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Economic Development from New Generation and Transmission in Wyoming and Colorado

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Executive Summary

This research quantifies the gross jobs and economic development impacts that could result from a 900-MW wind power plant and a 225-MW natural gas-fired power plant, both located in southeast Wyoming, as well as a 180-mile transmission line originating in southeast Wyoming and terminating in northeast Colorado. Based on the proposed Wyoming-Colorado Intertie Project, this scenario allows wind and natural gas-fired electricity generated in Wyoming to serve Colorado consumers. The projects, if implemented, are assumed to further impact the two-state region by increasing demand in the Colorado-based wind power manufacturing sector.

The combined investment in new power sector infrastructure (wind and natural gas generation and high voltage transmission) considered in this analysis is estimated at $1.8 billion. Of the total proposed capital investment, an estimated 80% would be spent in Wyoming and Colorado. Operations and maintenance cost of the facilities is estimated to require ongoing annual investments of approximately $65 million, with 27% flowing into the combined two-state region.

Given current economic conditions in Wyoming and Colorado, these expenditures are estimated to support:

- An average of nearly 4,000 jobs annually during the projects' three-year construction period–1,300 in Wyoming and 2,700 in Colorado
- Average annual wages paid to construction period jobs supported by the projects of $52,000 to $75,000
- Nearly 300 long-term jobs in Wyoming and 100 long-term jobs in Colorado that earn average wages between $41,000 and $63,000 annually while projects are in operation.
- Total economic activity (gross output) of $2.4 billion during the projects' construction and approximately $70 million annually during operation; assuming 20 years of operation, this results in a total cumulative impact of approximately $3.7 billion.

These impacts are dependent on several factors, some of which can vary based on underlying economic conditions and electricity sector market conditions. Significant potential sources of uncertainty include capital expenditures during construction, operations and maintenance (O&M) expenditures, and estimates of local content during both construction and operations.

Despite the possibility of variation in actual results, current economic conditions in the two states are consistent with the local content assumptions made in this analysis. Moreover, industries in which employment has been declining would be among the most heavily impacted by these proposed projects, suggesting that there is sufficient flexibility to serve an incremental increase in demand within these sectors. In addition, the results from this study are generally consistent with impacts observed elsewhere in the literature and reported by communities that have experienced wind power development activity in Colorado, Iowa, Minnesota, Texas, and elsewhere.

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1 Introduction

New investments in power generation and transmission infrastructure provide opportunities for short-term and long-term economic development in the states and at the sites where the investments are constructed, as well as in those regions that manufacture equipment for the power sector (Pfeifenberger and Hou 2011; Lantz and Tegen 2011; NorthStar Economics 2009). Short-term economic development opportunities are typically in the form of construction and manufacturing activities; long-term economic development results from ongoing payments to landowners (e.g., wind leases), state and local government (in the form of property, sales, and income tax), investors, and operations and maintenance (O&M) technicians.

Investments in renewables such as wind power are noteworthy because they often drive investment in rural areas where high quality resources are located (Slattery et al. 2011; Brown et al. 2012). In many cases, this results in opportunities for new economic development in regions that might otherwise be lacking sources of investment. Investments in new power generation and transmission infrastructure also support improvements in power system reliability and operations (Pfeifenberger and Hou 2011).

New power sector investments in Wyoming and Colorado create the opportunity for economic development in both states. Wyoming's high quality wind resource and Colorado's clean energy manufacturing base offer the potential to capture a substantial share of the economic development activity from new power sector investments in wind power within the region. This analysis was developed to inform stakeholders of the economic development potential to Colorado and Wyoming from new wind and natural gas power generation in Wyoming and new transmission located in both states.

This study was commissioned by the Wyoming Infrastructure Authority (WIA) and follows previous economic development impacts analysis completed by NREL for the WIA (Lantz and Tegen 2011).[1] This report and analysis are based on elements of the proposed Wyoming-Colorado Intertie Project, a transmission line first considered in 2004 that would link electricity generation and transmission infrastructure between Wyoming and Colorado.[2] Specifically, this analysis considers wind- and natural gas-driven electricity generation facilities located in Wyoming and new transmission capacity between Wyoming and Colorado.

