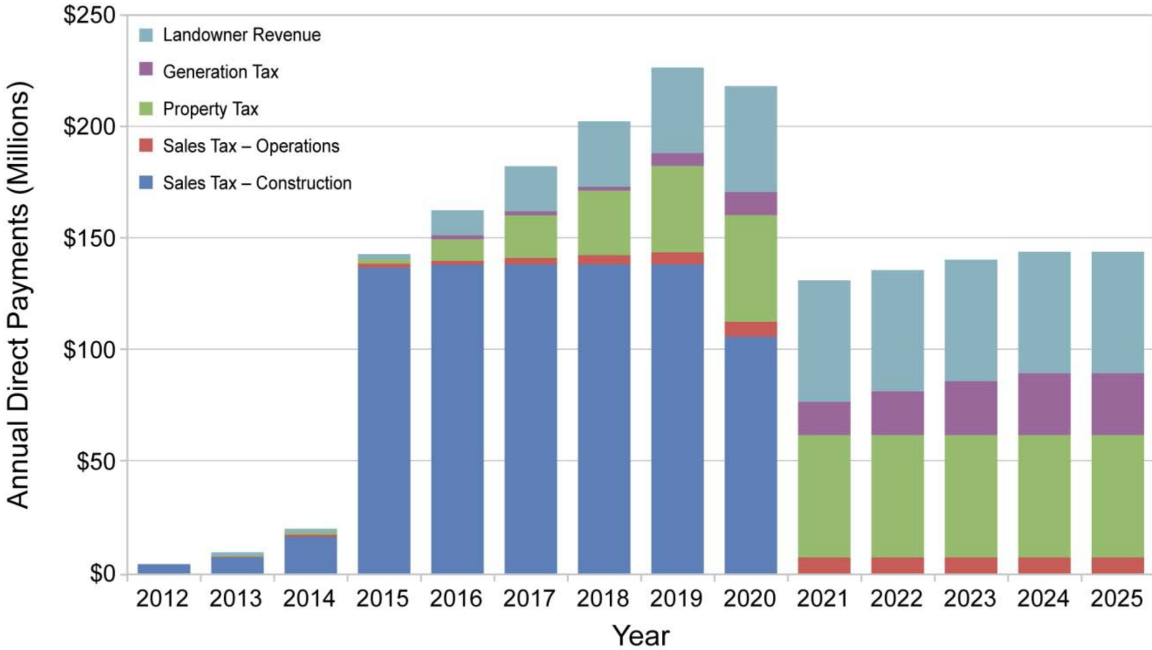

Figure 16. Direct payments to Wyoming landowners and government from new wind generation

Note: Property tax and landowner revenues shown here are based on the average payment in current dollars.

Natural Gas Generation

Although Wyoming has only modest natural gas generation assets today, approximately 156 MW (EIA 2010a), Wyoming's abundant natural gas resources and pipeline network make it a prime candidate for new natural gas generation. In addition, new flexible natural gas generation may potentially allow for Wyoming wind generators, whose output is variable, to offer firm power products to markets outside of the state. At a minimum, adding new natural gas generation in Wyoming is likely to assist in maximizing the value of new transmission capacity and may also increase system reliability.[24]

Modeling Inputs

The deployment scenario applied here assumes four new natural gas power plants, a total of 1,800 MW, are added to Wyoming's existing generation assets.[25] A single combined-cycle 300 MW plant is placed in service in 2015 and a second is added in 2018. Both these installations occur in conjunction with the in-service date for the new 500 kV HVAC transmission lines. Similarly, a 600 MW combined-cycle plant is added in 2016 and a second is added in 2019. These installations occur in conjunction with the in-service date of the new 500 kV HVDC lines. Basic cost and other high-level modeling inputs are shown in Table 7. Installation and O&M costs were developed via interviews with developers working in the Rocky Mountain region as well as engineering and design firms who also work in the Rocky Mountain region. As was the case for wind, equipment and materials purchased for use in the construction and ongoing maintenance of the facilities is subject to state and local sales tax. Although these new natural gas power plants could use up to 65,000 10^6 Btu of natural gas per day, they are not expected to result in any incremental change to Wyoming's natural gas production. As such, no economic activity resulting from the drilling or production of Wyoming natural gas is attributed to these power generation facilities. The distribution of expenditures between sectors during construction and operations is shown in Table 8. Table 8 also summarizes the local spending coefficients or percentage of Wyoming-based goods, services, and labor used in the base case, high case, and low case.

Table 7. High Level Natural Gas Generation Inputs

Installed Cost	Fixed O&M Cost	Variable O&M Cost (Excluding Fuel)	Property Tax ($/MW)*
$1,250/kW	$8.25/kW	$2.90/MWh	$5,600

*Represents the average payment in current dollars; calculated from the NPV (3% discount rate) of future property tax payments

[24] While typical wind energy capacity factors are on the order of 30%–35%, Wyoming wind energy capacity factors may be on the order of 45%. Even with the higher Wyoming capacity factors, new natural gas generation can help utilize transmission capacity during periods of low wind.

[25] This capacity is expected to be less than what might be needed to fully balance the variability of the wind installations occurring in this analysis.

Table 8. Natural Gas Power Project Cost Allocation and Percentage of Goods, Services, and Labor Procured in Wyoming

Construction Costs	*Cost Breakdown by Parameter*	*Base Case*	*High Case*	*Low Case*
Power Generation	34%	0%	0%	0%
General Facilities	9%	75%	85%	65%
Plant Equipment	15%	5%	5%	5%
Construction Labor	17%	50%	75%	30%
Project Management	9%	10%	20%	0%
Construction Utilities	> 1%	100%	100%	100%
Engineering/Design	2%	0%	0%	0%
Construction Insurance	> 1%	0%	0%	0%
Land	5%	100%	100%	100%
Permitting Fees	2%	100%	100%	100%
Grid Intertie	2%	25%	25%	25%
Spare Parts	> 1%	5%	5%	5%
Sales Tax	3%	100%	100%	100%
Total	**100%**	**28%***	**33%***	**22%***

Fixed Operations Costs	*Cost Breakdown by Parameter*	*Base Case*	*High Case*	*Low Case*
Labor	42%	100%	100%	100%
Materials	6%	25%	40%	10%
Services	52%	50%	75%	25%
Total	**100%**	**69%***	**83%***	**55%***

Variable Operations Costs	*Cost Breakdown by Parameter*	*Base Case Local Share*	*High Case Local Share*	*Low Case Local Share*
Routine Maintenance	84%	5%	5%	5%
Water	5%	100%	100%	100%
Catalysts & Chemicals	10%	85%	85%	85%
Total	**100%**	**18%***	**18%***	**18%***

Other Operations Costs	*Cost Breakdown by Parameter*	*Base Case Local Share*	*High Case Local Share*	*Low Case Local Share*
Fuel	100%	0%	0%	0%
Sales Tax	100%	100%	100%	100%

*Percent of the total category of expenditures procured in Wyoming.

Natural Gas Generation Results

The total investment in new natural gas generation is estimated to be $2.3 billion. Applying the local spending coefficients noted in Table 8, an estimated $500 million–$750 million flows through the Wyoming economy. Annual operating expenses from the full fleet of new natural gas plants, excluding fuel costs, are estimated to be $42 million/year. An estimated $21 million–$26 million, including sales and property tax, is estimated to flow through the Wyoming economy annually during operations of the full fleet of natural gas generation. At a fuel cost of $6/10^6 Btu, an additional $425 million/year could flow through the Wyoming economy. However, as these facilities are assumed to have no incremental impact on natural gas production in Wyoming, no economic activity resulting from these expenditures is captured in this analysis. To the extent that these facilities do support new natural gas production in Wyoming, the economic activity resulting from these power plants will be significantly increased.

A summary of the combined base case activity for full deployment of 1,800 MW of new natural gas generation is included in Table 9. From this we can see that construction-related activities are likely to support approximately an average of 510 Wyoming jobs for a period of 5 years and bring more than $360 million over the 5-year period in wages and benefits to these employees. Operations period results are estimated to support more than $12 million/year in wages and benefits to Wyoming residents and economic output on the order of $38 million/year once the full fleet of generation has been deployed.

Table 9. Construction- and Operations-related Economic Activity from 1,800 MW of New Natural Gas Generation

Construction Period (Average Annual for 5 Years)	Jobs	Wages ($Million)	Output ($Million)
Project Development and On-site Labor	510	$56	$72
Equipment and Supply Chain Activity	230	$10	$46
Induced Activity	200	$7	$24
Total	**940**	**$72**	**$140**
Operations Period (Average Annual for 30–40 Years)	**Jobs**	**Wages ($Million)**	**Output ($Million)**
On-site Labor	90	$5.8	$5.8
Local Revenue and Supply Chain Activity	95	$4.7	$26
Induced Activity	50	$1.8	$6.2
Total	**240**	**$12**	**$38**

Note: Totals may not add due to rounding.

To better illustrate the economic activity associated with new natural gas generation over time, Figure 17 couples the employment results shown in Table 9 with the deployment scenario for natural gas generation. Figure 18 details the economic output over time. New natural gas generation is observed to support a notable increase in economic activity. Construction activities are estimated to result in more than 750 short-term jobs and more than $100 million in economic output when building a 300 MW plant; more than 1,500 short-term jobs and nearly $250 million in economic output results when constructing a 600 MW plant.[26] Operations period employment is estimated to ramp from nearly 40 jobs after the first 300 MW up to 240 jobs once all natural gas generation facilities are operational. Approximately 50% of jobs supported by construction activities occur on-site while approximately 40% of operations period jobs occur on-site at the facilities.

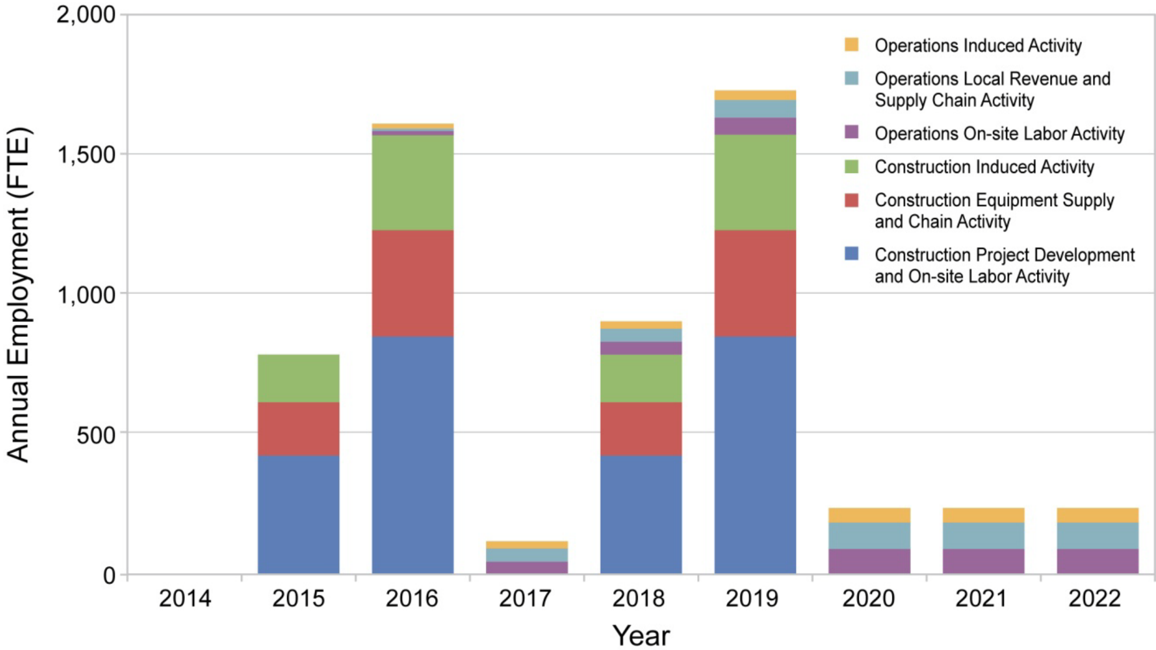

Figure 17. Wyoming employment from construction and operations of 1,800 MW of new natural gas generation

[26] Assuming it takes 1 year to construct each facility, the respective jobs will last for a period of 1 year. It is possible that fewer workers could work on each facility for a longer period of time (i.e., for the 300 MW plant, 375 workers could be employed for 2 years).

