Economic Impact & Job Creation Relative to Large-Scale, High Voltage Transmission Infrastructure

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Summary of Findings

The Interconnection Seam Study produced electricity transmission and growth scenarios that integrate renewable energy resources, maximize load diversity, and reduce greenhouse emissions. This assessment is an evaluation of the national, economy-wide consequences that would result from a significant increase in wind, solar, natural gas-fueled generation and transmission systems investments in the United States. Design 3 of the Interconnection Seam Study, the Macro-grid Overlay, is the technical and investment spending foundation for this assessment.

This economic evaluation considers two growth scenarios: Scenario A assesses Design 3 under current U.S. policy assuming no CO_2 costs or renewable portfolio standards (RPS) enacted at the state levels. Scenario A would result in $40 billion in transmission spending and $500 billion power generation spending over a 15 year time horizon beginning in 2024 and ending in 2038. Scenario B presumes an alternate policy scenario where there are CO_2 penalties but no RPS is enforced. Scenario B would result in $700 billion in power generation investments and $80 billion in transmission spending over the same 15 year period.

In this study, all financial data over all of the years of measurement are expressed in 2024 constant dollar amounts.

Scenario A, the current policy consideration, would ultimately result in

- 280,550 MW of new wind capacity
- 121,171 MW of new solar capacity
- 26,851 MW of new natural gas-fueled capacity
- 208,970 MW of retired capacity
- $40.04 billion in transmission investments

This economic impact assessment measures the annualized and temporary economic outcomes associated with the construction of these power generation and transmission systems over the 15 year investment period. This assessment also measures the cumulative and on-going outcomes that would be associated with operating and maintaining the new power generation and transmission capacities once completed. Data for wind, natural gas-fueled generation, and transmission investments by type of construction-related spending were obtained from the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impacts (JEDI) spreadsheets. Other NREL resources were used to parse the solar power generation investments. All of the economic impacts were measured using the IMPLAN, Inc., modeling system and a national IMPLAN 536 sector data base that was modified in part to adequately measure the several power generation and transmission sectors.

Given the high levels of investment over time, there would be substantial construction, supply sector, and other job and income-generating consequences nationally from the completion of these energy systems as well as from their annual operations once built.

Under Scenario A, spending an average of $36.03 billion annually on electricity generation and transmission additions between 2024 and 2028 would produce, after all multiplied-through consequences were considered,

- average annual total industrial output of $72.7 billion nationally
- average annual value added of $37.6 billion
- average annual labor income of $25.05 billion
- an average of 388,867 total jobs supported during each year of construction
- of all jobs supported nationwide, an average of 84,015 construction-only annually, which would earn $6.1 billion in labor income

To place the construction-related total job growth into context, average annual growth in the U.S. economy between 2009 and 2017 was just over 2.23 million jobs per year. These energy-related jobs would equate to 17.4 percent of that annual value, providing a potent construction and manufacturing-driven stimulus to the national economy.

Under Scenario A, there would be cumulative gains in employment in energy generation and transmission operations and maintenance. The value of that employment grows through the end of the construction period and then levels off thereafter. By 2040 and later throughout the operating life of these investments, the economic growth associated with operating these capital investments would yield, after all multiplied-through effects in the national economy were accounted,

- $33.9 billion in total industrial output
- $23.2 billion in total value added
- $7.0 billion in labor income
- 83,819 total jobs nationally

There would be energy generation retirements under Scenario A. The shuttering of 208,970 MWs of generation capacity over this investment horizon would sum, by 2040, to

- job reductions of 82,499
- value added reductions of $15.1 billion
- labor income reductions of $6.8 billion

Differencing the economic outcomes associated with the operational additions and the retirements nets these economic values by 2040 and thereafter:

- 1,320 jobs nationally
- $8.1 billion in value added nationally
- $183 million in labor income nationally

This sharp reduction in net operational jobs is due to the strong supply chain associated with fossil fuel generation and its high dependence on mining and transportation compared to wind and solar energy additions whose primary inputs, the wind and the sun, are essentially labor free.

Scenario B is the full build-out option. Under this scenario the U.S. would see

- 392,770 MW of new wind generation
- 169,639 MW of new solar generation
- 37,592 MW of new natural gas-fueled generation
- 292,558 of retired power generation
- $80.1 billion in transmission investments

Under Scenario B, spending an average of $52.04 billion annually on generation and transmission additions between 2024 and 2028 would produce, after all multiplied-through consequences were considered,

- average annual total industrial output of $105.3 billion nationally
- average annual value added of $54.3 billion
- average labor income added of $36.2 billion
- an average of 561,998 total jobs supported during each year of construction
- of all jobs supported nationwide, an average of 117,621 construction-only jobs during the years of construction, which would earn $8.55 billion in labor income

To place the construction-related total job growth under Scenario B into context, average annual growth in the U.S. economy between 2009 and 2017 was just over 2.23 million jobs per year. These energy-related jobs would equate to 25.2 percent of that annual value, providing a potent construction and manufacturing-driven stimulus to the national economy.

Under Scenario B, there would be cumulative additions in employment in the new energy generation and transmission operations and maintenance. By 2040 and later throughout the operating life of these investments, the economic growth associated with operating these capital investments would yield, after all multiplied-through effects in the national economy were accounted,

- $48.2 billion in total industrial output
- $32.8 billion in total value added
- $9.9 billion in labor income
- 118,581 total jobs nationally

There would be energy generation retirements under Scenario B. The shuttering of 292,558 MWs of generation capacity over this investment horizon would sum, by 2040, to

- job reductions of 115,498
- value added reductions of $21.2 billion
- labor income reductions of $9.5 billion

Differencing the economic outcomes associated with the operational additions and the retirements nets these economic values by 2040 and thereafter:

- 3,083 jobs nationally
- $11.6 billion in value added nationally
- $369 million in labor income nationally

Figure 1 through Figure 3 summarize for each scenario the job gains associated with construction and with operating the new energy generation and transmission systems. Table 1 and Table 2 display the net number of jobs supported by construction activity taking account both energy generation retirements and additions.

Figure 1 displays the annual total national job impacts associated with the two energy generation and transmission construction scenarios.

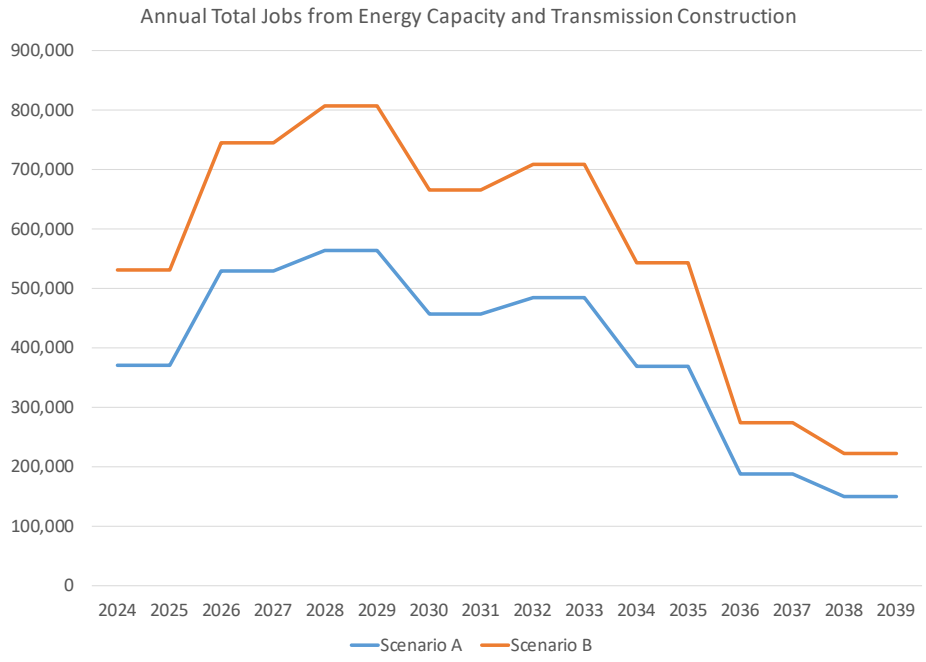

Figure 1

Figure 2 shows the cumulative operations and maintenance job growth that would align with the energy generation and transmission investments by scenario.

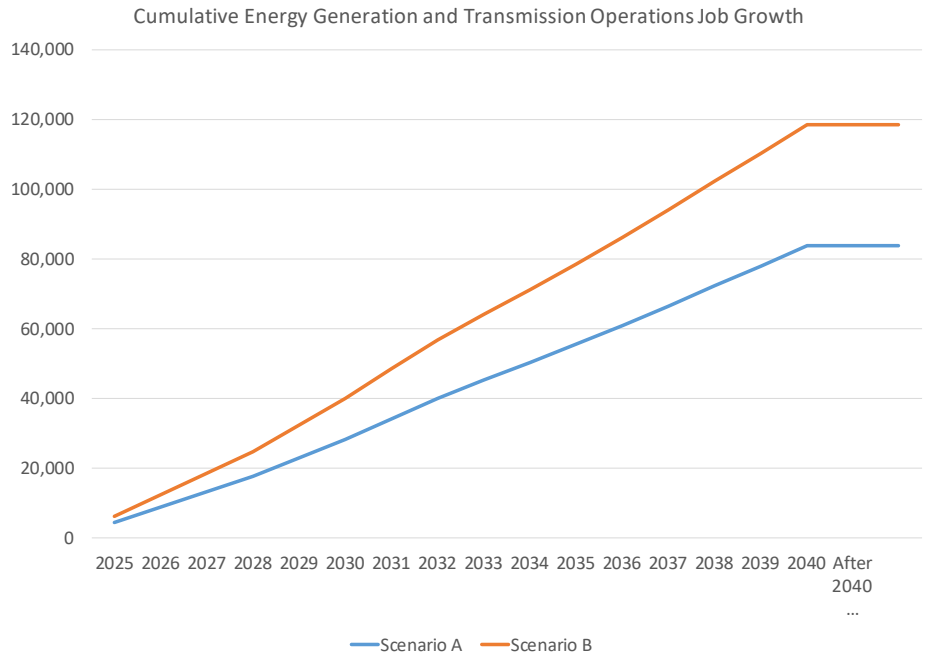

Figure 2

Finally, while there are new generation operations and maintenance additions to the nation's power grid, there are also retirements. Figure 3 shows the net operations job gains considering retirements that would be expected under the two scenarios.

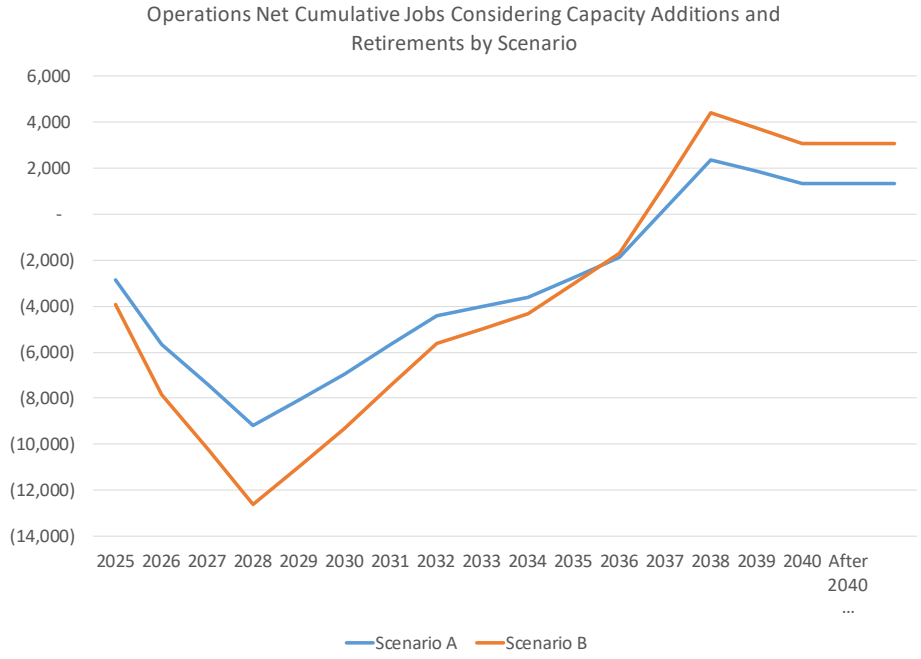

Figure 3

Notwithstanding initial net operations and maintenance job reductions between 2025 and 2036, net overall job growth considering construction through the investment period will be very high. Once, net operational changes are accounted (jobs gained from operating new facilities minus jobs lost from retired facilities), the average number of total jobs in the U.S. supported between 2024 and 2039 would be 385,243 under Scenario A. Under Scenario B that average grows to 557,469 jobs (see Table 1 and Table 2.