Recent Trends in Employment in Wyoming and Colorado

This study occurs in a year marked by relatively high unemployment and tepid job growth, both nationally and in Wyoming and Colorado. Wyoming observed average annual job growth of 1.7% between 2000 and 2010. Over this same time period, Colorado observed average annual growth of 0.8% each year (BEA 2012). However, annual job growth has not been consistent within individual sectors in each state's economy. For example, manufacturing jobs in both states have been declining since 2000. In Colorado, manufacturing shrank an average of 3.3% each year between 2000 and 2010; it decreased an average of 0.6% each year in Wyoming (BEA 2012). In addition, from 2000 to 2010 construction sector employment was up 1.9% per year on average in Wyoming and down 2.0% per year on average in Colorado (BEA 2012).

[1] For more information about the WIA, please see Appendix A: The Wyoming Infrastructure Authority.
[2] For more information about the Colorado-Wyoming Intertie Project, please see Appendix B.

More recently, the economic downturn of 2008 continues to be felt. Employment data from 2010 show year-over-year job losses of 0.7% in Wyoming and 0.3% in Colorado (BEA 2012).[3] This amounts to nearly 14,000 jobs lost between 2009 and 2010. Particularly, the construction sector has been hit hard. Between 2009 and 2010, construction jobs in Wyoming decreased 0.6%, while they contracted 9.4% in Colorado (BEA 2012). Nevertheless, approximately 70% of the population over 16 years of age, in both Wyoming and Colorado, is either employed or actively seeking work.[4] This is somewhat higher than national labor force participation, where only 65% of the population over 16 is active in the labor force (Census 2011a).

The downturns described here are primarily in industries directly affected by infrastructure development–those that construct projects and those that manufacture machinery and equipment. This, in combination with high labor force participation in Wyoming and Colorado, suggests that a regional labor force can be utilized to develop the potential project analyzed in this report.

[3] These numbers include farm workers and proprietors.
[4] Wyoming has a total population of 443,141 over the age of 16. Colorado has a total population of 3,937,831 over the age of 16 (Census 2011b).

2 Project Scenario

This analysis considers potential new wind and natural gas electricity generation capacity in Wyoming as well as new transmission capacity in both Wyoming and Colorado. Electricity generated and transported by these facilities could be purchased by both Wyoming and Colorado utilities. The economies of Wyoming and Colorado are both expected to be affected, so potential impacts to both states are analyzed.

New investments in infrastructure considered in this analysis were defined by the WIA and grounded in proposed projects. WIA also defined some key modeling variables, including expected procurement patterns for labor and wind turbines. Modeling inputs not defined by the WIA were estimated by NREL based on previously developed data (e.g., Lantz and Tegen 2011) and ongoing internal data collection. All modeling inputs have been reviewed and verified by the WIA and its partner organizations. Although attempts have been made to develop modeling inputs that reflect realistic investment levels and spending patterns, this analysis is not intended to be predictive of actual project specifications. Rather, it is an estimate given current plans or proposals.

For this analysis, project development is modeled over two periods: construction and operations. Construction is a three-year period during which planning, development, and construction of the proposed projects will occur. Once commissioning occurs, the operation period begins; it continues for the life of the facilities.

Wind Generation: 900 MW

New wind generation modeled in this analysis has a nameplate capacity of 900 MW; turbines are nominally assumed to be 3.0 MW each. The analysis assumes that wind turbine blades, nacelles, and towers are manufactured in Colorado. This premise is feasible based on Colorado's existing wind power manufacturing capacity, but will ultimately depend on the turbine vendor that is selected for this potential project. Labor and other basic materials used in the construction of the wind facility and procured from the two-state region are generally assumed to come from both states in equal proportions (e.g., 50:50). During the operating period, only wind turbine replacement components are sourced from Colorado. To the extent possible, general materials required during operations (e.g., gear oil, basic hardware, tools) are procured from Wyoming and operations personnel are assumed to reside in Wyoming.