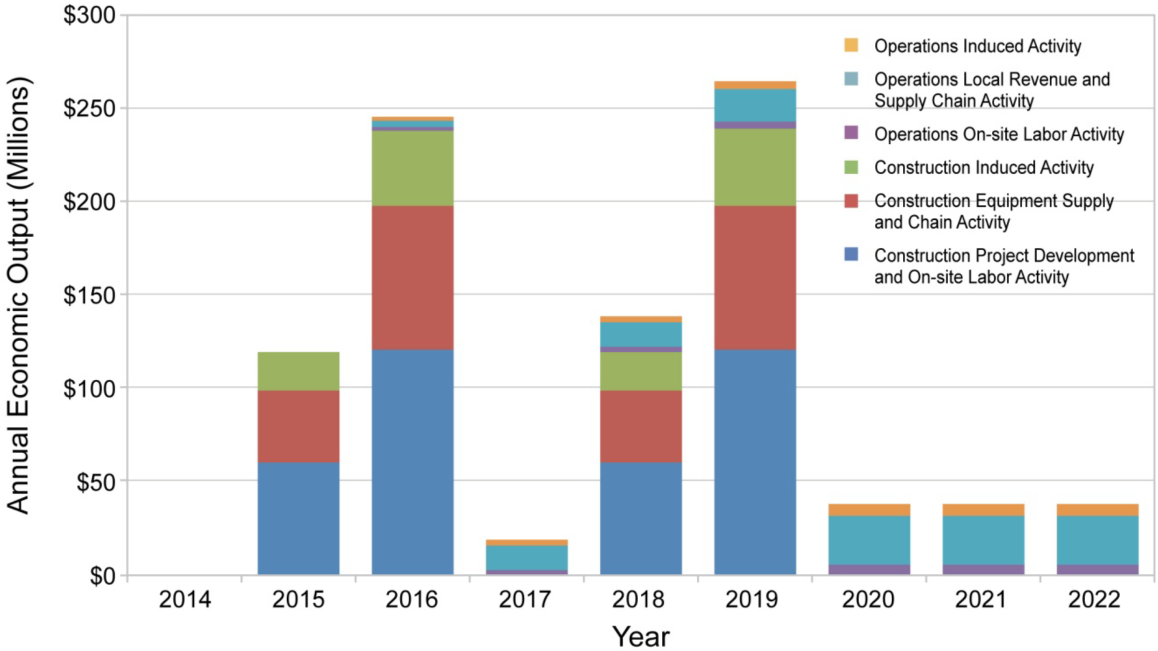

Figure 18. Wyoming economic output from construction and operations of 1,800 MW of new natural gas generation

Note: Results exclude potential economic activity resulting from incremental changes in the production of Wyoming natural gas.

Direct payments resulting from development and operation of new natural gas generation are exclusively sales and property tax. While use of Wyoming natural gas could potentially also generate royalty payments, severance tax payments, and ad valorem tax payments, these are not factored into this analysis since no incremental impact on Wyoming natural gas production is considered. Sales tax payments from construction activities are estimated at $12 million dollars for a 300 MW facility and $24 million for a 600 MW facility. Sales tax from purchases of equipment and basic materials during operations is significantly less at approximately $275,000/year. Property tax payments are estimated to average $10 million/year.[27]

To illustrate the potential variability in results, Figure 19 depicts the estimated employment associated with new natural gas generation when different levels of Wyoming goods and services are used in the construction and operations of the facilities. As shown in Table 8, the primary parameters that where adjusted—due to their uncertainty—include general facilities procurement, construction labor, and services. As such, these are the primary variables creating the range of results shown in Figure 19. Because the construction investments are much greater, small differences in the modeling inputs can have a larger impact on construction period results. In this case, construction period peak employment could range between 1,200 and 2,000 jobs depending on the degree to which Wyoming labor, along with basic goods and services, are utilized in this project. However, as is generally the case, the inherent nature of operations period expenditures increases certainty in the operations period modeling inputs and generates less

[27] As noted previously, real property tax payments will be greater than this early in the life of the facility but will decline over time as the assets are depreciated. In calculating the average property tax payment used here, plants were depreciated straight-line over a 40-year lifetime; a 3% discount rate was applied to future payments.

estimated variability during this period. Operations period employment is estimated to range from 215 to 260 jobs.

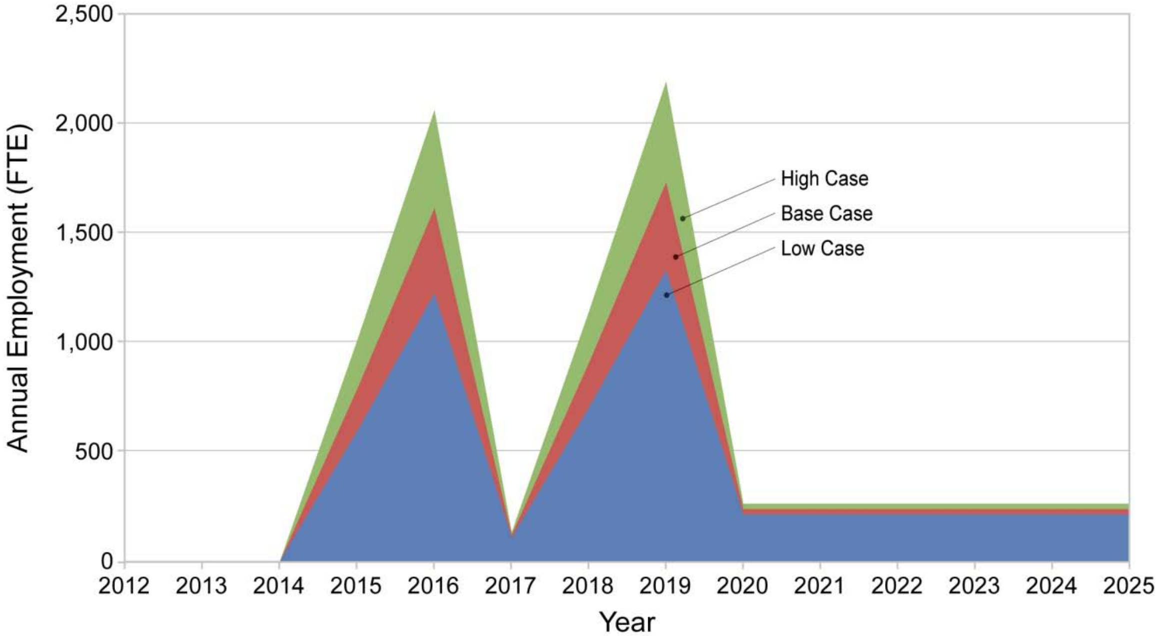

Figure 19. Estimated range of employment from 1,800 MW of new natural gas generation

High Voltage Transmission

The economic activity from the new wind and natural gas generation modeled here hinges on the development of new HV transmission. Wyoming's energy resources far exceed what can be consumed by local demand. New transmission connecting Wyoming energy resources with high demand population centers in California, Nevada, and Arizona would allow continued export of low-cost Wyoming wind and conventional energy resources. Of course, new transmission projects also contribute to economic development activity in Wyoming.

The deployment scenario that underlies this analysis assumes the construction of over 350 miles of 230 kV HVAC transmission in Wyoming to serve as a collector system for the 10,800 MW of new generation to be added. Construction of the collector system would begin as soon as 2012 and would be completed in 2020 when all new electricity generating capacity considered in here has been placed in service.

Four new HV interstate transmission lines are included in the deployment scenario. Two 500 kV HVDC lines, each with the capacity to move 3,000 MW of new generation, would be placed in service in 2016 and 2019. The Wyoming portion of both of these lines is assumed to be roughly 225 miles. Two 500 kV HVAC lines, each with the capacity to move 1,500 MW of new generation out of Wyoming, are placed in service in 2015 and 2018. The Wyoming portion of the 500 kV HVAC lines is 310 miles each. The deployment of new transmission is grounded in the projects that are currently under development in Wyoming. Figure 20 details the array of projects that could ultimately provide the capacity outlined in the deployment scenario used here. Additional information on the proposed interstate HV transmission lines is included in Appendix B.