Table 1

Scenario A: Total Construction-Related and Net Operations Job Growth During the Investment and Construction Period

	All Construction-Related	Operations Related	Net Job Growth
2024	370,950		370,950
2025	370,950	(2,835)	368,115
2026	528,856	(5,669)	523,186
2027	528,856	(7,421)	521,435
2028	563,933	(9,172)	554,762
2029	563,933	(8,057)	555,876
2030	456,239	(6,943)	449,297
2031	456,239	(5,677)	450,563
2032	484,015	(4,411)	479,604
2033	484,015	(4,023)	479,993
2034	369,490	(3,634)	365,856
2035	369,490	(2,750)	366,740
2036	188,393	(1,866)	186,527
2037	188,393	253	188,646
2038	149,059	2,372	151,431
2039	149,059	1,846	150,905

Table 2

Scenario B: Total Construction-Related and Net Operations Job Growth During the Investment and Construction Period

	All Construction-Related	Operations Related	Net Job Growth
2024	531,131		531,131
2025	531,131	(3,917)	527,214
2026	745,316	(7,834)	737,482
2027	745,316	(10,214)	735,102
2028	806,764	(12,594)	794,170
2029	806,764	(10,951)	795,813
2030	665,386	(9,308)	656,077
2031	665,386	(7,454)	657,932
2032	708,508	(5,599)	702,908
2033	708,508	(4,973)	703,534
2034	542,141	(4,347)	537,794
2035	542,141	(3,027)	539,114
2036	274,107	(1,707)	272,399
2037	274,107	1,342	275,449
2038	222,630	4,391	227,021
2039	222,630	3,737	226,367

The Interconnection Seam Study: Construction and Operational Economic Impacts

Introduction

The Interconnection Seam Study produced electricity transmission and growth scenarios that integrate renewable energy resources, maximize load diversity, and reduce greenhouse gas emissions. Although there was a clear set of alternatives modeled by the study research team, only Design 3, the Macro-grid Overlay scenario, is assessed in this evaluation.

There are three categories of power generation investments and ongoing operations evaluated using conventional economic impact analysis protocols: wind energy, solar, and natural gas-fueled. In addition, this analysis assesses both the construction and ongoing operations associated with transmission investments. There is 15 year time frame to the investment activity in transmission and generation beginning in 2024 and continuing through 2038.

The investment data, generation additions by type, transmission additions, and the timing of the additions were provided by the Interconnection Seam Study team. The total investment data were then allotted to different construction-related spending categories based on publications and resources available from the National Renewable Energy Laboratory (NREL). In particular, NREL's Jobs and Economic Development Impacts (JEDI) data sets were used to allocate investments in wind and natural gas-fueled generation as well as for power transmission. Solar investment allocations were discerned from other NREL sources.

The allocated construction investment data were then analyzed using a national-level IMPLAN, Inc., model to arrive at both the investment-related and the operational-related impacts. IMPLAN is a 536 sector inter-industrial accounting system that is updated annually, fully transparent, modifiable, and of sufficient industrial detail to allow for a high amount of specification and flexibility in modeling the scenarios for this study.

Two investment scenarios are assessed:

- Scenario A: $40 billion in transmission investments coupled with $500 billion in power generation in years 2024 through 2038
- Scenario B: $80 billion in transmission investments coupled with $700 billion in power generation in years 2024 through 2038

Scenario A is considered the current policy option assuming within the U.S. no CO_2 costs and no renewable portfolio standards (RPS) enacted at the state level. Scenario B reflects a full build-out option assuming CO_2 penalties, but no state mandated RPS.

This evaluation estimates the potential nationwide economic consequences of these scenarios for the 2024 through the 2038 investment period assessed by the study team.* This analysis also estimates the economic value of operating the newly-built energy generation and transmission systems. The initial analysis is for Scenario A, the current policy option, and this section will have a complete write-up. Scenario B tables for the full build-out option are presented in an appendix with limited write-up.

Investment Data: Scenario A

Investment data for Scenario A were provided by the Interconnection Seam Study team. All costs over all of the measurement years are in constant 2024 dollars as that year is the beginning period of investment. Accordingly, all financial data in this evaluation will be expressed in 2024 constant dollars.

Table 3 displays the timing and the amount of transmission investments under Scenario A. Spending is slightly more than $40 billion over the 15 investment years with the highest levels occurring during 2028 through 2034.

Table 3

Transmission Spending: Scenario A

		Investment
2024	$	3,358,790,097
2026	$	1,399,843,861
2028	$	4,911,671,066
2030	$	7,585,104,127
2032	$	8,790,759,701
2034	$	7,074,293,911
2036	$	2,947,686,594
2038	$	3,969,722,855
Total	$	40,037,872,212

Table 4 lists investment spending and energy additions over the 15 year period. Energy generation additions start at 35,714 MW in 2024 but grow to 57,143 MW biennially from 2028 through 2038. Nearly two-thirds of the new capacity would come from wind, 28 percent from solar, and just over 6 percent from natural gas-fueled additions. Total investment would be $500.4 billion.

* The resulting economic impact consequences do not constitute a declaration of national economic welfare gains of the kind that would be discerned through conventional benefit-cost analysis. The multiplied-through findings of economic impact evaluations supplement conventional benefit-cost studies, they do not supplant them. Design 3 produced a robust benefit-cost ratio of 2.52, which creates a strong argument for its adoption. The findings in this evaluation neither bolster nor diminish the key decision-making foundations of benefit-cost analysis. Robust economic impact results will also accrue for projects with benefit to cost ratios of less than 1.0.

Table 4

Energy Generation Investments and Capacities: Scenario A

Year	Wind	Solar	Natural Gas	Total
		Investment in Constant $2024		
2024	$ 47,723,487,060		$ 11,773,465,373	$ 59,496,952,433
2026	$ 83,579,641,771	$ 2,440,516,769	$ 383,423,131	$ 86,403,581,671
2028	$ 85,083,890,967		$ 3,485,935,660	$ 88,569,826,628
2030	$ 67,576,762,028		$ 6,962,694,708	$ 74,539,456,735
2032	$ 70,209,517,866		$ 1,133,013,787	$ 71,342,531,653
2034	$ 47,602,731,082	$ 8,385,085,334	$ 340,450,145	$ 56,328,266,561
2036	$ 7,639,522,081	$ 28,032,765,222	$ 177,987,931	$ 35,850,275,234
2038	$ 1,751,815,510	$ 26,081,828,480		$ 27,833,643,990
Total	$ 411,167,368,366	$ 64,940,195,804	$ 24,256,970,735	$ 500,364,534,905
		MWs of Installed Capacity		
2024	24,364		11,350	35,714
2026	47,228	2,351	420	50,000
2028	53,280		3,863	57,143
2030	48,498		8,645	57,143
2032	55,491		1,652	57,143
2034	43,060	13,501	581	57,143
2036	7,053	49,751	340	57,143
2038	1,575	55,568		57,143
Total	280,550	121,171	26,851	428,571

Determining the Construction Spending Categories

The JEDI resources at NREL are useful for determining initial categorical spending for particular kinds of energy investments. For this study, JEDI had relevant spreadsheets for wind and natural gas-fueled generation, and for transmission investments. Solar investments for commercial, residential, and utility scale photovoltaic systems were not available from JEDI, so cost of investment values were garnered from NREL's U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017.[*]

[*] Fu, Ran et al., U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017, NREL. Found at https://www.nrel.gov/docs/fy17osti/68925.pdf

In all, four separate cost of investment tables were constructed and applied to the spending amounts in Table 4. Only the solar percentages were derived from a non-JEDI source at NREL.* Investment spending allocations for the four categories – wind, solar, natural gas, and transmission – remain fixed throughout the analysis period.

Following are the four spending allocations by IMPLAN modeling category (Table 5 through Table 8). These percentages were applied to the investment values for each spending activity for each year there was spending. The resulting products were then entered into the national IMPLAN model using what is called a "bill of goods" approach to estimating impacts.** The IMPLAN model was set with 2024 as the base year for the data input and the reporting of the findings as all of the investment information over the 15 year period was presented in 2024 constant amounts.

The bill of goods approach to modeling is useful for construction or industrial categories that are unique or otherwise not well represented within the existing 536 sector IMPLAN modeling system. It allows, in many instances, for a better estimate of the economic outcomes than by using the default industrial sectors within the IMPLAN model. In so doing, it is also important to pay attention by category of spending to the likelihood that the purchase will be made from a domestic supplier.

In the ensuing analyses, the domestic purchasing percentages were usually set to the IMPLAN national default values. So for example, a payment to real estate-related services would flow entirely (100 percent) to a domestic firm, but just 57 percent of fabricated metal payments would go to a U.S. manufacturer, and 76 percent of spending for semiconductors and other related devices. When modeling the wind energy sector, however and for example, where the fabricated structural metal input would reflect primarily tower components, the national purchase percentage was set at 100 percent owing to their bulk and very high likelihood of being manufactured proximate to their installation sites.

* For the solar investments, it was assumed that 70 percent of the spending would go toward utility scale generation with commercial and residential splitting equally the remaining 30 percent. That meant that three sets of spending categories were created, weighted, and then combined to arrive at the values in Table 5.

** The procedures for conducting a bill of goods assessment are nicely outlined in this Bureau of Economic Analysis publication found here: https://bea.gov/regional/pdf/rims/RIMSII_User_Guide.pdf. See especially Chapter 6. This approach is also called "analysis by parts" by many IMPLAN practitioners.

Table 5

Wind Investment Spending Allocation

Implan Sector	Description	Percentage
195	Other plastics product manufacturing	13.1%
206	Ready-mix concrete manufacturing	1.8%
238	Fabricated structural metal manufacturing	10.2%
248	Spring and wire product manufacturing	2.3%
261	Other fabricated metal manufacturing	3.0%
283	Turbine and turbine generator set units manufacturing	30.7%
342	All other miscellaneous electrical equipment and component manufacturing	2.5%
411	Truck transportation	3.4%
448	Accounting, tax preparation, bookkeeping, and payroll services	2.8%
449	Architectural, engineering, and related services	2.8%
455	Environmental and other technical consulting services	2.8%
465	Business support services	2.9%
470	Other support services	1.9%
533	* Employment and payroll of local govt, non-education	0.8%
	Labor	15.8%
	Sales tax	3.1%
	Total	100.0%

Table 6

Natural Gas-Fueled Investment Spending Allocation

Implan Sector	Description	Percentage
42	Electric power generation - Fossil fuel	0.6%
54	Construction of new power and communication structures	10.8%
283	Turbine and turbine generator set units manufacturing	34.0%
285	Mechanical power transmission equipment manufacturing	15.9%
438	Insurance agencies, brokerages, and related activities	0.6%
449	Architectural, engineering, and related services	2.3%
533	* Employment and payroll of local govt, non-education	2.3%
	Labor	16.4%
	Proprietors/investors income	9.1%
	Sales tax	3.6%
	Land	4.5%
	Total	100.0%

Table 7

Solar Investment Spending Allocation

Implan Sector	Description	Percentage
42	Electric power generation - Fossil fuel	0.1%
50	Natural gas distribution	0.1%
51	Water, sewage and other systems	0.1%
54	Construction of new power and communication structures	1.1%
261	Other fabricated metal manufacturing	10.3%
309	Semiconductor and related device manufacturing	25.9%
313	Other electronic component manufacturing	10.1%
342	All other miscellaneous electrical equipment and component manufacturing	5.5%
395	Wholesale trade	3.2%
427	Wired telecommunications carriers	0.4%
440	Real estate	3.1%
442	Automotive equipment rental and leasing	2.3%
449	Architectural, engineering, and related services	6.6%
455	Environmental and other technical consulting services	2.3%
457	Advertising, public relations, and related services	1.7%
470	Other support services	1.5%
533	* Employment and payroll of local govt, non-education	1.1%
	Labor	10.5%
	Sales tax	3.9%
	Land	1.8%
	Contingency	2.1%
	Profit	6.2%
	Total	100.0%

Table 8

Transmission Investment Spending Allocation

Implan Sector	Description	Percentage
31	Sand and gravel mining	1.4%
54	Construction of new power and communication structures	27.7%
56	Construction of new highways and streets	10.4%
145	All other miscellaneous wood product manufacturing	11.5%
206	Ready-mix concrete manufacturing	1.4%
224	Other aluminum rolling, drawing and extruding	15.3%
238	Fabricated structural metal manufacturing	11.5%
438	Insurance agencies, brokerages, and related activities	0.1%
440	Real estate	1.7%
449	Architectural, engineering, and related services	4.2%
455	Environmental and other technical consulting services	3.1%
455	Environmental and other technical consulting services	4.7%
460	Marketing research and all other miscellaneous professional, scientific, and technical se	1.7%
	Land	3.0%
	Sales Tax	2.2%
	Total	100.0%

Understanding Input-Output Analysis Results

The input-output model used for this analysis produces a wide array of information. For our purposes, there are four types of data and four levels of data comprising a typical input-output results table.