Natural Gas-Fired Generation: 225 MW

A natural gas-fired generation facility with a nameplate capacity of 225 MW is also included. The operational efficiency and subsequent gas usage of facilities such as this can vary as a function of dispatch, altitude, and temperature.[5] This particular plant is not assumed to provide direct balancing for the proposed wind generation. Instead, it is intended to utilize excess transmission line capacity when available. For the purpose of this scenario, it is assumed that this new plant has no incremental impact on natural gas production from either Wyoming or

[5]The authors of the study are grateful to Joseph Ferrari and Dennis Finn of Wartsila North America, Inc. for their valuable insight into fuel requirements for natural gas driven-electricity generation and natural gas-powered generators in general.

Colorado, and therefore gas production is not considered to be an additional economic development source in this study. Nevertheless, natural gas fuel production does constitute a significant source of revenue in the form of severance taxes and jobs for both states.

Transmission: 180 miles of 345 kV

A single-circuit 900-MW, 345-kV alternating current (AC) transmission line represents the final component of this analysis. This line is modeled as a 180-mile line. One hundred miles are located in Wyoming and 80 miles are located in Colorado. The planned transmission line is assumed to rely on two existing substations, each requiring some improvements and upgrades.

Project Ownership: Independent Power Producer/Merchant Transmission Line

For the purposes of this study, financing from outside of the Wyoming and Colorado region was assumed. Accordingly, debt, equity, and interest payments from project revenues are not considered in the economic assessment. Nevertheless, if a portion of the financing was provided by Colorado or Wyoming shareholders or debt providers, additional revenues and economic impacts could result. Premising a potential 9.25% return on capital for a 50% equity share could result in more than $150 million in additional income over a 20-year financing period. Were such income reinvested or spent locally, the resulting economic effects would be above and beyond those captured in this study and what is summarized in Section 4.

A potential source of in-region or local financing includes the WIA which has $1 billion in bonding authority designated for the explicit purpose of financing transmission and generation infrastructure (Section 37-5-305 of the Wyoming Statutes).

3 Methodology

This analysis relies on the suite of NREL Input-Output (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.[6] I-O analysis is one of the most common methods used to estimate economic development potential from large investments in new infrastructure. I-O models represent a balanced set of relationships between industries, households and workers, governments, and other economic players within a specific region as well as economic players outside of the specific region that purchase exports or sell imports. Impact scenarios take the form of changes in demand, typically but not exclusively for the product of an industry or commodity. The linkages among industries and workers provided by I-O models generate particularly valuable information about the level of economic activity typically required to fulfill the change in demand specified by a given analysis scenario.

Although I-O analyses are widely used and recognized, relationships in I-O models are proportional and fixed. They do not account for changing relationships or input shares over time, and they assume fixed ratios of inputs regardless of the size of the change. This means that inputs are assumed to always be available, that prices do not change, and that scale is unrelated to production. In brief, I-O analyses illustrate the potential impacts of a proposed investment based on present conditions.

JEDI results are gross, not net. Far-reaching economic impacts, such as what might occur if electricity prices or property values change, are not analyzed by the model. Moreover, as I-O analyses only consider the impacts of a specific investment scenario, they do not consider the impact of a given investment relative to another alternative (i.e., they do not consider the opportunity cost of a given investment or set of investments).

NREL's JEDI models classify direct effects as onsite labor and professional services. These are dollars spent on labor from companies engaged in development and onsite construction and operation of power generation and transmission. These results include labor only—no materials.[7] 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 O&M personnel.

Indirect effects are classified as local revenues, equipment, and supply chain results. These reflect supporting industries or inputs and are driven by the increase in demand for goods and services from direct onsite 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

[6]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 the 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/.

[7] This category is narrower than typical direct economic impacts as it focuses exclusively on onsite labor expenditures.

projects, all equipment manufacturers (e.g., blade manufacturers), and manufacturers of replacement and repair parts.

Induced effects are driven by reinvestment and spending of earnings by direct and indirect beneficiaries. Induced results are often associated with increased business at local restaurants, hotels, and retail establishments but also include childcare providers and any other entity affected by increased economic activity and spending occurring at the first two tiers.

All jobs figures in this report are full time equivalents (FTE). One job is the equivalent of a worker employed full time over the period of one year. The construction jobs are reported cumulatively and averaged over a three-year construction period. These are the number of workers that would be required were the project to be built in one year. O&M jobs are annual and ongoing. These are the number of workers that would be employed each year that the project is in operation.