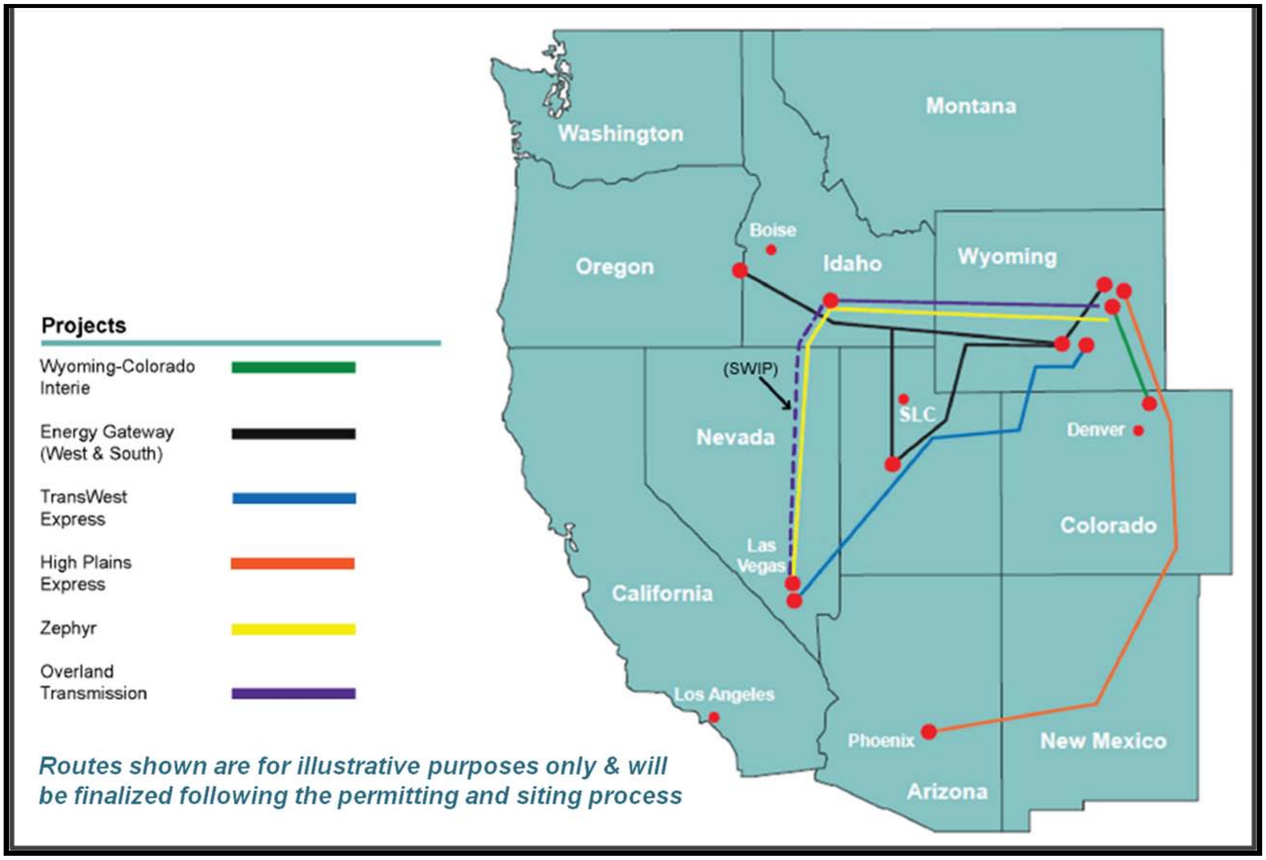

Figure 20. Conceptual representation of interstate transmission lines currently under development in Wyoming

Source: WIA 2011

Modeling Inputs

Table 10 shows the high level cost and direct payment inputs used in the modeling of HV transmission lines. These costs, as well as the allocation of costs detailed in Table 11, were derived from industry sources (e.g., Black and Veatch 2009; WECC 2010) and in conjunction with engineering and design firms working in the Rocky Mountain region. Cost estimates were reviewed by the WIA as well as transmission developers currently working in Wyoming. All material and equipment purchases utilized in the construction and operations of the lines are subject to the average Wyoming sales tax of 5.32%. Transmission right-of-way (ROW) payments are calculated as an annual equivalent over 40 years for the purpose of modeling the operations period results; however, on state and private land, these payments are ultimately more likely to be a one-time payment. This analysis does not capture any of the potential effects on electricity rates, system reliability, or grid congestion that may also result from the development and construction of these lines (e.g., Pfeifenberger and Newell 2010).

Table 10. High Level Transmission Cost Inputs

Line Type	Total Installed Cost ($Million)	Line Cost ($Million /Mile)	Sub/Converter Station Costs ($Million/Line)	O&M Costs (% of Initial CapEX)	Property Tax ($Million/Line)**	Weighted Average ROW Payments ($/Acre)**
500 kV HVDC	$1,100	$1.30	$715	2.5%	$2.90	$120
500 kV HVAC	$650	$1.70	$94	2.5%	$1.70	$120
230 kV HVAC	$650*	$0.64	$60	2.5%	$0.30	$120

*Estimated cost for more than 350 miles of a 230 kV collector system.
**Represents the average payment in current dollars; calculated from the NPV (3% discount rate) of future property tax and ROW payments

More detailed data showing the breakdown of the total installed cost between the various elements of each transmission line is shown in Table 11. The Wyoming purchase coefficients or the percentage of goods and services purchased from Wyoming businesses are shown in Table 12.

Table 11. Transmission Line Cost Breakdowns Applied in JEDI Modeling

Construction Costs	500 kV HVDC	500 kV HVAC	230 kV HVAC
Line Materials & Equipment	11%	35%	19%
Line Labor/Installation	13%	41%	13%
Converter/Substation Materials & Equipment	47%	6%	27%
Converter/Substation Labor	16%	8%	27%
Services & Other Costs	13%	10%	14%
Total Construction Costs	100%	100%	100%
Operations Costs			
Labor	20%	10%	10%
Materials and Services	79%	88%	88%
Other O&M Costs	1%	3%	3%
Total O&M Costs	100%	100%	100%

Table 12. Percentage of Transmission-related Expenditures Remaining in Wyoming

	500 kV HVDC			500 kV HVAC			230 kV HVAC		
Construction Costs	Base Case	High Case	Low Case	Base Case	High Case	Low Case	Base Case	High Case	Low Case
Line Materials		9%			7%			14%	
Line Labor	69%	79%	49%	70%	79%	50%	68%	77%	48%
Converter/ Substation Labor		0%			2%			2%	
Converter/ Substation Labor	64%	78%	44%	53%	68%	33%	50%	65%	31%
Services & Other Costs	44%	52%	38%	53%	68%	44%	46%	63%	36%
Total Construction Costs	**27%**	**32%**	**21%**	**43%**	**49%**	**32%**	**33%**	**40%**	**25%**
Operations Costs									
Labor	50%	80%	20%	50%	80%	20%	50%	80%	20%
Materials & Services		25%			25%			25%	
Total O&M Costs	**31%**	**37%**	**25%**	**29%**	**32%**	**26%**	**29%**	**32%**	**26%**

High Voltage Transmission Results

HV transmission projects are critical to realize the economic development potential of new generation; however, they are also a significant source of jobs and economic development activity. In this analysis, new HV transmission development is the second largest source of jobs and economic activity (after wind development) in Wyoming. More than $4 billion over a period of 10 years, with the vast majority of this investment occurring in a 5-year period late in the coming decade, would be invested in new transmission infrastructure. After project completion, an amount equivalent to 2.5% of the total initial capital expenditures, or about $110 million/year in operations-related expenditures, would continue to flow from these projects. Approximately 25%–38% of the initial capital expenditures and 26%–35% of the annual O&M expenditures are estimated to remain in Wyoming (Table 12).

A summary of the base case results for new HV transmission is included in Table 13. These results indicate that new transmission investments in Wyoming could support approximately 2,100 jobs for a period of 10 years. Combined total construction activity wages exceed $1 billion over the full 10-year period, or approximately $120 million/year on average. Total Wyoming economic output from construction of these lines approaches $2 billion. During operations, approximately 120 Wyoming jobs would result from activities including monitoring, ROW maintenance, and line repairs over the operating lifetime of the infrastructure. The total effect of combined O&M expenditures translates into more than 500 jobs for the life of the lines. Earnings (wages and benefits) for on-site O&M jobs are estimated to be on the order of $70,000–$80,000/year while average earnings for all jobs supported by O&M of these lines is on the order of $45,000 annually. Total economic output from O&M of this infrastructure is estimated to exceed $50 million/year.

Table 13. Construction- and Operations-related Economic Activity from New HV Transmission

Construction Period (Average Annual for 10 Years)	Jobs	Wages ($Million)	Output ($Million)
Project Development and On-site Labor	1,600	$100	$100
Equipment and Supply Chain Activity	240	$11	$43
Induced Activity	220	$8	$27
Total	**2,100**	**$120**	**$170**
Operations Period (Average Annual for 40 Years)	**Jobs**	**Wages ($Million)**	**Output ($Million)**
On-site Labor	120	$9	$9
Local Revenue and Supply Chain Activity	320	$11	$33
Induced Activity	80	$3	$10
Total	**520**	**$23**	**$52**

Note: Totals may not add due to rounding.

To better understand how this economic activity would be distributed over time, Figure 21 depicts the employment by year while Figure 22 depicts economic output by years. During transmission deployment there are two primary peaks. These peaks are associated with the estimated construction activities for the four interstate transmission lines. Peak employment is estimated at approximately 5,000 jobs, and peak output is estimated at approximately $450 million dollars. During construction, the on-site construction and project development activity is by far the largest segment capturing more than 70% of economic activity during the peak deployment periods. This is primarily a function of the relatively high labor component, nearly 50% in the case of the 500 kV HVAC transmission lines, of total project cost for transmission. In addition, most of the materials and equipment (e.g., conductor and towers), which contribute to the equipment and supply chain economic activity, must be brought in from out of state. This greatly reduces the equipment and supply chain economic activity to Wyoming. During the operations period, it is actually the local revenue and supply chain segment that provides the greatest economic activity with just over 60% of the total economic activity.

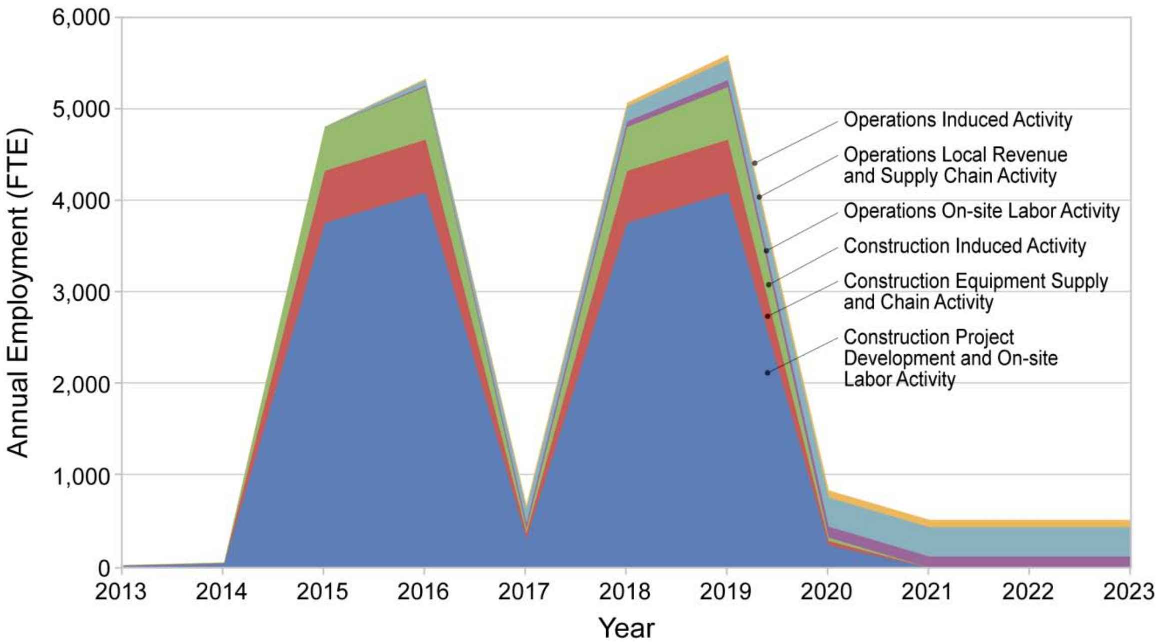

Figure 21. Wyoming employment annually from construction and operations of new HV transmission