The types of economic impact data are

- **Output**. This is the value of industrial productivity over the course of a year. It represents the worth of what was produced whether it was sold or not.
- **Labor income**. These are wage and salary payments to workers, including employer-provided benefits. Payments by proprietors to themselves for the management of their establishments are also counted as labor income payments.
- **Value added**. Value added includes all labor income (mentioned above) plus payments to investors (dividends, interests, and rents), and indirect tax payments to governments. Value added is the equivalent of Gross Domestic Product (GDP), which is the standard measure of total economic activity across the states and for the nation.
- **Jobs**. There are many kinds of jobs. I-O models measure the annualized job value in different industries. Many industries have mostly full-time jobs, but many others have part-time and seasonal jobs. I-O models do not convert jobs into full-time equivalencies, but they do express them as annualized equivalencies. As many people have more than one job, there are always more jobs in an economy than there are employed persons.

The levels of economic impact data are

- **Direct values**. These are usually the initial values associated with a particular industry that we are measuring. For example, a set amount of construction activity will initially require workers who receive labor income, and there will be an initial output level of spending by the direct firm.
- **Indirect values**. All direct firms require intermediate inputs into production. They may buy supplies, utilities, other agricultural or manufactured inputs, wholesale goods, transportation, and services, just to name a few.
- **Induced values**. When the workers in the direct industry and those in all of the indirect industries (the supplying sectors) convert their labor incomes into household spending they induce a third round of economic activity. Induced values are also called the household values.
- **Total values**. The sum of direct, indirect, and induced activity constitutes the total economic effect that is being measured.

These categories will all be used when describing the ongoing operational economic outcomes associated with the energy and transmission investments.

The modeling procedures used for the construction of energy and transmission systems required some modification to this standard reporting breakdown. As this study uses a bill of goods approach to estimate the economic impacts of the construction activity, the modeling process was specified such that the direct activity (construction only) and the indirect activity (the procurement of all inputs) are

combined in the initial IMPLAN run for each energy type and for transmission. After the initial analyses were completed, direct values for the construction jobs, labor incomes, value added, and output were manually added to the IMPLAN output to complete the industrial accounting.[*] Accordingly, the summary economic impact tables for the construction economic consequences (Table 14 through Table 18) will be

- **Construction plus supply chain values.** The direct construction activity plus the initial and subsequent indirect rounds of activity associated with the supply chain.
- **Induced values**. When the workers in the constructing sectors and those in all of the indirect industries (the supplying sectors) convert their labor incomes into household spending they induce another round of economic activity. Induced values are also called the household values.
- **Total values**. The sum of construction, supply chain, and induced activities constitute the total economic effect that is being measured.

Construction-Related Results

The following tables itemize by aforementioned categories the economic impacts associated with the electricity generation and transmission investments that are listed in Table 3and Table 4. Before presenting the data, a clarification needs to be made regarding standard input-output reporting protocols and how the investment data are presented in the tables.

The initial investment and energy generation additions data are expressed biennially – every two years there is an investment amount. Input-output models, however, are properly used on an annualized basis. It is generally inappropriate to run two (or more) years' worth of data through the model and then report that information out *as if* it occurred in one year. Therefore, for modeling purposes and for proper accounting and trend analysis the impacts need to be annualized. In this exercise that simply means putting half of the investments (or required labor, etc.) into one year and the other half the next.[**]

Initial Construction-Only Impacts: Scenario A

Table 9 through Table 13 reveal the construction-only (i.e., excluding all supply chain and induced effects) jobs, labor income, and initial total project investment amounts for each year of the two year period ranging from 2024 to 2039. It is clear that a strong majority of the direct construction jobs are associated with wind energy additions. In all, construction-only jobs grow from 79,695 (earning $5.8 billion in labor income annually) in the 2024 and 2025 starting period to 118,437 (earning $8.4 billion in

[*] Additional details on model and scenario specification are found in the methodological appendix.

[**] This is a smoothing procedure for the purposes of reporting the data annually. The analyst recognizes that the actual construction activity for many of the projects will take more than one year to complete.

labor income annually) for years 2028 and 2029 before tailing off eventually to 31,503 jobs (earning $2.6 billion in labor income) in each of the two final years (see Table 13).

Table 9

Scenario A: Wind Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	56,289	$ 3,776,690,035	$ 23,861,743,530
2026 and 2027	98,580	$ 6,614,235,875	$ 41,789,820,885
2028 and 2029	100,355	$ 6,733,277,531	$ 42,541,945,484
2030 and 2031	79,705	$ 5,347,817,174	$ 33,788,381,014
2032 and 2033	82,811	$ 5,556,165,377	$ 35,104,758,933
2024 and 2035	56,146	$ 3,767,133,778	$ 23,801,365,541
2036 and 2037	9,011	$ 604,568,289	$ 3,819,761,040
2038 and 2039	2,066	$ 138,633,293	$ 875,907,755

Table 10

Scenario A: Solar Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	1,651	$ 128,521,145	$ 1,220,258,927
2026 and 2027	-	$ -	$ -
2028 and 2029	-	$ -	$ -
2030 and 2031	-	$ -	$ -
2032 and 2033	-	$ -	$ -
2024 and 2035	5,671	$ 441,570,727	$ 4,192,544,532
2036 and 2037	18,959	$ 1,476,245,981	$ 14,016,388,847
2038 and 2039	17,640	$ 1,373,506,829	$ 13,040,920,042

Table 11

Scenario A: Natural Gas-Fueled Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	11,774	$ 967,567,824	$ 5,886,732,686
2026 and 2027	383	$ 31,510,509	$ 191,711,565
2028 and 2029	3,486	$ 286,481,429	$ 1,742,967,830
2030 and 2031	6,963	$ 572,208,704	$ 3,481,347,354
2032 and 2033	1,133	$ 93,113,425	$ 566,506,894
2024 and 2035	340	$ 27,978,900	$ 170,225,073
2036 and 2037	178	$ 14,627,418	$ 88,993,966
2038 and 2039	-	$ -	$ -

Table 12

Scenario A: Transmission Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	9,981	$ 914,550,561	$ 2,399,135,784
2026 and 2027	4,160	$ 381,157,485	$ 999,888,472
2028 and 2029	14,596	$ 1,337,377,864	$ 3,508,336,476
2030 and 2031	22,541	$ 2,065,315,495	$ 5,417,931,519
2032 and 2033	26,124	$ 2,393,598,284	$ 6,279,114,072
2024 and 2035	21,023	$ 1,926,229,171	$ 5,053,067,080
2036 and 2037	8,760	$ 802,612,950	$ 2,105,490,424
2038 and 2039	11,797	$ 1,080,898,823	$ 2,835,516,325

Table 13

Scenario A: Initial Construction Impacts from Energy and Transmission Investments

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	79,695	$ 5,787,329,564	$ 33,367,870,928
2026 and 2027	103,124	$ 7,026,903,869	$ 42,981,420,923
2028 and 2029	118,437	$ 8,357,136,824	$ 47,793,249,789
2030 and 2031	109,209	$ 7,985,341,374	$ 42,687,659,887
2032 and 2033	110,068	$ 8,042,877,086	$ 41,950,379,899
2024 and 2035	83,181	$ 6,162,912,576	$ 33,217,202,225
2036 and 2037	36,907	$ 2,898,054,638	$ 20,030,634,277
2038 and 2039	31,503	$ 2,593,038,946	$ 16,752,344,123

All Energy and Transmission Investment Impacts: Scenario A

The following tables itemize the multiplied-through expected total construction plus supply chain and the induced economic impacts for each year of the sets of two year periods beginning in 2024 and ending in 2039. As this analysis uses a national model, the amount of iterative supply chain activity (initial suppliers need supplies, and so on, and so on) coupled with all of the induced activity results in comparatively high multiplied-through economic totals.

Table 14 displays the multiplied through impacts of wind energy construction for the 2024 through the 2039 period. On an annualized basis, total job impacts grow from 290,000 in years 2024 and 2025 to 517,027 jobs in 2028 and 2029. Total output in that peak year is $95.2 billion and value added is $48.6 billion, of which $33.0 billion is labor income.

Table 15 lists the solar energy impact additions where 70 percent of the investments were allocated to utility scale solar generation and the remaining 30 percent split evenly between commercial and residential configurations. The initial job creation in each of years 2026 and 2027 is 10,776. There would be no additional solar spending until 2034. Peak impacts are realized in 2036 and 2037 with an estimated total output value of $25.25 billion and $14.7 billion in value added, of which $8.6 billion would be labor income to 123,782 total jobholders.

Table 16 lists natural gas-fueled generation additions. These investments are front-loaded with the peak construction effects occurring in 2024 and 2025. In those years $12.0 billion in total output would be produced annually after all multiplied-through transactions were accounted and $6.5 billion in value added, of which $4.3 billion would be labor income to 61,281 jobholders.

Table 17 shows the transmission investment impacts. Total annual job creation starts at 19,669 in each of years 2024 and 2025 and then eventually grows to a peak level in 2032 and 2033. Total multiplied-through output in each of those peak years would be $10.0 billion and value added would be $4.9 billion, of which $3.2 billion would be labor income to 51,477 jobholders.

Finally, Table 18 combines all energy and transmission investments over the period of capital deployment. Initial job creation would be very strong. In years 2024 and 2035 this activity would support 370,950 national jobs after all multiplied through construction, supply chain, and induced effects were accounted. Peak economic activity would occur in 2028 and 2029 where in each year $104.3 billion in total industrial output would be generated and $53.2 billion of value added, of which $36.1 billion would be labor income to a total of 563,933 jobholders. Job levels remain comparatively high for the next four years before tailing off substantially for years 2036 through 2039.

Table 14

Scenario A: Annualized Wind Construction Impacts in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	178,815	$ 12,505,350,865	$ 16,778,784,734	$ 34,203,132,078
Induced	111,185	$ 6,005,905,920	$ 10,492,697,178	$ 19,177,818,370
Total	290,000	$ 18,511,256,785	$ 27,271,481,911	$ 53,380,950,448

Scenario A: Annualized Wind Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	313,164	$ 21,901,013,733	$ 29,385,212,686	$ 59,901,019,448
Induced	194,722	$ 10,518,331,669	$ 18,376,190,118	$ 33,586,715,641
Total	507,886	$ 32,419,345,402	$ 47,761,402,804	$ 93,487,735,089

Scenario A: Annualized Wind Construction Impacts in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	318,801	$ 22,295,183,672	$ 29,914,081,698	$ 60,979,105,671
Induced	198,226	$ 10,707,638,438	$ 18,706,921,007	$ 34,191,202,439
Total	517,027	$ 33,002,822,110	$ 48,621,002,705	$ 95,170,308,110

Scenario A: Annualized Wind Construction Impacts in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	253,203	$ 17,707,656,576	$ 23,758,866,187	$ 48,431,853,148
Induced	157,439	$ 8,504,401,085	$ 14,857,726,120	$ 27,155,913,116
Total	410,642	$ 26,212,057,660	$ 38,616,592,307	$ 75,587,766,264

Scenario A: Annualized Wind Construction Impacts in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	263,068	$ 18,397,537,754	$ 24,684,499,375	$ 50,318,733,199
Induced	163,572	$ 8,835,728,170	$ 15,436,575,476	$ 28,213,893,502
Total	426,640	$ 27,233,265,924	$ 40,121,074,851	$ 78,532,626,701

Scenario A: Annualized Wind Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	178,363	$ 12,473,708,251	$ 16,736,328,939	$ 34,116,587,005
Induced	110,904	$ 5,990,709,020	$ 10,466,147,234	$ 19,129,292,238
Total	289,266	$ 18,464,417,271	$ 27,202,476,173	$ 53,245,879,244

Scenario A: Annualized Wind Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	28,625	$ 2,001,842,488	$ 2,685,928,970	$ 5,475,198,877
Induced	17,798	$ 961,418,658	$ 1,679,659,151	$ 3,069,963,574
Total	46,423	$ 2,963,261,146	$ 4,365,588,122	$ 8,545,162,451