4 Results

Cost and Local Sourcing Assumptions

The natural gas and wind generation projects and new transmission line are estimated to cost $1.8 billion to construct, with nearly $370 million spent in Wyoming and $1.1 billion spent in Colorado (Table 1). Ongoing annual O&M expenditures will be approximately $65 million, with $9 million occurring in Wyoming and $9 million occurring in Colorado. The remaining expenditures–those not considered to be made locally–do not influence the economic impacts reported in this analysis.[8] These non-local expenditures are approximately $340 million during the construction period and $47 million annually during the O&M period.

Table 1. Anticipated Project Expenditures ($ millions) and Local Shares

	Construction Period			Operations Period		
Project	Installed cost	Expenditures in Wyoming	Expenditures in Colorado	Annual O&M	Expenditures in Wyoming	Expenditures in Colorado
Transmission	$200	26%	25%	$7	25%	25%
Gas*	$280	27%	12%	$41	5%	1%
Wind	$1,350	18%	77%	$17	29%	42%
Total Local		$370	$1,100		$9	$9

*Natural gas fuel expenditures are not included in local content.

The installed cost includes all construction costs, including labor, materials, development, engineering, and equipment. The largest portion of these is turbines and generators for wind- and gas-powered electricity, respectively. In the case of transmission lines, the conductors and their installation make up the largest portion of the installed cost.

The O&M expenditures presented in Table 1 are the labor, materials, and parts needed to keep the generation or transmission facility operational. These expenditures do not include debt payments, payments to landowners, or taxes.

Tax Revenue

Tax revenue to governments during the O&M period is expected to come from sales/use taxes, property taxes, and taxes on generation. Governments in Wyoming and Colorado are estimated to collect approximately $88 million in sales/use taxes during the construction of the three projects (Table 2).[9] Most sales/use tax revenue ($74 million) is associated with the wind plant, which requires capital-intensive wind turbines. The remaining balance is primarily from the capital-intensive gas generation plant ($10 million) with the transmission facility generating roughly $4 million in sales/use tax revenue. Because the substantial majority of new capital is sited in Wyoming, governments in Wyoming will collect nearly 99% of the estimated

[8] See Appendix C for details on local expenditure assumptions.

[9] Sales/use taxes are assumed to be 6% (4% state and 2% county) in Wyoming and 2.9% (state) in Colorado. Estimates are specific to Plat County, Wyoming and the state of Colorado. Sales and use tax estimates are assumed to apply to capital goods (e.g., wind turbines) and materials only (i.e., labor expenditures are not assumed to be subject to sales/use tax).

construction period sales/use tax revenue. Colorado will collect just over $1 million from the transmission project based on 80 miles of the line being located in Colorado.

Table 2. Estimated Sales and Use Tax Revenue during the Construction Period

Project	Wyoming Sales/Use Tax Revenue ($ 1,000)	Colorado Sales/Use Tax Revenue ($ 1,000)	Total
Transmission	$2,760	$1,050	$3,800
Gas	$10,200	n/a	$10,200
Wind	$74,200	n/a	$74,200
Total	$87,200	$1,050	$88,300

Note: Totals may not sum due to rounding.

On an ongoing basis, annual tax revenue is estimated to be nearly $17 million in Wyoming and $1.8 million in Colorado (Table 3).[10] Property taxes on wind equipment in Wyoming ($9 million) are the largest portion of this revenue; Wyoming's wind generation tax is estimated to provide nearly $4 million in additional revenue to the state. Taxes levied on natural gas extraction and sales are not included in these estimates.

Table 3. Estimated Annual Tax Revenue during the Operations Period ($ 1,000)

	Type	Transmission	Gas	Wind	Total
Wyoming	**Sales/Use**	$14	$40	$570	$630
	Generation	n/a	n/a	$3,800	$3,800
	Property	$830	$1,860	$9,320	$12,000
	Total	$840	$1,900	$13,700	$16,450
Colorado	**Sales/Use**	$5	n/a	n/a	$5
	Property	$1,750	n/a	n/a	$1,750
	Total	$1,750	n/a	n/a	$1,750
Both States	**Total**	$2,600	$1,900	$13,700	$18,200

Note: Totals may not sum due to rounding.