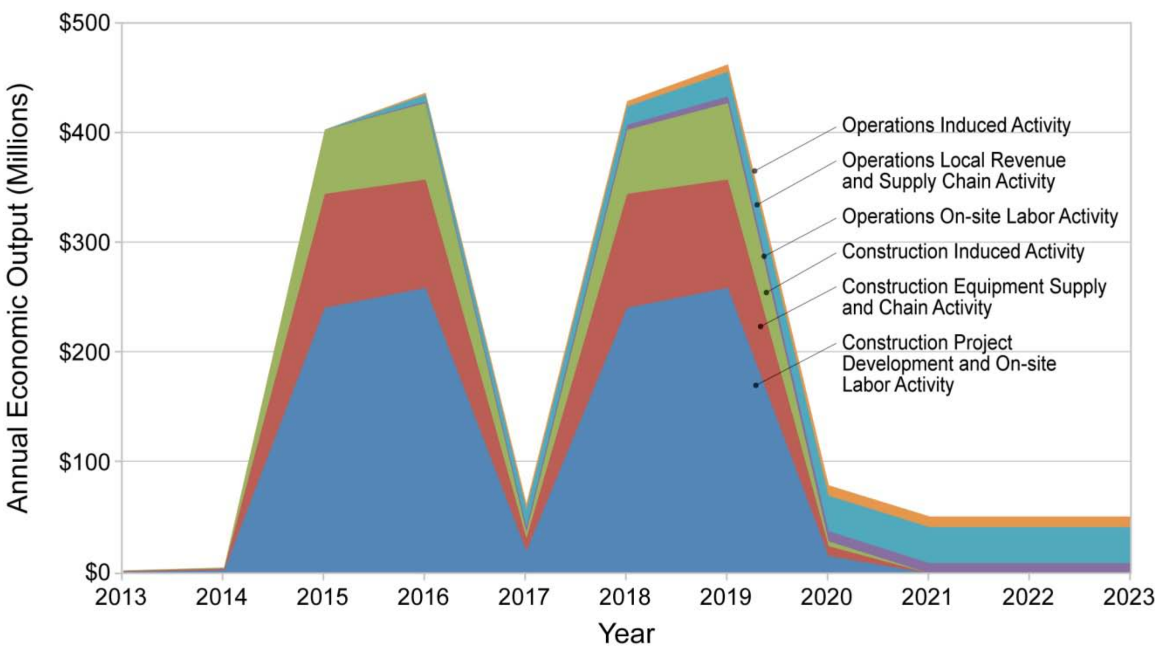

Figure 22. Wyoming economic output annually from construction and operations of new HV transmission

Direct payments to Wyoming government and landowners are primarily in the form of sales tax, property tax, and ROW payments. Sales tax from construction material and equipment purchases is estimated to range from $75,000 to nearly $38 million during peak construction (Figure 23). Sales taxes from material and equipment purchases during operations were estimated at approximately $400,000/year. Average property tax payments per year on the full portfolio of

HV transmission, projects are estimated at nearly $11 million/year.[28] Using estimated ROW payments to state and local landowners and excluding ROW payments to the federal government, the annual equivalent ROW payments were calculated to be approximately $1.8 million/year.[29]

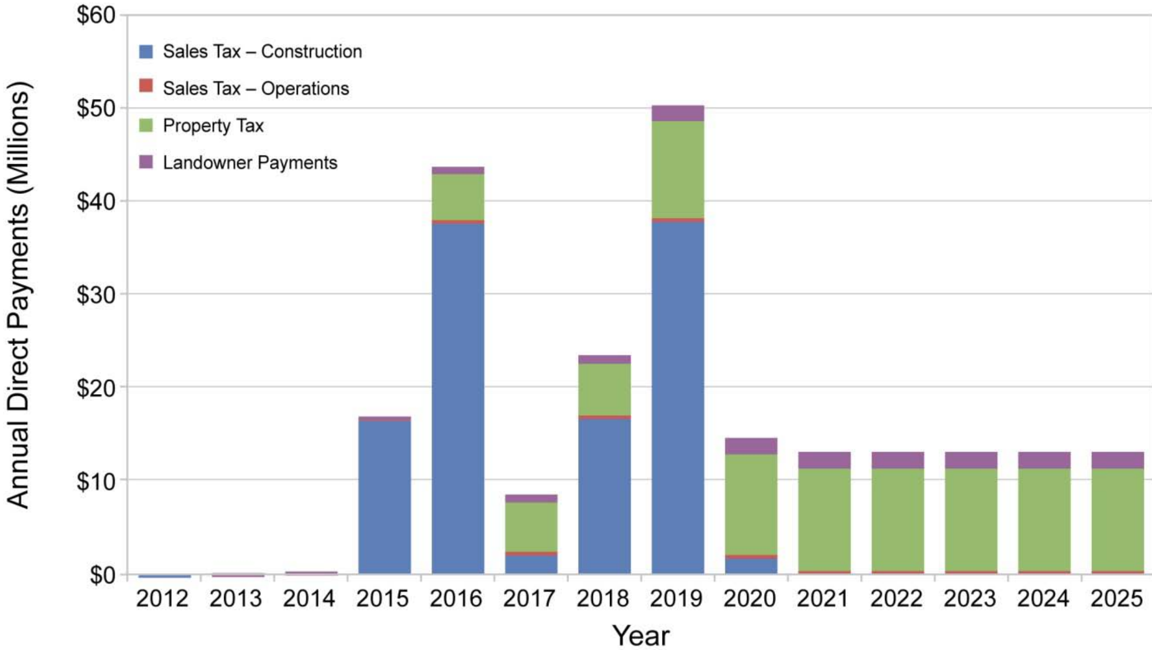

Figure 23. Direct payments to Wyoming government and landowners

For transmission, there is a relatively large amount of uncertainty in some of the key input parameters, as indicated by the range of local purchase coefficients in Table 12. This uncertainty is primarily related to the level of Wyoming construction labor that would be utilized in these projects. Uncertainty exists in these parameters for a variety of reasons. Transmission investments are typically "lumpy" and result in very large expenditures in a very short period of time during construction. If the Wyoming construction sector is at or near full employment—a phenomena that could be exacerbated by the large deployments of wind and natural gas generation occurring at the same time—it may be difficult for Wyoming construction firms to meet the demand for these projects. Uncertainty in the share of Wyoming labor that could be used on these transmission projects persists into the operations period but is somewhat smaller. Nevertheless, significant operations-related labor expenditures (e.g., ROW maintenance) could be contracted to out-of-state firms. Given these uncertainties, Figure 24 illustrates that peak annual employment estimates range from about 3,800 jobs to more than 6,000 jobs. Operations

[28] This estimate is an average based on the NPV (3% discount rate) of all future property tax payments and assumes property tax calculated on the installed cost less depreciation (depreciation is straight-line over 40 years) plus the estimated capitalized value of the land. To the extent that these projects are sited on federal land and make payments in lieu of tax, values may vary.

[29] ROW payments were allocated to each landowner type based on their respective share of Wyoming land as estimated by the University of Wyoming, Department of Geography and Recreation (Drain 2011). Annual equivalent private landowner payments were estimated at approximately $130/acre/year (Black and Veatch 2009), while the annual equivalent ROW payment on state land was estimated at approximately $40/acre/year (Vigil 2010).

period employment is estimated to range from 430–620 Wyoming jobs annually. Output and wages vary to a similar degree.

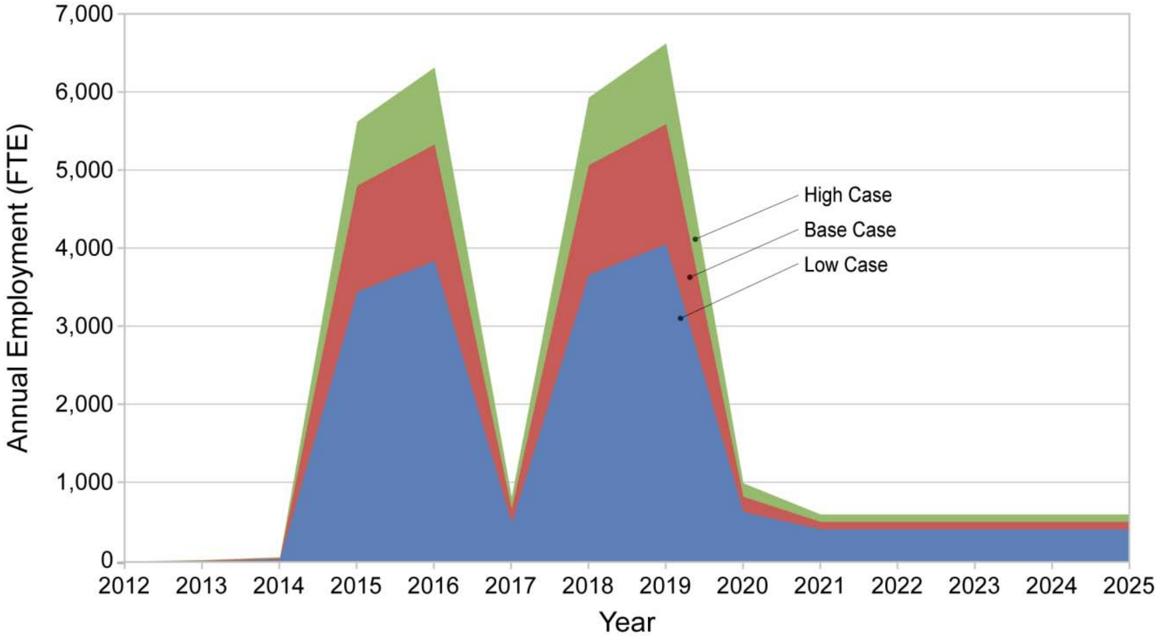

Figure 24. Estimated range of employment from new HV transmission

Summary & Conclusions

Based on the deployment scenario outlined here, as well as current Wyoming market and labor conditions, new wind power, new natural gas generation, and new transmission development in Wyoming could provide a sizable boost to the Wyoming economy and its workers. These projects represent a significant source of new investment in the state during the construction and operations periods (Table 14).

Table 14. Wyoming Share of Project Spending (For Equipment Installed within Wyoming)

Infrastructure Type	Units Installed	Total Installed Cost	Wyoming Share	Annual Operating Expenditures	Wyoming Share
Wind Generation	9,000 MW	$18 billion	16%–22%	$225 million	37%
Natural Gas Generation	1,800 MW	$2.3 billion	22%–33%	$42 million*	18%**
500 kV HVDC Transmission	2	$2.2 billion	21%–32%	$60 million	25%–37%
500 kV HVAC Transmission	2	$1.3 billion	32%–49%	$35 million	26%–32%
230 kV HVAC Transmission	Multiple*	$660 million	25%–40%	$17 million	26%–32%
Total		**$25 billion**	**19%–26%**	**$380 million**	**31%–34%**

*Excludes fuel cost as no incremental change in Wyoming based gas production is expected from these projects.
**Weighted average fixed and variable costs.
Note: Totals may not add due to rounding.