Scenario A: Annualized Wind Construction Impacts in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	6,564	$ 459,041,637	$ 615,909,213	$ 1,255,515,491
Induced	4,081	$ 220,462,497	$ 385,161,915	$ 703,972,022
Total	10,645	$ 679,504,134	$ 1,001,071,128	$ 1,959,487,513

Table 15

Scenario A: Annualized Solar Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	6,294	$ 504,952,810	$ 860,593,556	$ 1,424,793,449
Induced	4,483	$ 242,153,188	$ 423,056,681	$ 773,237,083
Total	10,776	$ 747,105,998	$ 1,283,650,237	$ 2,198,030,532

Scenario A: Annualized Solar Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	21,623	$ 1,734,908,138	$ 2,956,812,467	$ 4,895,280,707
Induced	15,402	$ 831,985,736	$ 1,453,530,832	$ 2,656,674,604
Total	37,025	$ 2,566,893,875	$ 4,410,343,298	$ 7,551,955,311

Scenario A: Annualized Solar Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	72,291	$ 5,800,092,734	$ 9,885,126,553	$ 16,365,755,302
Induced	51,492	$ 2,781,469,703	$ 4,859,400,582	$ 8,881,714,673
Total	123,782	$ 8,581,562,438	$ 14,744,527,135	$ 25,247,469,974

Scenario A: Annualized Solar Construction Impacts in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	67,260	$ 5,396,436,016	$ 9,197,172,424	$ 15,226,782,636
Induced	47,908	$ 2,587,893,672	$ 4,521,211,214	$ 8,263,592,866
Total	115,168	$ 7,984,329,688	$ 13,718,383,638	$ 23,490,375,502

Table 16

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	35,323	$ 2,918,485,514	$ 4,008,490,343	$ 7,518,869,624
Induced	25,958	$ 1,402,296,369	$ 2,449,862,724	$ 4,477,818,398
Total	61,281	$ 4,320,781,883	$ 6,458,353,067	$ 11,996,688,022

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	1,150	$ 95,045,496	$ 130,543,376	$ 244,864,909
Induced	845	$ 45,668,191	$ 79,783,989	$ 145,827,851
Total	1,996	$ 140,713,687	$ 210,327,365	$ 390,692,760

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	10,459	$ 864,117,098	$ 1,186,850,174	$ 2,226,217,594
Induced	7,686	$ 415,197,630	$ 725,365,350	$ 1,325,810,740
Total	18,144	$ 1,279,314,728	$ 1,912,215,524	$ 3,552,028,333

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	680	$ 56,208,835	$ 77,201,881	$ 144,810,347
Induced	500	$ 27,007,653	$ 47,183,352	$ 86,240,947
Total	1,180	$ 83,216,488	$ 124,385,233	$ 231,051,294

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	3,399	$ 280,859,052	$ 385,755,143	$ 723,574,808
Induced	2,498	$ 134,949,318	$ 235,761,363	$ 430,920,703
Total	5,897	$ 415,808,370	$ 621,516,506	$ 1,154,495,512

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	1,021	$ 84,393,064	$ 115,912,442	$ 217,421,139
Induced	751	$ 40,549,829	$ 70,842,024	$ 129,483,875
Total	1,772	$ 124,942,893	$ 186,754,466	$ 346,905,015

Scenario A: Annualized Natural Gas-Fueled Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	534	$ 44,120,841	$ 60,599,227	$ 113,668,152
Induced	392	$ 21,199,521	$ 37,036,334	$ 67,694,396
Total	926	$ 65,320,363	$ 97,635,561	$ 181,362,548

Table 17

Scenario A: Annualized Transmission Construction Impacts in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	12,345	$ 826,898,186	$ 1,201,339,212	$ 2,661,066,960
Induced	7,323	$ 395,271,777	$ 690,673,531	$ 1,261,987,570
Total	19,669	$ 1,222,169,963	$ 1,854,291,937	$ 3,834,351,702

Scenario A: Annualized Transmission Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	5,145	$ 344,626,581	$ 500,682,469	$ 1,109,053,599
Induced	3,052	$ 164,737,526	$ 287,852,195	$ 525,958,902
Total	8,197	$ 509,364,107	$ 772,813,754	$ 1,598,043,799

Scenario A: Annualized Transmission Construction Impacts in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	18,053	$ 1,209,200,866	$ 1,756,758,498	$ 3,891,367,193
Induced	10,709	$ 578,019,135	$ 1,009,994,998	$ 1,845,446,620
Total	28,762	$ 1,787,220,001	$ 2,711,593,101	$ 5,607,100,701

Scenario A: Annualized Transmission Construction Impacts in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	27,879	$ 1,867,371,482	$ 2,712,965,904	$ 6,009,446,675
Induced	16,538	$ 892,636,186	$ 1,559,737,435	$ 2,849,927,161
Total	44,417	$ 2,760,007,669	$ 4,187,519,023	$ 8,659,057,599

Scenario A: Annualized Transmission Construction Impacts in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	32,311	$ 2,164,190,985	$ 3,144,193,006	$ 6,964,650,817
Induced	19,167	$ 1,034,521,093	$ 1,807,658,373	$ 3,302,924,313
Total	51,477	$ 3,198,712,079	$ 4,853,126,978	$ 10,035,418,540

Scenario A: Annualized Transmission Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	26,002	$ 1,741,615,472	$ 2,530,264,299	$ 5,604,747,319
Induced	15,424	$ 832,522,617	$ 1,454,698,690	$ 2,658,002,055
Total	41,426	$ 2,574,138,089	$ 3,905,515,314	$ 8,075,923,207

Scenario A: Annualized Transmission Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	10,834	$ 725,688,902	$ 1,054,299,729	$ 2,335,362,192
Induced	6,427	$ 346,891,971	$ 606,137,642	$ 1,107,524,952
Total	17,261	$ 1,072,580,873	$ 1,627,333,452	$ 3,365,041,214

Scenario A: Annualized Transmission Construction Impacts in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	14,591	$ 977,303,295	$ 1,419,851,669	$ 3,145,090,353
Induced	8,655	$ 467,168,046	$ 816,300,639	$ 1,491,531,401
Total	23,246	$ 1,444,471,340	$ 2,191,570,438	$ 4,531,784,703

Table 18

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	226,484	$ 16,250,734,565	$ 21,988,614,289	$ 44,383,068,662
Induced	144,466	$ 7,803,474,065	$ 13,633,233,432	$ 24,917,624,338
Total	370,950	$ 24,054,208,630	$ 35,584,126,915	$ 69,211,990,172

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	325,753	$ 22,845,638,620	$ 30,877,032,088	$ 62,679,731,406
Induced	203,102	$ 10,970,890,573	$ 19,166,882,984	$ 35,031,739,477
Total	528,856	$ 33,816,529,193	$ 50,028,194,161	$ 97,674,502,180

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	347,312	$ 24,368,501,636	$ 32,857,690,371	$ 67,096,690,458
Induced	216,621	$ 11,700,855,203	$ 20,442,281,356	$ 37,362,459,799
Total	563,933	$ 36,069,356,839	$ 53,244,811,331	$ 104,329,437,144

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	281,763	$ 19,631,236,893	$ 26,549,033,973	$ 54,586,110,171
Induced	174,477	$ 9,424,044,924	$ 16,464,646,906	$ 30,092,081,224
Total	456,239	$ 29,055,281,817	$ 42,928,496,563	$ 84,477,875,158

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	298,778	$ 20,842,587,792	$ 28,214,447,524	$ 58,006,958,824
Induced	185,237	$ 10,005,198,581	$ 17,479,995,212	$ 31,947,738,519
Total	484,015	$ 30,847,786,373	$ 45,595,718,336	$ 89,722,540,753

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	227,009	$ 16,034,624,926	$ 22,339,318,147	$ 44,834,036,171
Induced	142,481	$ 7,695,767,202	$ 13,445,218,780	$ 24,573,452,773
Total	369,490	$ 23,730,392,128	$ 35,705,089,251	$ 69,220,662,776

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	112,284	$ 8,571,744,965	$ 13,685,954,480	$ 24,289,984,522
Induced	76,109	$ 4,110,979,854	$ 7,182,233,709	$ 13,126,897,595
Total	188,393	$ 12,682,724,819	$ 20,835,084,270	$ 37,339,036,187

Scenario A: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	88,414	$ 6,832,780,947	$ 11,232,933,306	$ 19,627,388,480
Induced	60,645	$ 3,275,524,215	$ 5,722,673,768	$ 10,459,096,289
Total	149,059	$ 10,108,305,162	$ 16,911,025,203	$ 29,981,647,718

Annualized Investment Impacts, 2024 through 2039: Scenario A

Table 19 and Figure 4 display the total short-term jobs outcomes associated with energy production and transmission investments over the economic impact measurement period of 2024 through 2039. Total employment is very robust beginning at 370,950 jobs in years 2024 and in 2025, growing to 563,933 jobs in 2028 and 2029, and then declining in the last two years to 149,059 jobs. Figure 4 illustrates the pattern and the magnitude of these investments. More than three-quarters of the total jobs impacts are from wind energy spending, and that investment occurs mainly during the first half of the measurement period. The latter part of the timeline sees boosts in the solar-related job impacts. Natural gas has an initially substantial total jobs contribution that dwindles, comparatively, over time. Finally, transmission jobs impacts build slowly to a peak in 2032 and 2033 at 51,477 jobs and then decline to nearly 23,246 jobs in the last two years.

Table 19

Scenario A: Total Energy Production and Distribution Investment-Related Jobs , 2024 through 2039

	Wind	Solar	Natural Gas	Transmission	Total
2024	290,000		61,281	19,669	370,950
2025	290,000		61,281	19,669	370,950
2026	507,886	10,776	1,996	8,197	528,856
2027	507,886	10,776	1,996	8,197	528,856
2028	517,027		18,144	28,762	563,933
2029	517,027		18,144	28,762	563,933
2030	410,642		1,180	44,417	456,239
2031	410,642		1,180	44,417	456,239
2032	426,640		5,897	51,477	484,015
2033	426,640		5,897	51,477	484,015
2034	289,266	37,025	1,772	41,426	369,490
2035	289,266	37,025	1,772	41,426	369,490
2036	46,423	123,782	926	17,261	188,393
2037	46,423	123,782	926	17,261	188,393
2038	10,645	115,168		23,246	149,059
2039	10,645	115,168		23,246	149,059

It is useful to put these total construction-related job impacts into some kind of comparative context. While it is impossible to guess the rate of job growth that will occur during the 2024 through 2038 investment cycle, we can use the past to help us understand the value of this investment-driven job growth. Between 2009 and 2017, the U.S. 2.2 million payroll jobs on average annually. These energy-related investments would support 388,867 jobs annually during the construction activity, which would equate to 17.6 percent of the job growth that the U.S. has enjoyed over the past nine years.