Landowner Income

Landowners will benefit from the development of these three projects, although this will likely occur during construction for natural gas generation and transmission, while payments from

[10] Property tax estimates assume an average mill levy of 60 in Colorado and Wyoming. Wyoming assesses 11.5% of actual value; Colorado assesses 29% of actual value. The wind-driven electricity generation tax in Wyoming is $1/MWh; its estimate assumes a net capacity factor of 48.5% for wind. Sales/use taxes are 6% (4% state and 2% county) in Wyoming and 2.9% (state) in Colorado.

wind generation will occur while the project is in operation. This analysis assumes that land will be leased for wind facilities and purchased for the natural gas generation plant and transmission infrastructure. One-time land purchases are estimated to be approximately $26 million; ongoing leases for wind turbines are estimated to be $10 million annually.[11]

Gross Economic Output

Approximately $790 million in annual gross economic output in Wyoming and Colorado will be supported by these projects during the three-year construction period (Table 4). Over 70% of this output—nearly $570 million annually—will be from expenditures associated with the production and fabrication of the wind turbines and affiliated equipment. This assumes that turbines, blades, and nacelles will be manufactured in Colorado. An annual average of roughly $60 million will arise from onsite expenditures on Wyoming and Colorado labor and approximately $130 million will go to Wyoming and Colorado merchants, retailers, and service providers as onsite and supply chain workers make purchases in their communities.

Table 4. Estimated Gross Economic Output Over the Three-Year Construction Period ($ millions)

		Annual Average				Cumulative
		Transmission	Gas	Wind	Total	Total
Project development and onsite labor	Wyoming	$11	$15	$9.7	$36	$110
	Colorado	$11	$10	$2	$24	$71
	Both States	$23	$25	$12	$60	$180
Turbine, power generation, and equipment supply chain	Wyoming	$7.4	$9.8	$83	$100	$300
	Colorado	$9.8	$4.9	$480	$500	$1,500
	Both States	$17.2	$15	$570	$600	$1,800
Induced - local expenditures	Wyoming	$3.2	$5.2	$14	$22	$67
	Colorado	$6.6	$4.1	$96	$110	$320
	Both States	$9.8	$9.3	$110	$130	$390
Total	Wyoming	$22	$30	$110	$160	$480
	Colorado	$28	$19	$580	$630	$1,900
	Both States	$50	$49	$690	$790	$2,400

Note: Totals may not sum due to rounding.

The transmission line, gas plant, and wind plant will continue to contribute to Wyoming and Colorado economies after construction is completed. Wind will continually make the largest contribution ($50 million) to the roughly $70 million in annual gross output supported by the

[11] Landowner lease payments vary based on multiple factors; however, this estimate is based on values that are assumed to be broadly representative of wind projects in southeast Wyoming. These are based on conversations with developers and figures from Lantz and Tegen (2011).

three projects (Table 5). During operations, all infrastructure types support the greatest portion of economic output through supply chain effects–locally purchased materials, services, parts, and transportation fuel.

Assuming a 20-year life for these facilities, the total cumulative gross economic output is estimated at $3.7 billion.

Table 5. Estimated Annual Gross Output from Operations and Maintenance ($ millions)

		Transmission	Gas	Wind	Total
Onsite labor impacts	Wyoming	$1.1	$0.72	$2.4	$4.2
	Colorado	$1.1	$0	$0	$1.1
	Both States	$2.1	$0.72	$2.4	$5.3
Local revenue and supply chain	Wyoming	$1.4	$4.4	$31	$37
	Colorado	$1.9	$0.45	$10	$13
	Both States	$3.4	$4.9	$41	$50
Induced - local expenditures	Wyoming	$0.58	$1.1	$6.8	$8.5
	Colorado	$1.7	$0.13	$2.3	$4.2
	Both States	$2.3	$1.2	$9.1	$13
Total	Wyoming	$3.1	$6.2	$41	$50
	Colorado	$4.7	$0.59	$12	$18
	Both States	$7.8	$6.8	$53	$68

Note: Totals may not sum due to rounding.