As these investments flow through the Wyoming economy, the total economic activity resulting from these investments is expected to support:

- 8,000–14,000 Wyoming jobs annually during peak construction activity; 35%–50% of peak construction activity is directly in the construction sector
- An average (as opposed to peak) of 4,000–5,900 Wyoming jobs each year for 10 years for construction-related activities
- Wages and benefits to Wyoming workers averaging $200 million–$330 million/year during the 10-year construction period
- 2,300–2,600 Wyoming jobs annually during the operational period of the infrastructure lifecycle (at least 20 years, based on typical financing for new wind power projects)
- Wages and benefits ranging from $100 million–$120 million/year during operations
- Statewide economic activity of $1.2 billion in 2016 and $1.4 billion in 2019 (during peak construction) and $380 million/year during operations-only years
- Total Wyoming economic activity on the order of $12 billion–$15 billion (construction plus 20 years of operations); this represents approximately 30% of the total potential economic activity associated with these projects.

While the heavy construction sector would see a significant boost in activity from this development, the economic activity resulting from these projects is not limited to the construction industry sector. Other Wyoming sectors and businesses would also see significant economic activity. Wyoming businesses that supply the construction sector, including quarries, cement producers, and hardware suppliers would also be affected. Metal fabricators, equipment sales firms, legal and financial services personnel, engineers, and even Wyoming banks may likewise see a boost in business and economic activity. To the extent that existing or new Wyoming manufacturers could supply these projects, a whole array of potential manufacturers could also be affected. Finally, service providers, including restaurants, retailers, childcare providers, and grocery stores, among many others, would see increased business as construction workers and other project beneficiaries spend their paychecks in Wyoming.

Whether this economic potential is ultimately realized or not will depend on a variety of factors. Foremost among these is the demand for Wyoming wind along with the development of new transmission infrastructure to export wind power and natural gas generated electricity across the West. In addition, should the deployment scenario presented here, or one comparable to it, become a reality, an array of factors will influence whether Wyoming will capture this level of economic activity. Parallel deployment of wind, transmission, and natural gas generation could limit Wyoming's ability to contribute local goods and services to this set of projects at the level they have been able to for individual projects in the past and reduce the economic activity below what is estimated here. Alternatively, the development of a Wyoming labor force that can support this type of infrastructure development, along with a modest amount of Wyoming manufacturing capacity to support these types of projects, could significantly increase the potential economic activity occurring in Wyoming from these projects (Lantz and Tegen 2008). In this regard, data suggests that the wind sector has been responsive to the development of large state and regional markets (Lantz et al. 2010) and thus, under the right market conditions, Wyoming may be able to capture a greater share of economic activity resulting from these projects than has been identified in this study.

References

American Wind Energy Association (AWEA). (2011). "U.S. Projects Database." http://www.awea.org/la_usprojects.cfm. Accessed February 2011.

Black and Veatch. (2009). "Western Renewable Energy Zones Generation & Transmission Model Methodology & Assumptions. Version 2.0." Western Governors Association. http://www.westgov.org/wga/initiatives/wrez/gtm/documents/GTM%20V%202.0%20Method%20Assumptions.pdf. Accessed February 2011.

Bureau of Economic Analysis (BEA). (2010). "Regional Economic Accounts: GDP by State." U.S. Department of Commerce. http://www.bea.gov/regional/gsp/ . Accessed February 2011.

Bureau of Labor Statistics (BLS). (2011). "Economy at a Glance: Wyoming." U.S. Department of Labor. http://bls.gov/eag/eag.wy.htm. Accessed February 2011.

Denholm, P.; Hand, M.; Jackson, M.; Ong, S. (2009). *Land Use Requirements of Modern Wind Power Plants in the United States*. NREL/TP-6A2-45834. Golden, CO: National Renewable Energy Laboratory.

Drain, L. (January 6, 2011). Email communication. Wyoming Infrastructure Authority, Cheyenne, WY.

Energy Information Administration (EIA). (2010a). "State Energy Data System (SEDS)." Washington, DC: Energy Information Administration. http://www.eia.doe.gov/states/_seds.html. Accessed February 2011.

EIA. (2010b). "Annual Energy Outlook 2010." Report #:DOE/EIA-0383.Washington DC: Energy Information Administration. http://www.eia.doe.gov/oiaf/archive/aeo10/index.html. Accessed February 2011.

Energy Gateway (2011). *Energy Gateway Conceptual Map.* Pacificorp. http://www.pacificorp.com/tran/tp/eg.html. Accessed February 2011.

Felton, J. (November 22, 2010). Telephone communication. Property Tax Division, Wyoming Department of Revenue, Cheyenne, WY.

High Plains Express. (2010). *Conceptual Drawing. High Plains Express.* http://www.rmao.com/wtpp/HPX_Studies.html. Accessed February 2011.

Justia Laws and Regulations. (2010). "2010 Wyoming Code Title 39: Taxation and Revenue." (W.S. 39-22-101 to 39-22-111). http://law.justia.com/wyoming/codes/2010/Title39/chapter19.html. Accessed February 2011.

Lantz, E.; Oteri, F.; Tegen, S.; Doris, E. (2010). *State Clean Energy Policies Analysis: State Policy and the Pursuit of Renewable Energy Manufacturing.* NREL/TP-6A2-46672. Golden, CO: National Renewable Energy Laboratory.

Lantz, E.; Tegen, S. (2008). *Variables Affecting Economic Development of Wind Energy.* NREL/CP-500-43506. Golden, CO: National Renewable Energy Laboratory.

Overland Transmission Project. (2011). *Conceptual Drawing Overland Transmission Project.* Overland Transmission Project. http://www.overlandtransmission.com/projects.htm. Accessed February 2011.

Parady, K; Lovato, J; Wolf, J; D. Hulme; I. Burke. 2009. *Commercial Wind Energy Development In Wyoming: A Guide For Landowners*. William D. Ruckelshaus Institute of Environment and Natural Resources. University of Wyoming-Laramie, WY, 92 pp.

Pfeifenberger, J; Newell, S. (2010). *Direct Testimony of Johannes Pfeifenberger and Samuel Newell before the Federal Energy Regulatory Committee.* Docket Nos. EL11, ER11; Exhibit AWC-400.

State of Wyoming. (2004). *Rocky Mountain Area Transmission Study.* http://psc.state.wy.us/rmats/rmats.htm. Accessed February 2011.

Threewitt, D.; Vigil, T. (November 16, 2010). Telephone communication. Office of State Lands & Investments, Cheyenne, WY.

TransCanada. (2011). *Zephyr and Chinook Power Transmission Lines.* TransCanada. http://www.transcanada.com/zephyr.html. Accessed February 2011.

TransWest Express (TWE). 2010. *Proposed TWE Project with Route Alternatives Wyoming to Nevada with Potential IPP Interconnection.* TransWest Express LLC.

U.S. Census Bureau. (2010). "National and State Population Estimates: Annual Population Estimates 2000 to 2009." http://www.census.gov/popest/states/NST-ann-est.html. Accessed February 2011.

U.S. Department of Energy. (2008). *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply*. DOE/GO-102008-2567. Washington, DC: U.S. Department of Energy.

U.S. Office of Energy Efficiency and Renewable Energy (EERE). (10 June 2010). "Wyoming: Energy Summary Fact Sheet." http://apps1.eere.energy.gov/states/energy_summary_print.cfm?state=WY. Accessed February 2011.

Western Energy Coordinating Council (WECC). "TEPPC Capital Cost Model." San Francisco, CA: Energy and Environmental Economists, Inc.(http://www.wecc.biz/committees/BOD/TEPPC/Shared%20Documents/Forms/AllItems.aspx?RootFolder=%2fcommittees%2fBOD%2fTEPPC%2fShared%20Documents%2fE3%20Capital%20Cost%20Tool&FolderCTID=&View={3FECCB9E-172C-41C1-9880-A1CF02C537B7}. Accessed February 2011.

Western Governors Association (WGA). (June 2009). *Western Renewable Energy Zones - Phase 1 Report.* http://www.westgov.org/rtep/219. Accessed February 2011.

WGA. (June 2006). *Clean Energy, a Strong Economy and a Healthy Environment.* http://www.westgov.org/wga/publicat/CDEAC06.pdf. Accessed February 2011.

Wind Powering America (WPA) (2010). *80-Meter Wind Maps and Wind Resource Potential.* U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. http://www.windpoweringamerica.gov/wind_maps.asp. Accessed February 2011.

Wiser, R; Bolinger, M. (2010). *2009 Wind Technologies Market Report.* DOE/GO-102010-3107. Washington DC: U.S. Department of Energy.

Wyoming Department of Revenue (WY DOR) (2010). *Sales and Use Tax Rates (effective 10/01/2010).* Wyoming Department of Revenue. http://revenue.state.wy.us/PortalVBVS/DesktopDefault.aspx?tabindex=3&tabid=10

Wyoming Infrastructure Authority (WIA) 2011. *Transmission Projects Currently Under Development in Wyoming.* http://wyia.org/projects/. Accessed February 2011.

Wyoming-Colorado Intertie (WCI) (2011). *Map 1.* http://www.wcintertie.com/maps/Map%201.pdf.

Appendix A: Supplementary Background on the Wyoming Infrastructure Authority

On August 22, 2003, Wyoming Governor Dave Freudenthal and Utah Governor Mike Leavitt announced the formation of the *Rocky Mountain Area Transmission Study* (RMATS). The governors found that:

> For many years, utilities and other entities have been reluctant to make investments in needed electric transmission infrastructure. This was due to a number of factors, including protracted uncertainties in the regulatory environment and nascent regional transmission organizations under development. As a consequence of this lack of transmission expansion, transmission congestion and bottlenecks were increasing. While this was a problem throughout the western interconnect, it was becoming an acute issue in areas of the Rocky Mountain sub-region (State of Wyoming 2004, pp. 1-5–1-6).

The governors directed that a charter be developed for the study that specified goals, principles, and operating procedures. The study covered several western states including Colorado, Idaho, Montana, Utah, and Wyoming.

Emerging from these efforts, the WIA was established by the Wyoming Legislature in 2004 to diversify and expand the state's economy through improvements in the electric transmission system to resolve constraints and create new capacity for the export of Wyoming resources in the form of electricity. The enabling legislation authorizes the WIA to plan, finance, construct, develop, acquire, own, maintain, and operate transmission infrastructure within and outside the State of Wyoming. Also, the legislation provided the WIA with bonding authority of $1 billion and other powers to promote transmission development in the state and throughout the region. It also provided the State Treasurer, with the approval of the State Loan and Investment Board, the authority to invest in WIA bonds. To date the WIA has closed a private placement of $34.5 million in bonds with the Wyoming State Treasurer for a transmission-related project.

In order to encourage and assure the development of new transmission originating in Wyoming, the WIA, in support of the findings and recommendations from the RMATS report (State of Wyoming 2004), became a partner in various planning and project efforts within 2 years of the release of the report. In addition to its operating budgets, the legislature authorized the State Treasury to loan up to $10 million to the WIA in the form of loans to be used for project development purposes. Two million dollars has been drawn to date and has been expended on specific project development initiatives.