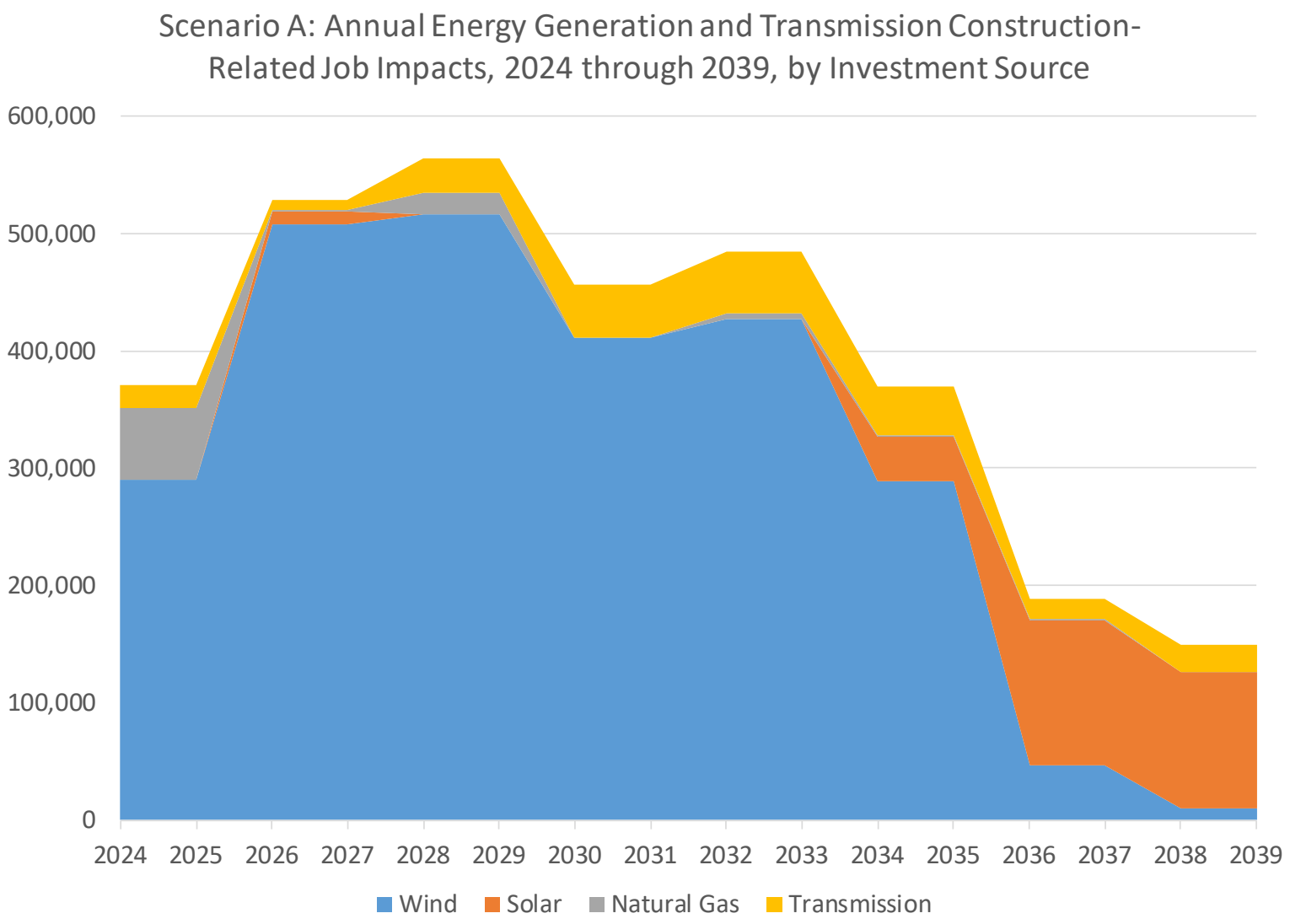
Scenario A: Annual Energy Generation and Transmission Construction-Related Job Impacts, 2024 through 2039, by Investment Source
600,000
500,000
400,000
300,000
200,000
100,000
0
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
Wind
Solar
Natural Gas
Transmission

Figure 4

Energy Utility and Transmission System Operational Impacts: Scenario A

New investments in energy production and in transmission ultimately lead to operations and maintenance employment to maintain and administer those sectors of the economy. The national IMPLAN model used for this analysis contains summary industrial detail (jobs, labor income, value added, and total output) for all of the electricity production categories assessed in this study. Combining that information with information from the U.S. Energy Information Administration on electricity generation by source allowed for a determination of initial jobs per 100 MW of energy production in each sector. Table 20, from the Department of Energy, shows production distributions by source nationally, and Table 21 shows the resulting direct job requirements for each energy sector per 100 MWs of production.

Table 20

U.S. electricity generation by source, amount, and share of total in 2017[1]		
Energy source	**Billion kWh**	**Share of total**
Total - all sources	4,015	
Fossil fuels (total)	2,516	62.7%
Natural gas	1,273	31.7%
Coal	1,208	30.1%
Petroleum (total)	21	0.5%
Petroleum liquids	13	0.3%
Petroleum coke	9	0.2%
Other gases	14	0.4%
Nuclear	805	20.0%
Renewables (total)	687	17.1%
Hydropower	300	7.5%
Wind	254	6.3%
Biomass (total)	64	1.6%
Wood	43	1.1%
Landfill gas	11	0.3%
Municipal solid waste (biogenic)	7	0.2%
Other biomass waste	3	0.1%
Solar (total)	53	1.3%
Photovoltaic	50	1.2%
Solar thermal	3	0.1%
Geothermal	16	0.4%
Pumped storage hydropower[3]	-6	-0.2%
Other sources	13	0.3%

Table 21

U.S. Utility Direct Employment Per 100 Megawatts of Production in 2015

IMPLAN Industry Code	Energy Sector	Employment
41	Electric power generation - Hydroelectric	2.59
42	Electric power generation - Fossil fuel	4.02
43	Electric power generation - Nuclear	5.97
44	Electric power generation - Solar	6.20
45	Electric power generation - Wind	2.20
46	Electric power generation - Geothermal	8.16
47	Electric power generation - Biomass	4.56
48	Electric power generation - All other	11.91

As specific industrial sector impacts in the model can be driven by either job changes or output changes, the employment factors in Table 21 were multiplied, for each sector, by the amount of energy capacity added to the national electricity grid by each category of the 2024 through 2039 period of spending activity. Those direct utility and transmission employment change values were then used to shock the appropriate IMPLAN energy sectors to produce the operational economic impact projections associated with the completed construction additions. Unlike the construction impacts, which occur only during the period of construction, i.e., they are temporary and short-term, operational impacts are both continuous and cumulative. They represent summed job additions associated with incremental gains in the annual production and transmission of electricity by source.

These additions are cumulative, but they do not start until after construction is completed. In this analysis, then, all operations and maintenance impacts lag construction impacts by one full year. So construction of, say, wind energy capacity in 2024 and in 2025 would lead to incremental employment growth in wind energy operations in years 2025 and 2026.

All of the operational impacts are presented in Table 22 through Table 26, the last of which combines all of the energy and transmission impacts. As these are actual industrial output additions, conventional input-output terminology is used to describe the impacts. Further, as already mentioned, the amounts reported in the tables represent the additions per year, and those additions are annually and ultimately cumulative. This set of tables, however, only lists the annualized values that align with specific increments of energy generation and transmission additions. Table 27 following these tables displays the job values that would accumulate during the 2025 through 2040 period.

Table 22 shows the annualized additions to wind energy operations by investment period lagged by one year. As these represent typical industrial expansions, interpretation of the findings in each table that follows is demonstrated in the next paragraph.

In each of the years 2025 and 2026, the wind energy generation sector would require 268 new direct jobholders earning $44.2 million in total labor income to account for $603.9 million in direct output. That industry would next require $180.4 million in indirect supplies and services, which would in turn

employ 850 persons making $61.1billion in labor income. When the direct sector (the utility) and the supplying sector (the indirect activity) jobholders convert their labor income into household purchases, they would induce $159.5 million in additional national output, which would require 926 jobs making $50.0 million in labor income. Summed, these operational additions would account for $943.8 million in total output and $672.7 million in value added, of which $155.2 million would be labor income to a total of 2,043 jobholders.

There are some characteristics of these results that need to be addressed at this point. First, jobs in the nation's utilities have very high rates of pay. In the wind energy sector just portrayed, the model estimates the average worker in utility operations would make just under $165,000 in wages and salaries plus benefits in 2024. These modeled values were checked against the Bureau of Labor Statistics Quarterly Census of Employment and Wages per wind energy worker nationwide, inflated to 2024 values using a 2.5 percent annual compounded rate of change and multiplied times 1.35 to reflect the value of employee benefits. There was no substantial difference between the model results and the hand-calculated results. Accordingly, having validated the high income levels independent of the model, the modeled changes in all energy sector employment will yield robust induced effects – higher incomes lead to higher household spending.

The second point is a caution and has to do with the structure of input-output models like IMPLAN. They are not designed to consider marginal changes: all increments or decrements to productivity in a model run assume average effects. Thus, if additions, for example, to wind energy are simply administered within an existing utility operational structure that does not change (or changes very little) given increments of growth (up to some limit), then these values will overstate the annual job growth. As utilities are large, declining-cost industries that capitalize strongly on economies of scale, this concern must be acknowledge.

That means that the model has, given the average employment requirements that currently exist in the energy sector, produced estimates of the average value of economic activity that would be expected to align with the energy and transmission additions in the future given current average U.S. staffing requirements. If future staffing requirements require less labor per added MW of generation over time, then these results will over-estimate the ongoing job and labor income growth consequences.

Further, cumulative operations economic activity is offset from operations losses associated with energy production retirements. All in all, the operations impacts should be interpreted and described carefully so as to not overstate the net job growth that will occur from the mix of energy investments and operations studied in this analysis.

Last, the assessment of the transmission operational impacts requires special care in input-output modeling. Shocking that sector pre-supposes the addition of new generation capacities and all of the supply sector jobs that would be associated with those capacities, *ceteris paribus*. As this study has already added electricity generation, those assumptions were offset in the modeling process so as to not double-count jobs and other economic outcomes that had already been tallied.

Table 22

Scenario A: Annualized Wind Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	268	$44,169,350	$490,537,790	$603,850,484
Indirect	850	$61,107,841	$94,887,870	$180,408,721
Induced	926	$49,958,732	$87,302,405	$159,493,053
Total	2,043	$155,235,923	$672,728,065	$943,752,257

Scenario A: Annualized Wind Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	519	$85,618,790	$950,868,693	$1,170,516,385
Indirect	1,647	$118,452,716	$183,932,629	$349,708,031
Induced	1,795	$96,841,049	$169,228,804	$309,164,663
Total	3,961	$300,912,555	$1,304,030,126	$1,829,389,078

Scenario A: Annualized Wind Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	586	$96,589,568	$1,072,708,424	$1,320,500,712
Indirect	1,858	$133,630,676	$207,500,869	$394,517,932
Induced	2,025	$109,249,795	$190,912,967	$348,779,532
Total	4,469	$339,470,039	$1,471,122,260	$2,063,798,177

Scenario A: Annualized Wind Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	533	$87,920,363	$976,429,601	$1,201,981,783
Indirect	1,691	$121,636,919	$188,877,039	$359,108,756
Induced	1,843	$99,444,296	$173,777,951	$317,475,516
Total	4,068	$309,001,577	$1,339,084,592	$1,878,566,054

Scenario A: Annualized Wind Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	610	$100,598,071	$1,117,226,218	$1,375,301,978
Indirect	1,935	$139,176,398	$216,112,232	$410,890,572
Induced	2,109	$113,783,701	$198,835,926	$363,254,012
Total	4,654	$353,558,170	$1,532,174,376	$2,149,446,561

Scenario A: Annualized Wind Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	473	$78,062,865	$866,953,799	$1,067,217,412
Indirect	1,502	$107,999,172	$167,700,433	$318,846,028
Induced	1,637	$88,294,752	$154,294,232	$281,880,643
Total	3,611	$274,356,790	$1,188,948,463	$1,667,944,083

Scenario A: Annualized Wind Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	78	$12,785,490	$141,993,621	$174,793,703
Indirect	246	$17,688,594	$27,466,737	$52,222,047
Induced	268	$14,461,315	$25,271,008	$46,167,689
Total	592	$44,935,398	$194,731,366	$273,183,439

Scenario A: Annualized Wind Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	17	$2,855,874	$31,716,880	$39,043,379
Indirect	55	$3,951,072	$6,135,199	$11,664,752
Induced	60	$3,230,200	$5,644,743	$10,312,400
Total	132	$10,037,145	$43,496,822	$61,020,532

Table 23

Scenario A: Annualized Solar Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	73	$13,578,888	$35,178,730	$38,658,595
Indirect	26	$1,843,823	$2,862,298	$5,479,923
Induced	135	$7,257,570	$12,685,163	$23,165,583
Total	233	$22,680,282	$50,726,191	$67,304,101

Scenario A: Annualized Solar Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	418	$77,965,023	$201,983,433	$221,963,553
Indirect	147	$10,586,560	$16,434,270	$31,463,716
Induced	773	$41,670,322	$72,833,580	$133,008,329
Total	1,338	$130,221,905	$291,251,283	$386,435,597

Scenario A: Annualized Solar Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	1,541	$287,296,818	$744,297,835	$817,923,476
Indirect	540	$39,010,892	$60,559,381	$115,942,062
Induced	2,849	$153,552,842	$268,387,734	$490,128,370
Total	4,931	$479,860,552	$1,073,244,950	$1,423,993,908

Scenario A: Annualized Solar Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	1,722	$320,888,000	$831,322,272	$913,556,335
Indirect	603	$43,572,105	$67,640,076	$129,498,185
Induced	3,182	$171,506,474	$299,768,036	$547,434,926
Total	5,508	$535,966,579	$1,198,730,385	$1,590,489,446

Table 24

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	227	$37,698,134	$150,622,999	$376,894,390
Indirect	916	$88,808,338	$159,791,317	$300,128,668
Induced	1,114	$60,121,846	$105,058,974	$191,944,038
Total	2,258	$186,628,318	$415,473,290	$868,967,097

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	8	$1,395,942	$5,577,491	$13,956,203
Indirect	34	$3,288,527	$5,916,989	$11,113,608
Induced	41	$2,226,281	$3,890,279	$7,107,588
Total	84	$6,910,750	$15,384,760	$32,177,399