Employment and Income Effects

The increase in economic activity that occurs during the three-year construction period will support an annual average of nearly 4,000 FTE jobs in Colorado and Wyoming (Table 3). The majority of these jobs--2,400--will be in industries that supply inputs, while approximately 700 jobs will be onsite or otherwise directly involved with the projects' construction. This difference between the number of onsite and supply chain/input jobs is driven largely by the wind plant. Significantly more labor is required to manufacture major wind turbine components (i.e., blades, towers, and nacelles) than to install them. These results assume that turbine components will be manufactured in Colorado while purchases of other basic construction materials and labor will be split between Colorado and Wyoming.

Notably the largest contributor to onsite labor during the construction period is the transmission project. This result is a function of the relative share of direct labor expenditures for development and construction of transmission lines as compared with wind and natural gas. Because of its greater construction labor intensity, the transmission project actually results in more onsite jobs than the larger and more capital-intensive wind power project.

Table 6. Annual Average Jobs Estimates Related to Construction over the Three-Year Construction Period

		Annual Average				Cumulative
		Transmission	Gas	Wind	Total	Total
Project development and onsite labor	Wyoming	176	103	151	430	1,291
	Colorado	174	71	25	270	809
	Both States	350	174	176	700	2,099
Turbine, power generation, and equipment supply chain	Wyoming	37	47	569	654	1,962
	Colorado	48	27	1,676	1,751	5,252
	Both States	85	74	2,245	2,404	7,214
Induced – local expenditures	Wyoming	26	40	112	178	544
	Colorado	44	28	631	703	2,108
	Both States	69	68	743	881	2,652
Total	Wyoming	239	191	832	1,262	3,797
	Colorado	266	125	2,332	2,723	8,169
	Both States	504	317	3,164	3,985	11,966

Note: Totals may not sum due to rounding.

Nearly 400 long-term jobs will be supported each year through the proposed projects (Table 5). Half of these are involved in the supply chain, which includes lease payments to landowners as well as the production and assembly of replacement parts for the facilities' equipment. Approximately 90 jobs are directly involved with operating and maintaining facilities. Local expenditures made by onsite personnel, supply chain workers, and landowners support an additional 100 jobs.

Table 7. Long-Term Annual Jobs Estimates Related to Operations and Maintenance

		Transmission	Gas	Wind	Total
Onsite labor impacts	Wyoming	17	11	41	70
	Colorado	17	-	-	17
	Both States	35	11	41	87
Local revenue and supply chain impacts	Wyoming	11	16	121	148
	Colorado	12	3	39	55
	Both States	23	19	160	203
Induced – local expenditures	Wyoming	5	9	55	69
	Colorado	11	1	15	28
	Both States	16	10	70	96
Total	Wyoming	33	36	217	286
	Colorado	41	4	54	99
	Both States	74	40	271	386

Note: Totals may not sum due to rounding.

Jobs supported by this development are well compensated (Table 3). In 2010, the average income of working individuals in Wyoming was $46,442 annually and $51,498 in Colorado (BEA 2010).[12] Only indirect and induced jobs from O&M have compensation that is below state averages. Induced jobs typically fall in to service or retail industries; this result is consistent with expected income within these industries.

Table 8. Combined Wyoming and Colorado Average Worker Compensation Estimates by Period and Impact Type

	Construction	Operations and Maintenance
Direct – onsite	$75,000	$62,000
Indirect – supply chain	$74,000	$50,000
Induced – local expenditures	$52,000	$41,000
Total	$69,000	$50,000

[12] These income figures include wage and salary income, self-employment income, and supplements to wage and salary income such as employer contributions to retirement funds and insurance. This definition is comparable to the definition of compensation in Table 6.

5 Conclusions

Electricity generation and transmission projects in Wyoming and Colorado have the potential to support an average of nearly 4,000 jobs annually while under construction and nearly 400 long-term jobs in industries such as manufacturing and O&M in Colorado and Wyoming. Total economic output within the two states is estimated to be an average of $790 million annually during construction and $70 million per year during operations. The cumulative 20-year impact is estimated at $3.7 billion.