The governing body of the Authority is composed of a five-member Board of Directors appointed by the Governor, with the advice and consent of the Wyoming State Senate. Current Board Members and staff are as follows:

- Mike Easley (Chairman), CEO of Powder River Energy
- Kyle White (Vice-Chairman), Vice President of Regulatory and Governmental Affairs for Black Hills Corporation

- Bryce Freeman (Treasurer), Administrator of the Wyoming Office of Consumer Advocate
- J.M. Shafer, (Member), Recently retired from Tri-State Generation and Transmission Association, Inc.
- Bret Jones, (Member), Senior Vice President, George K. Baum & Company

Current staff consists of:

- Loyd Drain, Executive Director
- Holly Martinez, Administrative Manager

Appendix B: Transmission Projects Currently Under Development in Wyoming

At the time of the formation of the WIA in 2004, no major power transmission projects had been developed in Wyoming in over 20 years. Given Wyoming's excellent wind resources and in part as a result of WIA's monetary participation and support, there are currently six major projects under varying stages of development in Wyoming (Figure B-1). The details on each of the projects under development are discussed below in the order of their announced formation.

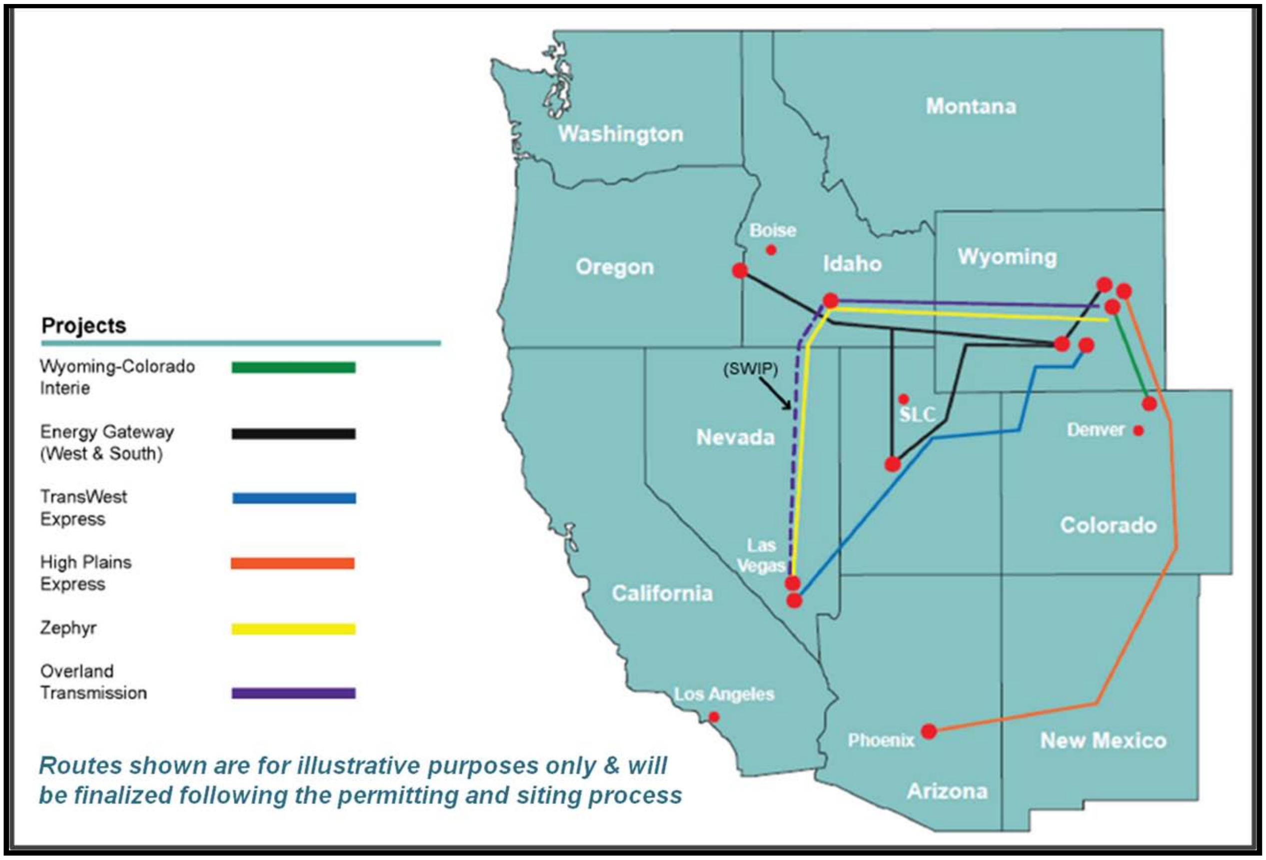

Figure B-1. Transmission Projects in Various Stages of Development in Wyoming

Source: WIA 2011

TransWest Express Transmission Project

The TransWest Express (TWE) Transmission Project is a HVDC transmission line that will deliver 3,000 MW of electric power generated in Wyoming to people in California, Arizona, and Nevada. With a 725 mile proposed route, the TWE project takes the shortest path between the two regions and provides a high-capacity direct link that is intended to be both economically and environmentally sensitive, efforts that are facilitated by the use of DC technology. The proposed project is sited primarily on federal land.

The TWE project was inspired in part by the RMATS study (State of Wyoming 2004), which identified the potential for communities in the western United States to access the rich renewable energy resources in the Rocky Mountains through the development of major transmission lines. Originally initiated by Arizona Public Service Company in 2005 with the WIA as a project participant, the TWE project was acquired in 2008 by private developer TransWest Express LLC.

TWE has pursued the next phase of development through its permitting and Western Electricity Coordinating Council (WECC) rating activities. In 2008, TWE filed an amended ROW application with the Bureau of Land Management (BLM), which is preparing an Environmental Impact Statement pursuant to the National Environmental Policy Act (NEPA). In 2010, Western Area Power Administration (WAPA) joined BLM as a lead agency on the Environmental Impact Statement (EIS). WAPA also decided to pursue a 50% equity partnership in the TWE project, underscoring the project's sensibility and strategic importance. Meanwhile, the TWE project continues to move through the WECC Path Rating process with a planned rating of 3,000 MW. The proposed routing of the TWE is shown in Figure B-2.

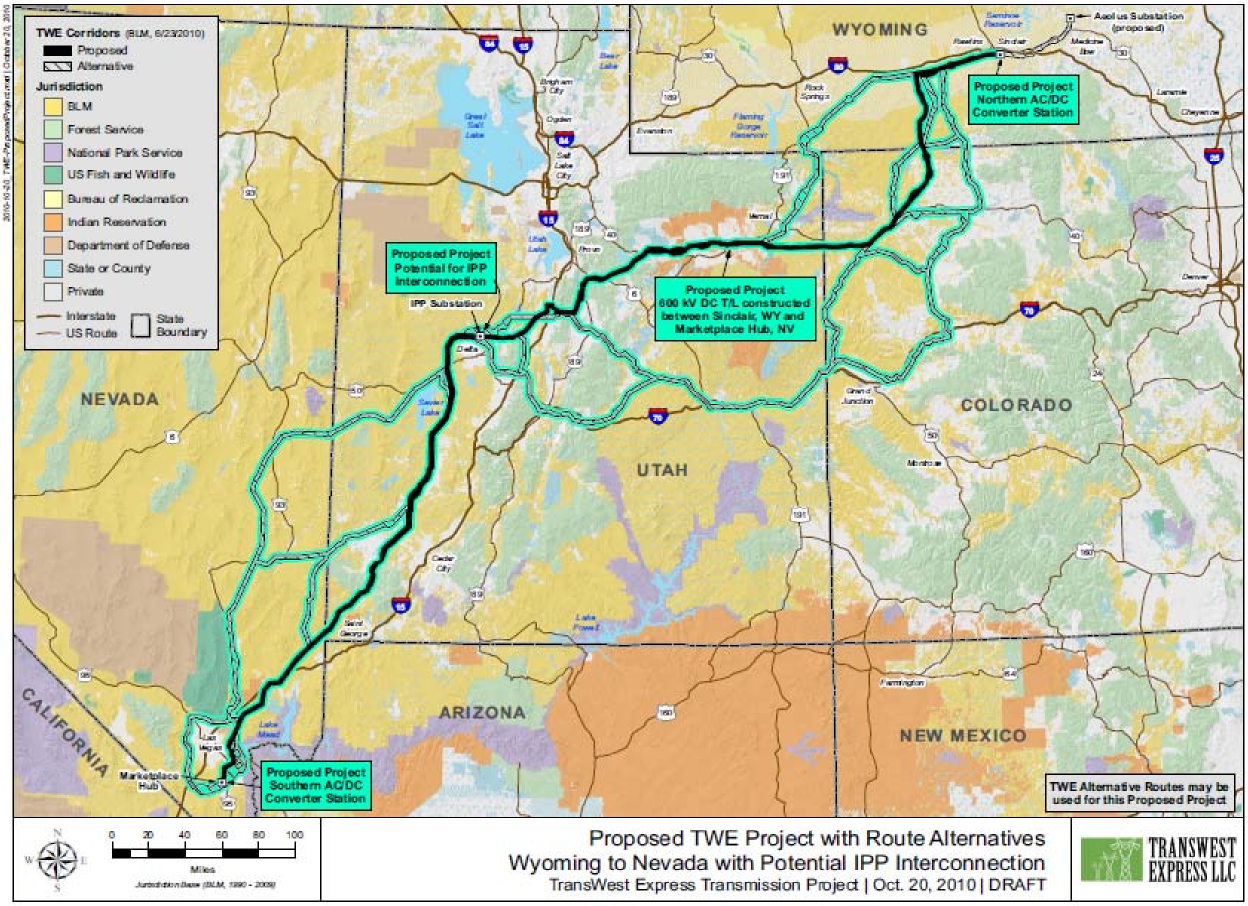

Figure B-2. Conceptual routing of TWE 600 kV HVDC transmission line

Source: TWE 2010

TWE Project at a Glance:

- 600 kV HVDC
- Capacity: 3,000 MW capacity
- Length: 725 mile proposed route starting in Carbon County, Wyoming, and ending south of Las Vegas
- In-service date: 2015
- Cost: $3 billion
- Developer: TransWest Express LLC
- Permit status: BLM and WAPA are joint lead agencies for NEPA compliance; TWE submitted amended ROW application in 2008; BLM and WAPA planning to hold public scoping meetings in the first quarter of 2011

- Business model: Focused on development activities, including permitting; business model to be determined; WAPA's portion of the project to be funded through its Transmission Infrastructure Program
- Contact: David Smith, David.Smith@tac-denver.com, 303-299-1000 www.transwestexpress.net.

Wyoming-Colorado Intertie Project

In the fall of 2005, a public/private partnership consisting of the WIA, Trans-Elect Development Company (Trans-Elect), and WAPA was formed to consider the expansion of transmission capacity across the long-standing transmission constraint along the Wyoming-Colorado border known as TOT 3. Today, the project is known as the Wyoming-Colorado Intertie (WCI) project—a project that was suggested for development by a consensus of regional stakeholders in the RMATS study (State of Wyoming 2004). On behalf of the partnership, in November 2005, WAPA posted a solicitation of interest in the federal register to gain a measure of interest in the project. On the basis of the robust response to the WAPA posting, the parties were sufficiently encouraged to proceed with studies. Trans-Elect subsequently assigned their interest to an affiliate of AES Corporation (AES), and in 2009, an LS Power Affiliate (LS Power) acquired the WCI project from AES. LS Power and WIA continue to maintain a 50/50 partnership for the development stage of the WCI project. The proposed routing of the WCI project is shown in Figure B-3.