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	77	$12,830,560	$51,264,539	$128,276,010
Indirect	312	$30,225,919	$54,384,976	$102,148,796
Induced	379	$20,462,471	$35,756,823	$65,328,156
Total	768	$63,518,950	$141,406,339	$295,752,961

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	173	$28,713,737	$114,725,814	$287,071,138
Indirect	698	$67,643,115	$121,709,095	$228,600,586
Induced	849	$45,793,323	$80,020,823	$146,199,028
Total	1,719	$142,150,176	$316,455,732	$661,870,752

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	33	$5,486,433	$21,921,056	$54,851,671
Indirect	133	$12,924,803	$23,255,376	$43,679,501
Induced	162	$8,749,888	$15,289,854	$27,934,752
Total	329	$27,161,123	$60,466,286	$126,465,923

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	12	$1,931,268	$7,716,387	$19,308,227
Indirect	47	$4,549,634	$8,186,078	$15,375,534
Induced	57	$3,080,031	$5,382,151	$9,833,256
Total	116	$9,560,933	$21,284,617	$44,517,017

Scenario A: Annualized Natural Gas-Fueled Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	7	$1,128,053	$4,507,140	$11,277,930
Indirect	27	$2,657,440	$4,781,486	$8,980,845
Induced	33	$1,799,045	$3,143,713	$5,743,602
Total	68	$5,584,538	$12,432,339	$26,002,378

Table 25

Scenario A: Annualized Net Transmission Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	14	$2,014,515	$7,831,059	$20,789,953
Indirect	32	$3,706,249	$9,761,248	$19,873,938
Induced	40	$2,141,733	$3,741,871	$6,838,729
Total	86	$7,862,497	$21,334,178	$47,502,620

Scenario A: Annualized Net Transmission Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	19	$2,820,321	$10,963,482	$29,105,935
Indirect	45	$5,188,749	$13,665,747	$27,823,513
Induced	56	$2,998,427	$5,238,619	$9,574,220
Total	120	$11,007,496	$29,867,849	$66,503,667

Scenario A: Annualized Net Transmission Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	22	$3,223,224	$12,529,694	$33,263,925
Indirect	52	$5,929,998	$15,617,997	$31,798,300
Induced	63	$3,426,773	$5,986,993	$10,941,966
Total	137	$12,579,996	$34,134,684	$76,004,191

Scenario A: Annualized Net Transmission Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	22	$3,223,224	$12,529,694	$33,263,925
Indirect	52	$5,929,998	$15,617,997	$31,798,300
Induced	63	$3,426,773	$5,986,993	$10,941,966
Total	137	$12,579,996	$34,134,684	$76,004,191

Scenario A: Annualized Net Transmission Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	22	$3,223,224	$12,529,694	$33,263,925
Indirect	52	$5,929,998	$15,617,997	$31,798,300
Induced	63	$3,426,773	$5,986,993	$10,941,966
Total	137	$12,579,996	$34,134,684	$76,004,191

Scenario A: Annualized Net Transmission Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	22	$3,223,224	$12,529,694	$33,263,925
Indirect	52	$5,929,998	$15,617,997	$31,798,300
Induced	63	$3,426,773	$5,986,993	$10,941,966
Total	137	$12,579,996	$34,134,684	$76,004,191

Scenario A: Annualized Net Transmission Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	22	$3,223,224	$12,529,694	$33,263,925
Indirect	52	$5,929,998	$15,617,997	$31,798,300
Induced	63	$3,426,773	$5,986,993	$10,941,966
Total	137	$12,579,996	$34,134,684	$76,004,191

Scenario A: Annualized Net Transmission Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	22	$3,223,224	$12,529,694	$33,263,925
Indirect	52	$5,929,998	$15,617,997	$31,798,300
Induced	63	$3,426,773	$5,986,993	$10,941,966
Total	137	$12,579,996	$34,134,684	$76,004,191

Table 26

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	509	$83,881,999	$648,991,848	$1,001,534,827
Indirect	1,798	$153,622,429	$264,440,435	$500,411,327
Induced	2,080	$112,222,311	$196,103,249	$358,275,819
Total	4,387	$349,726,739	$1,109,535,532	$1,860,221,973

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	620	$103,413,941	$1,002,588,396	$1,252,237,118
Indirect	1,752	$128,773,814	$206,377,663	$394,125,075
Induced	2,026	$109,323,327	$191,042,865	$349,012,054
Total	4,398	$341,511,082	$1,400,008,925	$1,995,374,246

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	685	$112,643,353	$1,136,502,657	$1,482,040,647
Indirect	2,222	$169,786,593	$277,503,843	$528,465,028
Induced	2,468	$133,139,039	$232,656,783	$425,049,654
Total	5,374	$415,568,985	$1,646,663,283	$2,435,555,329

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	728	$119,857,324	$1,103,685,110	$1,522,316,846
Indirect	2,441	$195,210,032	$326,204,131	$619,507,642
Induced	2,755	$148,664,392	$259,785,767	$474,616,509
Total	5,924	$463,731,748	$1,689,675,008	$2,616,440,997

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	665	$109,307,728	$1,151,676,969	$1,463,417,574
Indirect	2,120	$158,031,199	$254,985,605	$486,368,373
Induced	2,335	$125,960,363	$220,112,773	$402,130,729
Total	5,120	$393,299,290	$1,626,775,346	$2,351,916,676

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	925	$161,182,380	$1,089,183,313	$1,341,753,117
Indirect	1,747	$129,065,365	$207,938,778	$397,483,578
Induced	2,530	$136,471,878	$238,496,956	$435,664,194
Total	5,202	$426,719,623	$1,535,619,047	$2,174,900,889

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	1,648	$304,433,585	$903,328,290	$1,037,259,035
Indirect	865	$65,286,924	$108,425,601	$208,943,255
Induced	3,214	$173,239,975	$302,789,448	$552,981,627
Total	5,727	$542,960,484	$1,314,543,339	$1,799,183,917

Scenario A: Annualized Energy and Transmission Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	1,761	$326,967,098	$875,568,846	$985,863,640
Indirect	710	$53,453,175	$89,393,273	$172,961,237
Induced	3,305	$178,163,447	$311,399,773	$568,689,292
Total	5,777	$558,583,720	$1,276,361,891	$1,727,514,169

Cumulative Operations Impact Values, 2025 through 2030: Scenario A

The value of energy and transmission operations associated with incremental power generation investments results in cumulative job growth over time by category of operation (see Table 27 and Figure 5). After of the all annual additions were tallied, the modeling projected total U.S. job growth in energy production and transmission of 4,387 jobs in 2025 climbing to a peak of 83,819 jobs for year 2040 and thereafter. Recalling the caveats mentioned in the previous subsection, these values represent the estimated number of jobs that would be associated with energy generation and transmission additions but, owing to likely economies of scale in modern energy generation and transmission systems, may overstate the ultimate gains in each sector over time.

Table 27

Scenario A: Cumulative Operations Jobs Impacts, 2025 through 2030

	Wind	Solar	Natural Gas	Transmission	Total
2025	2,043		2,258	86	4,387
2026	4,087		4,515	171	8,773
2027	8,048	233	4,599	291	13,171
2028	12,009	466	4,682	411	17,569
2029	16,477	466	5,451	549	22,943
2030	20,946	466	6,219	686	28,317
2031	25,014	466	7,938	823	34,241
2032	29,081	466	9,658	960	40,165
2033	33,735	466	9,986	1,097	45,285
2034	38,389	466	10,315	1,234	50,405
2035	42,001	1,804	10,431	1,372	55,607
2036	45,612	3,143	10,546	1,509	60,810
2037	46,204	8,074	10,614	1,646	66,537
2038	46,795	13,005	10,681	1,783	72,265
2039	46,927	18,513	10,681	1,920	78,042
2040	47,059	24,021	10,681	2,057	83,819
After 2040 …	*47,059*	*24,021*	*10,681*	*2,057*	*83,819*

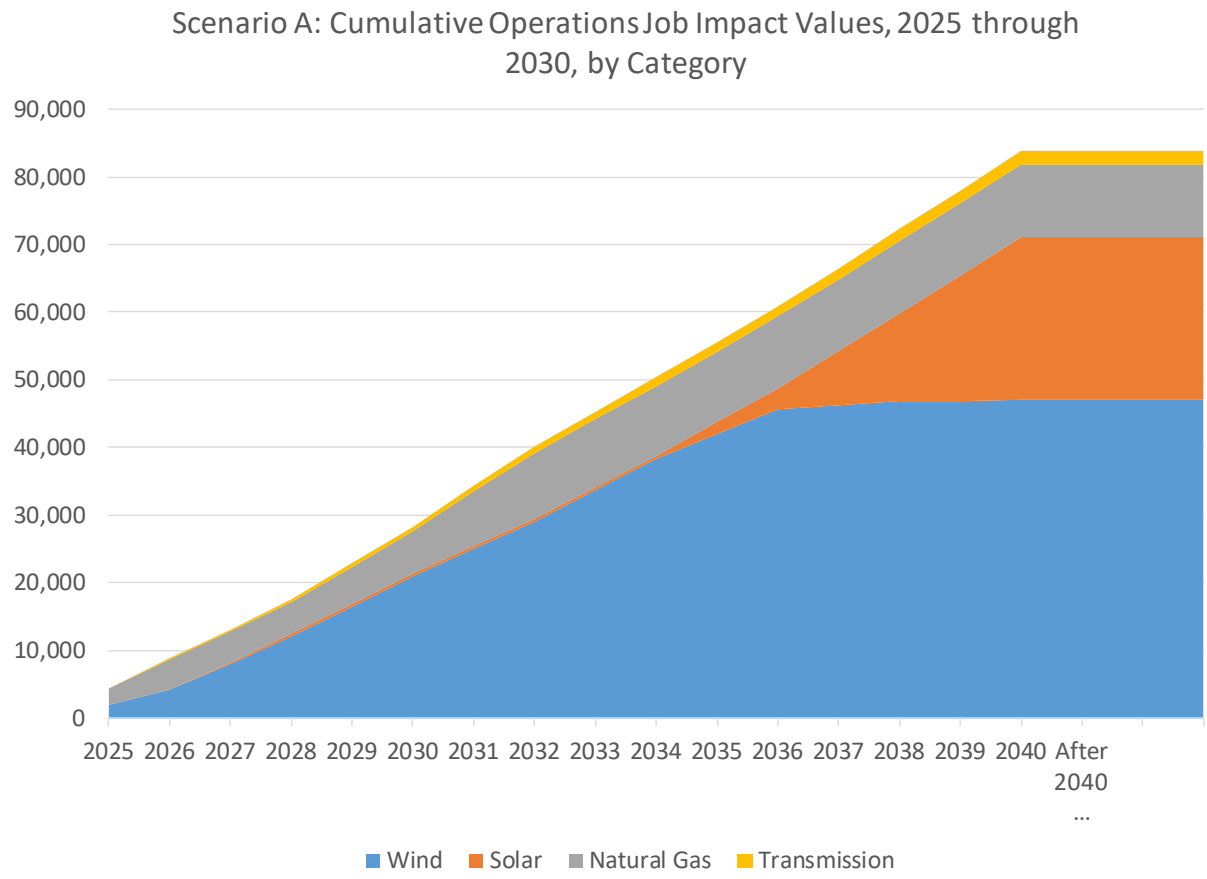

Figure 5

Table 28 shows the expected value for all of the economic variables when all of the investments are fully operational. Overall, using the current modeling configuration, operating and maintaining this new electric generation would produce $33.9 billion annually in total industrial output and generate $23.2 billion in total value added, of which $7.0 billion would be labor income to 83,819 workers.

Table 28

Scenario A: Energy and Transmission Operations Annual Impacts 2040 and Thereafter

	Jobs	Labor Income	Value Added	Output
Direct	15,079	$2,643,374,816	$15,823,050,856	$20,172,845,606
Indirect	27,311	$2,106,459,064	$3,470,538,656	$6,616,531,028
Induced	41,424	$2,234,369,462	$3,904,775,228	$7,132,839,756
Total	83,819	$6,984,203,342	$23,198,364,740	$33,922,216,390

The job reducing consequences of energy generation retirements must be factored into this long-range outlook. Those values are displayed in Table 29. Cumulative energy production retirements grow from

7,211 jobs in 2025 to a final 82,499 by 2040. The retiring of nearly all fossil-fuel-driven energy production has large expected job impacts. Those energy sectors have strong backward linkages to fossil fuel extraction and transportation as well as industries that further support their supply sources.

The new energy investments, in contrast, rely on "free" inputs of wind and solar energy; hence, the total number of jobs that would link to their ongoing operations over time are significantly different than has been the status quo. Consequently, net energy generation operations jobs under Scenario A nationally would be expected to erode consistently through2028 where it hits its trough. Slowly the new energy and transmission investments offset those losses such that by 2040 there is a net gain in operations employment.