Approximately 32% of construction period jobs and 74% of operations period jobs will be in Wyoming; 68% of construction period jobs will be supported in Colorado as well as 26% of operations jobs. Wind power constitutes the largest share of local Wyoming and Colorado economic activity during both construction and operations. During the construction period, the greatest impact is in Colorado's wind manufacturing supply chain primarily in the form of manufacturing of replacement parts and equipment, while during operations, the impact is distributed more evenly with Wyoming seeing impacts in the form of onsite O&M employment property tax payments, wind generation tax payments, and landowner lease payments. Wind's dominant role in terms of driving economic impacts in this scenario is a function of the capital expenditure requirements for the wind facility relative to the gas and transmission lines during construction and operations, as well as the ability of Colorado's clean energy manufacturing sector to contribute to these projects.

These results can be compared with those determined elsewhere in the literature. Total dollars invested in the two-state region per FTE estimated in this study are estimated at approximately $120,000/FTE during construction and $45,000/FTE during operations. The higher dollars per FTE reported during construction results from the relatively capital-intensive nature of these projects, particularly in the wind and natural gas facilities. Lantz and Tegen (2012) estimated dollars invested in Wyoming per FTE from a similar, larger scenario to be $105,000/FTE during construction and $50,000/FTE during operations. Focusing just on the construction of transmission, this study estimates approximately $66,000/FTE while Pfeifenberger and Hou (2011) estimated approximately $65,000/FTE. Taking a closer look at operations-related employment from wind, this study indicates that onsite labor will result in approximately 0.2 jobs per MW and an approximately $10,000/MW increase in individual earnings in the state of Wyoming. These results are similar to those estimated by a broad-based empirical study (Brown et al. 2012) which found that wind projects completed between 2000 and 2008 boosted median county level employment by 0.5 jobs/MW and personal income by approximately $11,000/MW.

Wind related infrastructure investments have also been observed anecdotally to result in significant new business activity in the localities where projects are sited. Communities such as Sweetwater and Abilene, Texas (Slattery et al., 2011, Pedden 2006) and Prowers County Colorado (Baranowski 2004) as well as others in Southwest, Minnesota and Iowa (GAO 2004) have all reported economic development activity that, absent the manufacturing activity that is captured here, are generally aligned with estimated wind related impacts projected here.

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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 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 and 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 two years of the release of the report. In addition to its operating budgets, the legislature authorized the State Treasury to advance 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 Corporation in Sundance, WY
- Kyle White (Vice-Chairman), Vice President, Regulatory Affairs for Black Hills Corporation in Rapid City, SD
- Bryce Freeman (Treasurer), Director of the Wyoming Office of Consumer Advocate in Cheyenne, WY
- J.M. Shafer (Member), Professional Engineer in Windsor, CO and former executive with Western Area Power Administration and Tri-State Generation and Transmission
- David Sparks (Member), Executive Vice President, TransCore in Jackson, WY

Current staff consists of:

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

Appendix B: The Wyoming-Colorado Intertie Project

Wyoming-Colorado Intertie Project

In the fall of 2005, a public/private partnership consisting of the WIA, Trans-Elect Development Company (Trans-Elect), and Western Area Power Administration (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, which was suggested for development by a consensus of regional stakeholders in the Rocky Mountain Area Transmission 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.