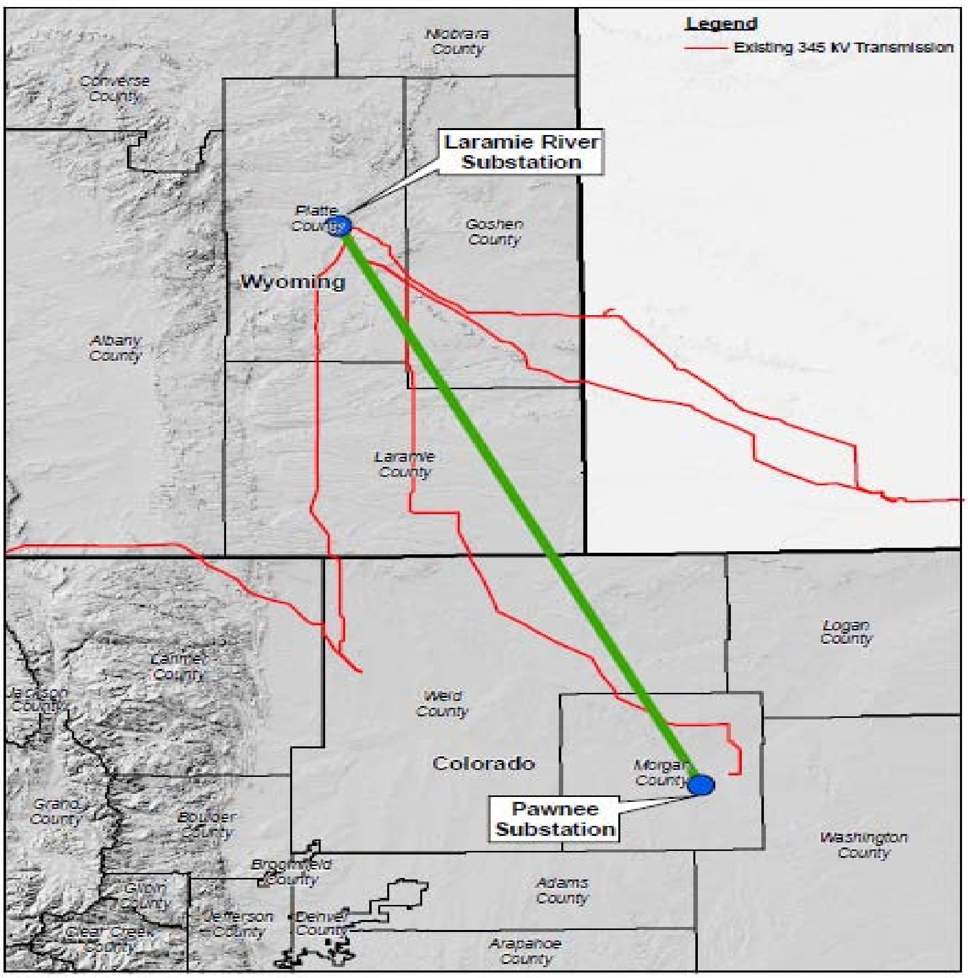

Figure B-3. Conceptual route for the WCI project

Source: WCI 2011

The project partners have completed a series of technical, cost, and market fundamentals studies with independent consultants. These studies were utilized to create system design, determine project costs, identify potential corridors and configurations, develop project schedules, ascertain permitting requirements, and assess the competitive position of the WCI. Simultaneously, the project partners have held a number of public and individual meetings with generation developers and utilities to assess the market demand and the project's economic feasibility. The project feasibility assessments have taken advantage of input from stakeholders to gauge support for the project as well as other studies that have been or are being conducted within the TOT 3 area, including the Colorado Long-Range Transmission Plan, developed under the auspices of the Colorado Coordinated Planning Group (CCPG), and the Wyoming Joint Queue Study.

Activities have confirmed the presence of large amounts of wind generation projects under development along the path of the WCI project that are expected to have high quality wind regimes. The development of the WCI project is expected to be capable of providing low-cost wind energy and add geographic diversity to Colorado's wind energy supply. The WCI project may offer increased reliability, relieve an existing transmission constraint, and increase firm transmission capacity to neighboring systems.

WCI Project at a Glance:

- 345 kV HVAC
- Capacity: 850 MW
- Length: 180 mile transmission line between Wyoming and the Colorado front range delivering Wyoming generation to Colorado
- In-service date: 2014
- Cost: < $300 million
- Developers: LS Power, WAPA, WIA
- WECC Path Rating Process: Phase I complete; currently in Phase II
- ROW & Permitting Status: Will proceed after the awarding of capacity
- Status:
    - FERC approval to sell transmission rights at negotiated rates
    - FERC approved open access transmission tariff
    - Project has been entered into the WECC CCPG regional planning group

- Business Model: independent model, end market(s): Load serving entities (i.e., retail electricity providers) in Colorado
- Complementary Projects: Public Service Company of Colorado (PSCO)'s expansion of their system in northeast Colorado and the High Plains Express.
- Contact: Adam Gassaway, agassaway@lspower.com, 636-532-2200 www.WCIntertie.com.

Energy Gateway Projects

In May 2007, PacifiCorp launched the Energy Gateway Transmission Expansion—a multi-year $6 billion investment plan that will add approximately 2,000 miles of new transmission line across the West. Energy Gateway and projects planned by other entities are expected to alleviate constraints and address current and future electricity load growth. The network of new transmission constituting the Energy Gateway project is shown in Figure B-4.

Figure B-4. Energy Gateway transmission network, conceptual design

Source: PacifiCorp 2011

Today, while construction is underway on one Energy Gateway segment and outreach, siting and permitting processes continue for several others. Major segments are scheduled to be in service by 2014.

Among its attributes, Energy Gateway will provide access to conventional energy sources and connect areas where renewable energy development possibilities are strong including wind, solar, biomass, and geothermal potential.

The Energy Gateway projects are integral to PacifiCorp's Integrated Resource Plan. This plan identifies a need for more transmission lines to deliver electricity from new generating resources—either from new generating plants or to provide a path for additional energy purchases from other entities in the region. PacifiCorp's Energy Gateway network of proposed transmission seeks to accommodate broad regional transmission needs but prioritizes projects with a direct impact on PacifiCorp's service territory and ratepayers.

Energy Gateway Projects at a Glance:

Energy Gateway West (GWW)

- 500 kV HVAC and 230 kV HVAC in and between Wyoming and Idaho
- Capacity: Up to 3,000 MW to Wyoming and Idaho
- Length: Part of approximately 2,000 miles of new HV transmission lines PacifiCorp plans to build to address long-term, native-load, and third-party needs in its six-state service territory (WY, UT, ID, OR, WA, CA)
- In-service date (estimated): 2014–2018
- Cost: Part of $6 billion total Energy Gateway estimated project cost
- Developers: PacifiCorp and Idaho Power
- WECC Path Rating Process: Phase II
- ROW & permitting status: Formal application was filed with the BLM in 2007
- Status:
    - BLM scheduled to publish the draft Environmental Impact Statement in December 2010
    - BLM Record of Decision scheduled for November 2012
    - Local and state permitting to occur during 2011–2012
- Business Model: Utilities rate-base, end market(s): to address PacifiCorp's and Idaho Power's native-load and third-party needs

Energy Gateway South (GWS)

- Single Circuit 500 kV HVAC transmission line from Wyoming to central Utah
- Capacity: Up to 1,500 MW
- Length: Part of approximately 2,000 miles of new HV transmission lines; PacifiCorp plans to build to address long-term, native-load, and third-party needs in its six-state service territory (WY, UT, ID, OR, WA, CA)
- In-service date (estimated): 2017–2019
- Cost: Part of $6 billion total Energy Gateway estimated project cost
- Developers: PacifiCorp is leading the development
- WECC Path Rating Process: Phase II

- ROW & permitting status: Formal ROW application has been filed with BLM in 2007; third-party contractor for NEPA compliance has been retained
- Status:
    - BLM Agency scoping scheduled for first quarter 2011
    - Feasibility studies have been completed
    - Stakeholder meetings have been held in Utah, Wyoming, Colorado, and Nevada
    - Project has been entered into the WECC, Northern Tier Transmission Group, and Southwest Area Transmission regional planning groups
    - Study group meetings started May 2009
- Business model: Utility-rate base model, end market(s): to address PacifiCorp's native-load needs and third-party transmission service requests
- Contact: ConstructionProjects@pacificorp.com, 801-220-4221 http://www.pacificorp.com/tran/tp/eg/gs.html.

Zephyr Project

The Zephyr project is a proposed 500 kV HVDC power transmission line originating near Chugwater, Wyoming, traversing Idaho, and terminating in the Eldorado Valley, south of Las Vegas (Figure B-5). The Zephyr project is estimated to cost approximately $3 billion and is scheduled to commence operations in 2016. The Eldorado Valley was chosen as the southern terminus as it represents the electric transmission gateway to California and other major markets in the Southwest and creates the possibility of a renewable energy trading and balancing hub. Zephyr may add an intermediate converter station near the existing Borah substation in southern Idaho should future market conditions warrant.

Figure B-5. Conceptual routing for the 500 kV HVDC Zephyr Project

Source: TransCanada 2011

In February 2009, TransCanada, the project developer, obtained negotiated rate authority from the Federal Energy Regulatory Commission and held an open season for transmission capacity. This open season resulted in the full 3,000 MW of capacity being subscribed by major wind developers operating in Wyoming. Zephyr is the first multi-state transmission project in the United States to be fully subscribed by renewable energy developers.

Zephyr will deliver 3,000 MW of new wind energy generation from Wyoming to loads in the Southwest, including California, Nevada, and Arizona. The Zephyr line and the 3,000 MW of wind development that would underpin the line are expected to result in approximately $9 billion in new investment in the West. Zephyr's firm delivery of Wyoming wind into California is expected to reduce the carbon footprint of needed, new generation resources in the Western Interconnection.

Zephyr's direct and contiguous transmission path from the very high quality wind resource in Wyoming to southwestern markets, backed by TransCanada, is one possible solution to renewable energy objectives in the West.

Zephyr Project at a Glance:

- 500 kV HVDC
- Capacity: 3,000 MW
- Length: 1,000 miles
- In-service date: 2016
- Cost: $3 billion
- Market(s): Nevada, Arizona, and California
- Developer: TransCanada
- Status:
    - Fully subscribed to three creditworthy wind developers
    - In WECC Path Rating Process, Phase 1
    - Preliminary application filed with the BLM
    - Project is in pre-permitting phase
- Contact: John Dunn, Project Manager—Zephyr Power Transmission Line, john_dunn@transcanada.com, 403-920-5566 http://www.transcanada.com/zephyr.html.

High Plains Express Transmission Project

The High Plains Express Transmission Project (HPX) is a plan for the expansion and reinforcement of the transmission grid in the states of Wyoming, Colorado, New Mexico, and Arizona. The goal is to develop a HV backbone transmission system that will enhance reliability and increase access to renewable and other diverse generation resources within regional energy resource zones (Figure B-6).