Table 29

Scenario A: Operations Net Cumulative Jobs Considering Capacity Additions and Retirements

	New Investment	Losses Due to Retirements	Net Change
2025	4,387	(7,221)	(2,835)
2026	8,773	(14,443)	(5,669)
2027	13,171	(20,592)	(7,421)
2028	17,569	(26,741)	(9,172)
2029	22,943	(31,000)	(8,057)
2030	28,317	(35,259)	(6,943)
2031	34,241	(39,918)	(5,677)
2032	40,165	(44,576)	(4,411)
2033	45,285	(49,308)	(4,023)
2034	50,405	(54,039)	(3,634)
2035	55,607	(58,357)	(2,750)
2036	60,810	(62,676)	(1,866)
2037	66,537	(66,284)	253
2038	72,265	(69,892)	2,372
2039	78,042	(76,195)	1,846
2040	83,819	(82,499)	1,320

Appendix -- Scenario B: The Full Build-Out Option

Scenario B assumes an optimal policy foundation that allows for the full build-out of Design 3 over the 15 year investment horizon. Under Scenario B, there are CO_2 penalties, but state renewable portfolio standards are not in effect. Given these considerations, transmission investments double to $80.1 billion, and energy generation investment grows by 40 percent to $700.5 billion.

What follows is a listing of all pertinent Scenario B tables for both construction and for ongoing operations that align with the tables presented in Scenario A. In this section of the report, the tables will be introduced but not elaborated on as was the case for Scenario A.

Table 30 and Table 31 display the transmission spending under the full build-out scenario as well as capacity additions in MWs and costs for each energy generation source.

Table 30

Transmission Spending: Scenario B

		Investment
2024	$	6,717,580,195
2026	$	2,799,687,721
2028	$	9,823,342,132
2030	$	15,170,208,254
2032	$	17,581,519,402
2034	$	14,148,587,823
2036	$	5,895,373,187
2038	$	7,939,445,711
Total	$	80,075,744,425

Table 31

Energy Generation Investments and Capacities: Scenario B

Year	Wind	Solar	Natural Gas	Total
		Investment in Constant $2024		
2024	$ 66,812,881,884		$ 16,482,851,522	$ 83,295,733,406
2026	$ 117,011,498,479	$ 3,416,723,476	$ 536,792,383	$ 120,965,014,339
2028	$ 119,117,447,354		$ 4,880,309,925	$ 123,997,757,279
2030	$ 94,607,466,839		$ 9,747,772,591	$ 104,355,239,429
2032	$ 98,293,325,013		$ 1,586,219,302	$ 99,879,544,315
2034	$ 66,643,823,515	$ 11,739,119,467	$ 476,630,203	$ 78,859,573,186
2036	$ 10,695,330,913	$ 39,245,871,310	$ 249,183,104	$ 50,190,385,327
2038	$ 2,452,541,714	$ 36,514,559,872		$ 38,967,101,587
Total	$ 575,634,315,712	$ 90,916,274,126	$ 33,959,759,029	$ 700,510,348,867
		MWs of Installed Capacity		
2024	34,110		15,890	50,000
2026	66,120	3,292	588	70,000
2028	74,592		5,408	80,000
2030	67,897		12,103	80,000
2032	77,687		2,313	80,000
2034	60,284	18,901	814	80,000
2036	9,874	69,651	475	80,000
2038	2,205	77,795		80,000
Total	392,770	169,639	37,592	600,000

Table 32 through Table 36 list the annualized and initial job and labor income values for each of the four investment categories for only the construction activity (excludes all supply chain and induced effects). The tables also list the total investment that would occur during each construction year.

Table 32

Scenario B: Wind Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	78,804	$ 5,287,366,049	$ 33,406,440,942
2026 and 2027	138,013	$ 9,259,930,225	$ 58,505,749,240
2028 and 2029	140,497	$ 9,426,588,544	$ 59,558,723,677
2030 and 2031	111,588	$ 7,486,944,044	$ 47,303,733,419
2032 and 2033	115,935	$ 7,778,631,528	$ 49,146,662,506
2024 and 2035	78,605	$ 5,273,987,289	$ 33,321,911,758
2036 and 2037	12,615	$ 846,395,604	$ 5,347,665,457
2038 and 2039	2,893	$ 194,086,611	$ 1,226,270,857

Table 33

Scenario B: Solar Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	2,311	$ 179,929,602	$ 1,708,362,498
2026 and 2027	-	$ -	$ -
2028 and 2029	-	$ -	$ -
2030 and 2031	-	$ -	$ -
2032 and 2033	-	$ -	$ -
2024 and 2035	7,939	$ 618,199,018	$ 5,869,562,345
2036 and 2037	26,543	$ 2,066,744,374	$ 19,622,944,386
2038 and 2039	24,695	$ 1,922,909,561	$ 18,257,288,059

Table 34

Scenario B: Natural Gas-Fueled Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	16,483	$ 1,354,594,953	$ 8,241,425,761
2026 and 2027	537	$ 44,114,712	$ 268,396,192
2028 and 2029	4,880	$ 401,074,000	$ 2,440,154,962
2030 and 2031	9,748	$ 801,092,186	$ 4,873,886,295
2032 and 2033	1,586	$ 130,358,795	$ 793,109,651
2024 and 2035	477	$ 39,170,459	$ 238,315,102
2036 and 2037	249	$ 20,478,385	$ 124,591,552
2038 and 2039	-	$ -	$ -

Table 35

Scenario B: Transmission Initial Construction Impacts

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	13,974	$ 1,280,370,785	$ 3,358,790,097
2026 and 2027	5,824	$ 533,620,480	$ 1,399,843,861
2028 and 2029	20,435	$ 1,872,329,010	$ 4,911,671,066
2030 and 2031	31,557	$ 2,891,441,693	$ 7,585,104,127
2032 and 2033	36,574	$ 3,351,037,598	$ 8,790,759,701
2024 and 2035	29,432	$ 2,696,720,839	$ 7,074,293,911
2036 and 2037	12,264	$ 1,123,658,130	$ 2,947,686,594
2038 and 2039	16,516	$ 1,513,258,352	$ 3,969,722,855

Table 36

Scenario B: Initial Construction Impacts from Energy and Transmission Investments

In Each of Years …	Initial Construction-Only Jobs	Initial Construction-Only Labor Income	Annual Project Spending
2024 and 2025	111,573	$ 8,102,261,389	$ 46,715,019,299
2026 and 2027	144,373	$ 9,837,665,417	$ 60,173,989,292
2028 and 2029	165,812	$ 11,699,991,554	$ 66,910,549,705
2030 and 2031	152,893	$ 11,179,477,924	$ 59,762,723,842
2032 and 2033	154,095	$ 11,260,027,920	$ 58,730,531,858
2024 and 2035	116,453	$ 8,628,077,606	$ 46,504,083,116
2036 and 2037	51,670	$ 4,057,276,493	$ 28,042,887,988
2038 and 2039	44,104	$ 3,630,254,524	$ 23,453,281,772

Table 37 through Table 41 display the energy and transmission total construction plus supply chain and induced impacts under the full build-out assumptions in Scenario B. Construction activity and supply sector iterative effects plus the induced effects yield the total economic outcomes for each measurement period. These tables reflect annualized impacts given the biennial investment patterns illustrated in Table 31 and Table 32.

Table 37

Scenario B: Annualized Wind Construction Impacts in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	250,341	$ 17,507,491,211	$ 23,490,298,627	$ 47,884,384,909
Induced	155,659	$ 8,408,268,288	$ 14,689,776,049	$ 26,848,945,718
Total	406,000	$ 25,915,759,499	$ 38,180,074,676	$ 74,733,330,627

Scenario B: Annualized Wind Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	438,430	$ 30,661,419,226	$ 41,139,297,760	$ 83,861,427,227
Induced	272,611	$ 14,725,664,337	$ 25,726,666,166	$ 47,021,401,898
Total	711,041	$ 45,387,083,563	$ 66,865,963,926	$ 130,882,829,125

Scenario B: Annualized Wind Construction Impacts in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	446,321	$ 31,213,257,141	$ 41,879,714,377	$ 85,370,747,940
Induced	277,517	$ 14,990,693,814	$ 26,189,689,410	$ 47,867,683,415
Total	723,838	$ 46,203,950,954	$ 68,069,403,787	$ 133,238,431,355

Scenario B: Annualized Wind Construction Impacts in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	354,484	$ 24,790,719,206	$ 33,262,412,662	$ 67,804,594,408
Induced	220,414	$ 11,906,161,518	$ 20,800,816,568	$ 38,018,278,362
Total	574,899	$ 36,696,880,724	$ 54,063,229,230	$ 105,822,872,770

Scenario B: Annualized Wind Construction Impacts in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	368,295	$ 25,756,552,856	34,558,299,125	$ 70,446,226,478
Induced	229,001	$ 12,370,019,438	21,611,205,666	$ 39,499,450,903
Total	597,296	$ 38,126,572,294	56,169,504,791	$ 109,945,677,382

Scenario B: Annualized Wind Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	249,708	$ 17,463,191,551	$ 23,430,860,515	$ 47,763,221,807
Induced	155,265	$ 8,386,992,629	$ 14,652,606,127	$ 26,781,009,134
Total	404,973	$ 25,850,184,180	$ 38,083,466,642	$ 74,544,230,941

Scenario B: Annualized Wind Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	40,074	$ 2,802,579,483	$ 3,760,300,558	$ 7,665,278,427
Induced	24,918	$ 1,345,986,121	$ 2,351,522,812	$ 4,297,949,004
Total	64,992	$ 4,148,565,604	$ 6,111,823,370	$ 11,963,227,431

Scenario B: Annualized Wind Construction Impacts in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	9,189	$ 642,658,291	$ 862,272,898	$ 1,757,721,687
Induced	5,714	$ 308,647,496	$ 539,226,681	$ 985,560,831
Total	14,903	$ 951,305,788	$ 1,401,499,579	$ 2,743,282,518

Table 38

Scenario B: Annualized Solar Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	8,811	$ 706,933,934	$ 1,204,830,979	$ 1,994,710,829
Induced	6,276	$ 339,014,463	$ 592,279,353	$ 1,082,531,916
Total	15,087	$ 1,045,948,397	$ 1,797,110,332	$ 3,077,242,744

Scenario B: Annualized Solar Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	30,273	$ 2,428,871,394	$ 4,139,537,453	$ 6,853,392,990
Induced	21,563	$ 1,164,780,031	$ 2,034,943,164	$ 3,719,344,445
Total	51,836	$ 3,593,651,424	$ 6,174,480,618	$ 10,572,737,435

Scenario B: Annualized Solar Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	101,207	$ 8,120,129,828	$ 13,839,177,175	$ 22,912,057,422
Induced	72,088	$ 3,894,057,585	$ 6,803,160,814	$ 12,434,400,542
Total	173,295	$ 12,014,187,413	$ 20,642,337,989	$ 35,346,457,964

Scenario B: Annualized Solar Construction Impacts in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	94,164	$ 7,555,010,422	$ 12,876,041,394	$ 21,317,495,691
Induced	67,071	$ 3,623,051,141	$ 6,329,695,700	$ 11,569,030,012
Total	161,235	$ 11,178,061,563	$ 19,205,737,094	$ 32,886,525,703

Table 39

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	49,453	$ 4,085,879,720	$ 5,611,886,480	$ 10,526,417,474
Induced	36,341	$ 1,963,214,916	$ 3,429,807,813	$ 6,268,945,757
Total	85,794	$ 6,049,094,636	$ 9,041,694,293	$ 16,795,363,231

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	1,611	$ 133,063,694	$ 182,760,726	$ 342,810,873
Induced	1,184	$ 63,935,467	$ 111,697,585	$ 204,158,991
Total	2,794	$ 196,999,161	$ 294,458,312	$ 546,969,864

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	14,642	$ 1,209,763,937	$ 1,661,590,244	$ 3,116,704,631
Induced	10,760	$ 581,276,682	$ 1,015,511,490	$ 1,856,135,035
Total	25,402	$ 1,791,040,619	$ 2,677,101,734	$ 4,972,839,666

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	952	$ 78,692,369	$ 108,082,634	$ 202,734,486
Induced	700	$ 37,810,715	$ 66,056,693	$ 120,737,326
Total	1,652	$ 116,503,083	$ 174,139,326	$ 323,471,812

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	4,759	$ 393,202,673	540,057,201	$ 1,013,004,731
Induced	3,497	$ 188,929,045	330,065,908	$ 603,288,985
Total	8,256	$ 582,131,718	870,123,109	$ 1,616,293,716