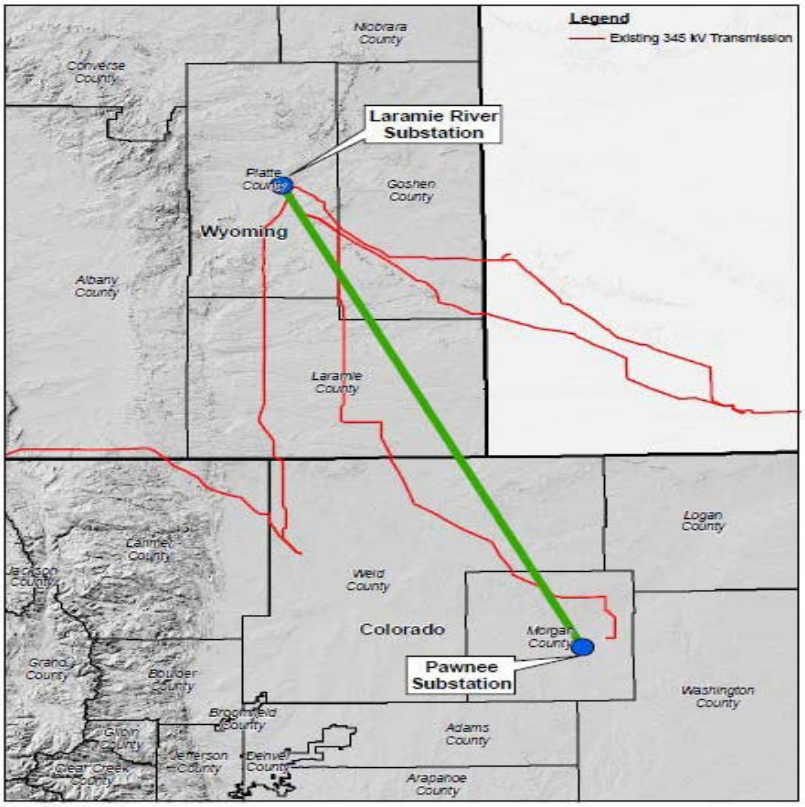

Figure B1. Proposed routing of the WCI project

Source: Wyoming Infrastructure Authority

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.

In July 2011, Wyoming Wind and Power (WWP) filed an application to acquire 100% of the capacity on WCI. Subsequent to that date, LS Power (the lead developer under a joint development agreement) negotiated a Transmission Service Agreement with WWP and an application was filed with FERC for approval (pending).

The WIA has commissioned the University of Wyoming to analyze the geographic diversity of wind in Wyoming compared to Colorado, which shows that such diversity exists. The report is posted on the WIA's website at: http://wyia.org/documents/reports .

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 (Lead Developer) and the 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
    - Wyoming Wind and Power has made application to acquire 100% of the capacity; approval pending at FERC
- 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.

Appendix C: Local Content Assumptions

The tables below reflect local content assumptions utilized in this analysis. Content that is not local is not included in the reported economic impact estimates. These are based on expected procurement patterns as defined by the WIA as well as NREL estimates based on previously developed data (e.g., Lantz and Tegen 2011) and ongoing internal data collection. All modeling inputs have been reviewed and verified by the WIA and its partner organizations.

Table C1. Regional Content Assumptions for Wind Plant

Construction	Share of Cost (%)	Wyoming Wind	Colorado Wind
Turbine Equipment	75%	0%	99%
BOP Material	16%	81%	8%
BOP Labor	6%	55%	19%
Development Other Costs	3%	54%	5%
Construction Total	*100%*	*18%*	*77%*
Operations and Maintenance	Share of Cost (%)	Wyoming Wind	Colorado Wind
Operations Personnel	15%	100%	0%
Operations Materials and Services (less replacement parts)	31%	41%	0%
Operations Replacement Parts	54%	2%	80%
Operations Total	*100%*	*29%*	*42%*

Table C2. Domestic Content Assumptions for Transmission

Construction	Share of Cost (%)	Wyoming T-Line	Colorado T-Line
Line Materials	35%	5%	5%
Line Labor	31%	46%	46%
Facilities Materials	8%	10%	10%
Facilities Labor	10%	26%	26%
ROW Payments	7%	56%	44%
Services	10%	27%	25%
Total	*100%*	*26%*	*25%*
Operations and Maintenance	Share of Cost (%)	Wyoming T-Line	Colorado T-Line
Operations Personnel	33%	50%	50%
Operations Materials and Services	61%	13%	13%
Operations Replacement Equipment	6%	5%	5%
Total	*100%*	*25%*	*25%*

Table C3. Domestic Content Assumptions for Gas Plant

Construction	Share of Cost (%)	Wyoming Gas	Colorado Gas
Facility and Equipment	60%	12%	4%
Labor and Management	27%	10%	10%
Other Costs (development, interconnection, etc)	13%	59%	5%
Total	*100%*	*24%*	*12%*
Operations and Maintenance	Share of Cost (%)	Wyoming Gas	Colorado Gas
Fixed O&M	33%	88%	7%
Variable O&M (excluding fuel)	67%	14%	1%
Total	*100%*	*39%*	*3%*