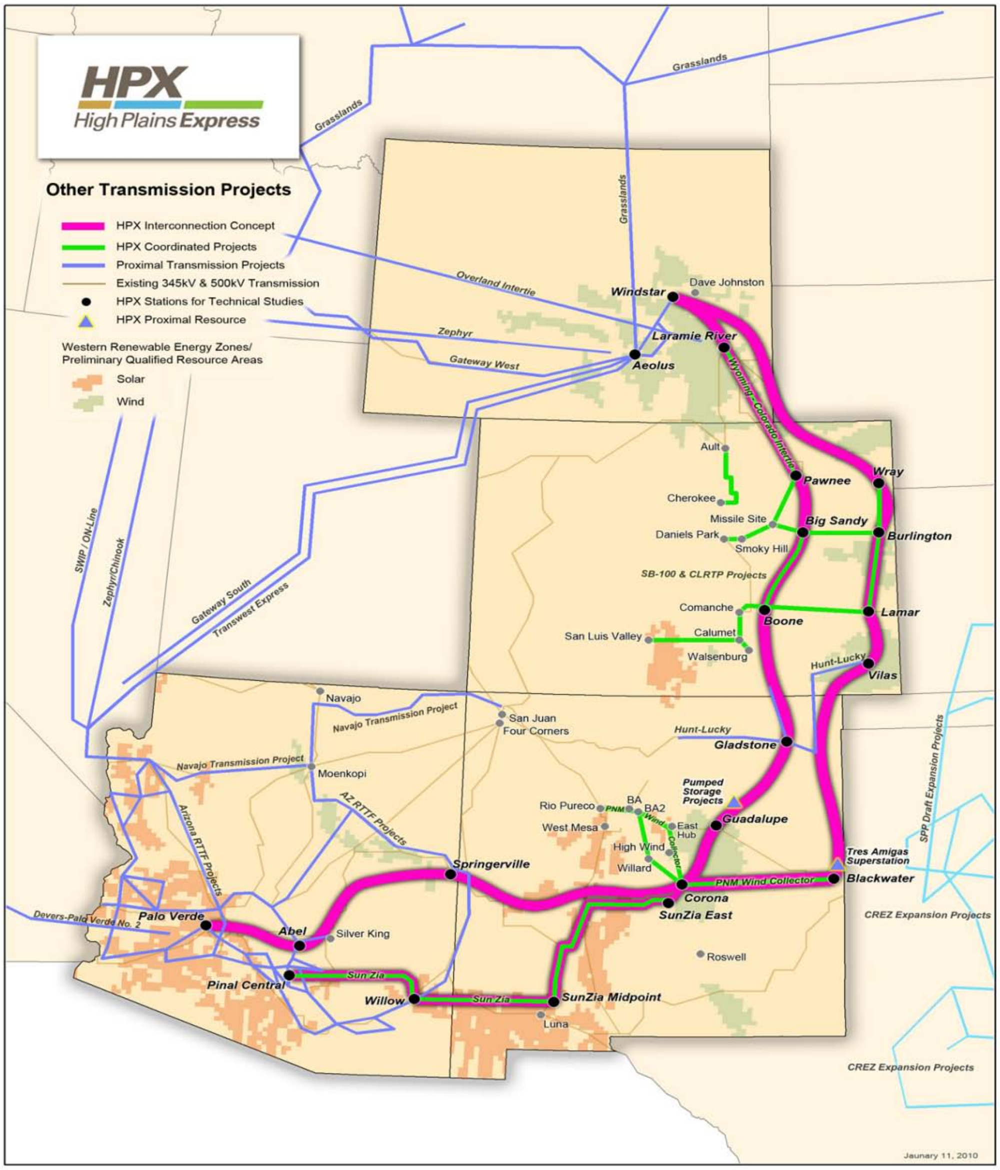

Figure B-6. Conceptual drawing of the proposed High Plains Express project

Source: High Plains Express 2010

The first stage of the HPX was a joint participation feasibility study that explored transmission alternatives and was completed in 2008. The second stage includes more detailed studies to further address issues such as siting, permitting, preliminary design options, and commercial feasibility. The second stage efforts are in the process of being completed including preparation of a final report. The HPX participants are planning to review the second stage results with stakeholders near the end of the first quarter of 2011.

The project participants are now planning to initiate an evaluation (stage 3) effort that will focus on evaluating the stage two results, monitoring pertinent regulatory developments, and considering the potential for development of the HPX project. The evaluation efforts will include further examination of energy demand forecasts, changes in projected costs, renewable technology developments and improvements, and other cost factors that could impact both the need and economic viability of the project.

Various potential attributes are driving development of the HPX project and the collaboration involved with this effort including:

- Increase transmission capability to reach various markets
- Increase import and export transfer capabilities
- Minimize environmental impacts by sharing utility corridors
- Help states meet renewable energy standards.

HPX Project at a Glance

- 500 kV AC transmission line
- Length: approximately 1,300 miles
- In-service date: To be determined
- Cost: Preliminary capital cost estimates range from $3.5 billion for a single circuit line to $5.5 billion for one double circuit line
- Project Participants: Colorado Springs Utilities, Public Service Company of New Mexico, Salt River Project, LS Power, Tri-State G&T, WAPA, Xcel Energy, New Mexico Renewable Energy Transmission Authority, WIA, Colorado Clean Energy Development Authority, Black Hills Corporation, and NextEra Energy Resources.
- Contact: Thomas Green, Thomas.Green@xcelenergy.com, 303-571-7223

Overland Transmission Project

LS Power, though its affiliate Jade Energy Associates, LLC (Jade Energy), is developing the Overland Transmission Project. The project is planned as a HVDC transmission project capable of transmitting 2,000–3,000 MW. The Overland Project will begin in the high wind region of southeastern Wyoming and continue west across southern Wyoming and Idaho to Midpoint Substation near Twin Falls, Idaho (Figure B-7). At Midpoint Substation, the Overland Project will connect with the Southwest Intertie Project (SWIP), which is also being developed by LS Power through its affiliate Great Basin Transmission, LLC (Great Basin). The SWIP is a 500 kV AC transmission project that will connect Midpoint Substation to the Desert Southwest and California load centers in the Eldorado Valley. SWIP is expected to begin construction in early 2011 and will provide the Overland Project a path to key markets.

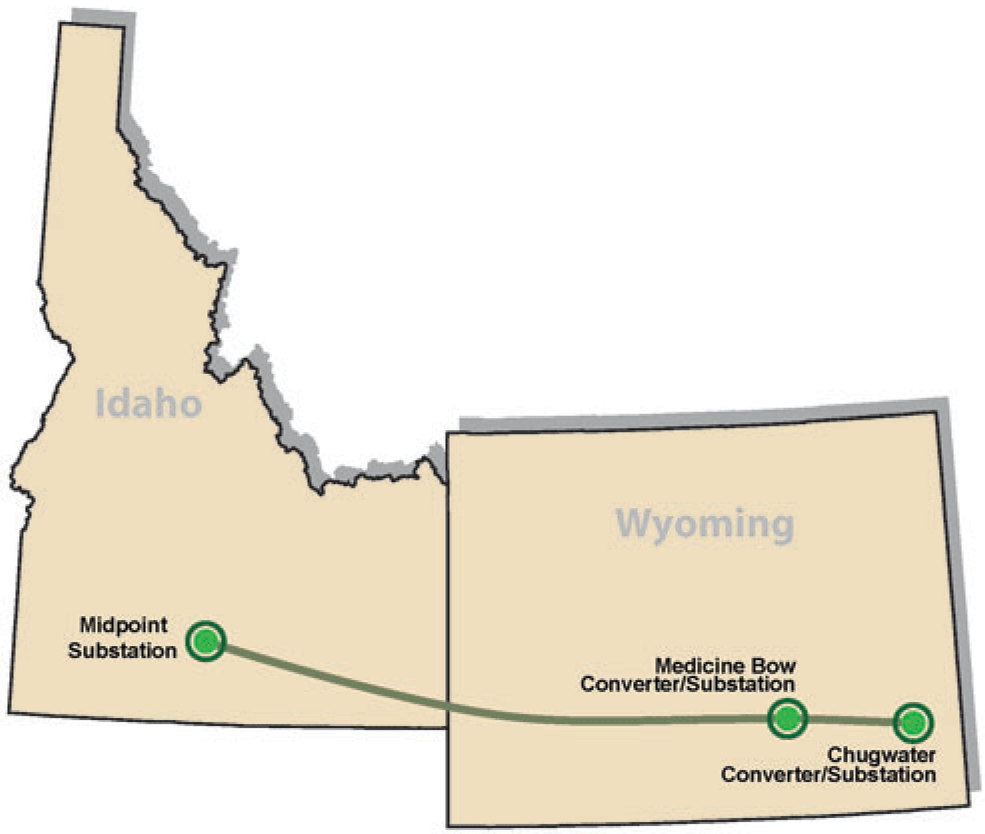

Figure B-7. Proposed Overland Transmission Project, conceptual design

Source: Overland Transmission Project 2011

Jade Energy's development activities have focused on working with regional communities, identifying potential route options, applying for long lead permits, and identifying potential transmission customers and market solutions. These efforts include identifying the proposed project area, meeting with key stakeholders within the project area, forming working groups comprised of members of communities in the region, gathering information critical for the development of routing alternatives, and engaging federal, state, and local permitting agencies to begin the pursuit of required permits and approvals. Jade Energy and Great Basin are conducting an open season process to identify transmission customers for the Overland Project and SWIP.

The companies received interest for the projects in amounts that far exceed the capacity of either project and are negotiating with interested parties.

Overland Project at a Glance:

- HVDC transmission line from Wyoming to Idaho.
- Capacity: 2,000–3,000 MW
- Length: approximately 550 miles
- In-service date: as early as 2016
- Cost: Confidential
- Developer: Jade Energy Associates, LLC
- ROW & permitting status: SF-299 application has been filed with BLM
- Business model: Independent or anchor tenant model, end market(s): Idaho, Nevada, Arizona, southern California, and Oregon
- Contact: Luke Papez, lpapez@lspower.com, 636-532-2200
- www.overlandtransmission.com, www.lspower.com/projects.htm.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*
March 2011

2. REPORT TYPE
Technical Report

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Jobs and Economic Development from New Transmission and Generation in Wyoming

5a. CONTRACT NUMBER
DE-AC36-08GO28308

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Eric Lantz and Suzanne Tegen

5d. PROJECT NUMBER
NREL/TP-6A20-50577

5e. TASK NUMBER
WTQ1.1000

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/TP-6A20-50577

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)
NREL

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*
This report is intended to inform policymakers, local government officials, and Wyoming residents about the jobs and economic development activity that could occur should new infrastructure investments in Wyoming move forward. The report and analysis presented is not a projection or a forecast of what will happen. Instead, the report uses a hypothetical deployment scenario and economic modeling tools to estimate the jobs and economic activity likely associated with these projects if or when they are built.

15. SUBJECT TERMS
Wyoming; wind; natural gas; jobs; economics; high voltage transmission

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	UL		
					19b. TELEPHONE NUMBER (*Include area code*)

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18