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	1,430	$ 118,150,290	$ 162,277,418	$ 304,389,595
Induced	1,051	$ 56,769,760	$ 99,178,834	$ 181,277,426
Total	2,481	$ 174,920,050	$ 261,456,252	$ 485,667,021

Scenario B: Annualized Natural Gas-Fueled Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	748	$ 61,769,178	$ 84,838,918	$ 159,135,413
Induced	549	$ 29,679,330	$ 51,850,868	$ 94,772,155
Total	1,297	$ 91,448,508	$ 136,689,786	$ 253,907,568

Table 40

Scenario B: Annualized Transmission Construction Impacts in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	24,691	$ 1,653,796,372	$ 2,402,678,424	$ 5,322,133,921
Induced	14,647	$ 790,543,553	$ 1,381,347,062	$ 2,523,975,140
Total	39,337	$ 2,444,339,925	$ 3,708,583,875	$ 7,668,703,403

Scenario B: Annualized Transmission Construction Impacts in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	10,290	$ 689,253,163	$ 1,001,364,939	$ 2,218,107,199
Induced	6,104	$ 329,475,051	$ 575,704,390	$ 1,051,917,804
Total	16,395	$ 1,018,728,214	$ 1,545,627,508	$ 3,196,087,599

Scenario B: Annualized Transmission Construction Impacts in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	36,106	$ 2,418,401,732	$ 3,513,516,996	$ 7,782,734,386
Induced	21,418	$ 1,156,038,271	$ 2,019,989,996	$ 3,690,893,240
Total	57,524	$ 3,574,440,003	$ 5,423,186,202	$ 11,214,201,401

Scenario B: Annualized Transmission Construction Impacts in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	55,758	$ 3,734,742,965	$ 5,425,931,809	$ 12,018,893,350
Induced	33,076	$ 1,785,272,373	$ 3,119,474,870	$ 5,699,854,321
Total	88,834	$ 5,520,015,338	$ 8,375,038,045	$ 17,318,115,198

Scenario B: Annualized Transmission Construction Impacts in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	64,621	$ 4,328,381,971	6,288,386,011	$ 13,929,301,634
Induced	38,334	$ 2,069,042,187	3,615,316,746	$ 6,605,848,625
Total	102,955	$ 6,397,424,157	9,706,253,956	$ 20,070,837,081

Scenario B: Annualized Transmission Construction Impacts in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	52,003	$ 3,483,230,945	$ 5,060,528,599	$ 11,209,494,639
Induced	30,849	$ 1,665,045,234	$ 2,909,397,380	$ 5,316,004,111
Total	82,852	$ 5,148,276,179	$ 7,811,030,628	$ 16,151,846,414

Scenario B: Annualized Transmission Construction Impacts in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	21,669	$ 1,451,377,804	$ 2,108,599,458	$ 4,670,724,384
Induced	12,854	$ 693,783,942	$ 1,212,275,283	$ 2,215,049,904
Total	34,522	$ 2,145,161,745	$ 3,254,666,904	$ 6,730,082,427

Scenario B: Annualized Transmission Construction Impacts in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	29,182	$ 1,954,606,589	$ 2,839,703,339	$ 6,290,180,705
Induced	17,311	$ 934,336,091	$ 1,632,601,277	$ 2,983,062,802
Total	46,492	$ 2,888,942,680	$ 4,383,140,875	$ 9,063,569,406

Table 41

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2024 and 2025

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	324,484	$ 23,247,167,303	$ 31,504,863,531	$ 63,732,936,304
Induced	206,647	$ 11,162,026,757	$ 19,500,930,924	$ 35,641,866,615
Total	531,131	$ 34,409,194,060	$ 50,930,352,844	$ 99,197,397,261

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2026 and 2027

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	459,142	$ 32,190,670,018	$ 43,528,254,405	$ 88,417,056,128
Induced	286,174	$ 15,458,089,318	$ 27,006,347,494	$ 49,360,010,609
Total	745,316	$ 47,648,759,335	$ 70,503,160,078	$ 137,703,129,332

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2028 and 2029

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	497,069	$ 34,841,422,810	$ 47,054,821,618	$ 96,270,186,957
Induced	309,695	$ 16,728,008,766	$ 29,225,190,897	$ 53,414,711,691
Total	806,764	$ 51,569,431,576	$ 76,169,691,724	$ 149,425,472,422

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2030 and 2031

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	411,195	$ 28,604,154,540	$ 38,796,427,105	$ 80,026,222,244
Induced	254,190	$ 13,729,244,606	$ 23,986,348,130	$ 43,838,870,010
Total	665,386	$ 42,333,399,145	$ 62,612,406,601	$ 123,464,459,780

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2032 and 2033

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	437,675	$ 30,478,137,500	$ 41,386,742,337	$ 85,388,532,844
Induced	270,832	$ 14,627,990,670	$ 25,556,588,320	$ 46,708,588,513
Total	708,508	$ 45,106,128,169	$ 66,745,881,857	$ 131,632,808,179

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2034 and 2035

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	333,414	$ 23,493,444,179	$ 32,793,203,985	$ 66,130,499,031
Induced	208,727	$ 11,273,587,653	$ 19,696,125,506	$ 35,997,635,116
Total	542,141	$ 34,767,031,833	$ 52,330,434,140	$ 101,754,481,811

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2036 and 2037

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	163,698	$ 12,435,856,293	$ 19,792,916,109	$ 35,407,195,646
Induced	110,409	$ 5,963,506,977	$ 10,418,809,777	$ 19,042,171,604
Total	274,107	$ 18,399,363,270	$ 30,145,518,050	$ 54,293,675,390

Scenario B: Annualized Construction Impacts for All Energy and Transmission Investments in Years 2038 and 2039

	Jobs	Labor Income	Value Added	Output
Construction Plus Supply Chain	132,535	$ 10,152,275,303	$ 16,578,017,630	$ 29,365,398,083
Induced	90,096	$ 4,866,034,728	$ 8,501,523,658	$ 15,537,653,645
Total	222,630	$ 15,018,310,031	$ 24,990,377,547	$ 44,693,377,627

Table 42 and Figure 6 display total annualized construction and investment related job impacts by energy source and transmission additions.

Table 42

Scenario B: Total Energy Production and Distribution Investment-Related Jobs , 2024 through 2039

	Wind	Solar	Natural Gas	Transmission	Total
2024	406,000		85,794	39,337	531,131
2025	406,000		85,794	39,337	531,131
2026	711,041	15,087	2,794	16,395	745,316
2027	711,041	15,087	2,794	16,395	745,316
2028	723,838		25,402	57,524	806,764
2029	723,838		25,402	57,524	806,764
2030	574,899		1,652	88,834	665,386
2031	574,899		1,652	88,834	665,386
2032	597,296		8,256	102,955	708,508
2033	597,296		8,256	102,955	708,508
2034	404,973	51,836	2,481	82,852	542,141
2035	404,973	51,836	2,481	82,852	542,141
2036	64,992	173,295	1,297	34,522	274,107
2037	64,992	173,295	1,297	34,522	274,107
2038	14,903	161,235		46,492	222,630
2039	14,903	161,235		46,492	222,630

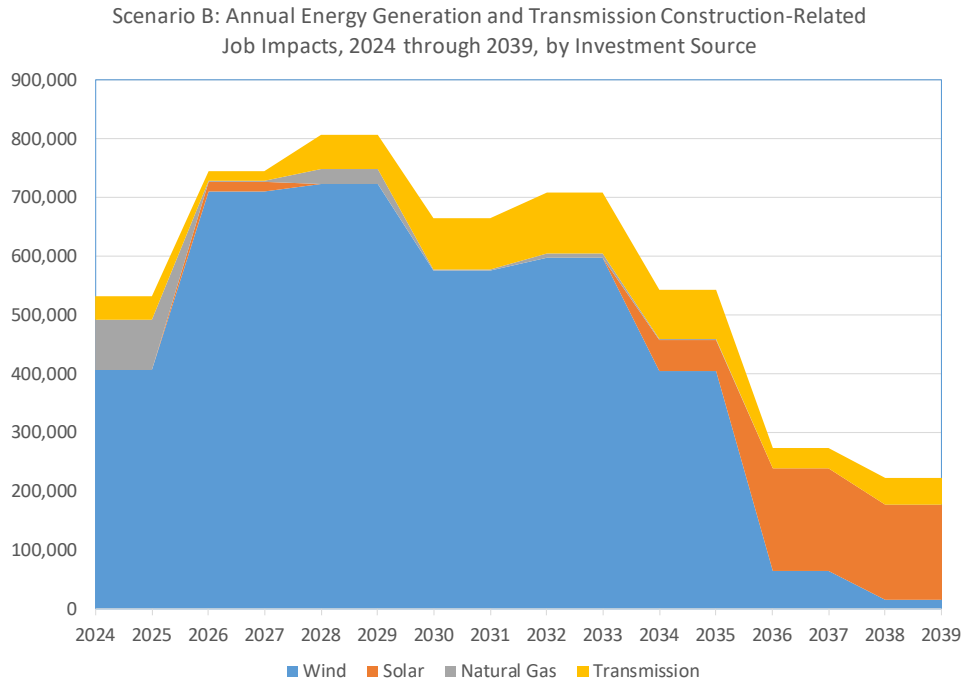

Figure 6

Table 43 through Table 47 present the utility and transportation system operations and maintenance impacts that correspond to each year of investment. Operations impacts lag construction activity by one year. They are cumulative as more generation and transmission capacity are added and are considered ongoing additions to industrial productivity. Cumulative job impacts are displayed in Table 48 and Figure 7.

As was done in Scenario A, these construction-related impacts need to be contextualized in terms of the whole U.S. economy. Between 2009 and 2017, the U.S. added an average of 2.23 million jobs per year. Scenario B would produce 561,998 annual average total jobs over the construction period, which would be the equivalent of 25.4 percent of the average number of jobs created annually in the recent U.S. economy.

Table 43

Scenario B: Annualized Wind Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	375	$61,837,090	$686,752,906	$845,390,677
Indirect	1,190	$85,550,978	$132,843,019	$252,572,209
Induced	1,296	$69,942,225	$122,223,367	$223,290,274
Total	2,861	$217,330,293	$941,819,291	$1,321,253,160

Scenario B: Annualized Wind Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	727	$119,866,305	$1,331,216,170	$1,638,722,938
Indirect	2,306	$165,833,802	$257,505,681	$489,591,243
Induced	2,513	$135,577,469	$236,920,325	$432,830,528
Total	5,545	$421,277,576	$1,825,642,176	$2,561,144,710

Scenario B: Annualized Wind Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	820	$135,225,396	$1,501,791,793	$1,848,700,997
Indirect	2,601	$187,082,946	$290,501,217	$552,325,105
Induced	2,835	$152,949,713	$267,278,154	$488,291,345
Total	6,256	$475,258,054	$2,059,571,164	$2,889,317,447

Scenario B: Annualized Wind Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	746	$123,088,508	$1,367,001,442	$1,682,774,496
Indirect	2,368	$170,291,686	$264,427,855	$502,752,258
Induced	2,580	$139,222,014	$243,289,132	$444,465,722
Total	5,695	$432,602,208	$1,874,718,429	$2,629,992,476

Scenario B: Annualized Wind Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	854	$140,837,300	$1,564,116,706	$1,925,422,769
Indirect	2,709	$194,846,957	$302,557,125	$575,246,800
Induced	2,953	$159,297,182	$278,370,296	$508,555,616
Total	6,516	$494,981,439	$2,145,044,126	$3,009,225,185

Scenario B: Annualized Wind Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	663	$109,288,012	$1,213,735,318	$1,494,104,377
Indirect	2,102	$151,198,841	$234,780,606	$446,384,439
Induced	2,291	$123,612,653	$216,011,924	$394,632,901
Total	5,056	$384,099,506	$1,664,527,848	$2,335,121,717

Scenario B: Annualized Wind Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	109	$17,899,686	$198,791,070	$244,711,185
Indirect	344	$24,764,031	$38,453,431	$73,110,866
Induced	375	$20,245,840	$35,379,412	$64,634,765
Total	828	$62,909,557	$272,623,913	$382,456,815

Scenario B: Annualized Wind Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	24	$3,998,223	$44,403,631	$54,660,731
Indirect	77	$5,531,501	$8,589,279	$16,330,653
Induced	84	$4,522,280	$7,902,640	$14,437,360
Total	185	$14,052,003	$60,895,551	$85,428,744

Table 44

Scenario B: Annualized Solar Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	102	$19,010,444	$49,250,222	$54,122,034
Indirect	36	$2,581,353	$4,007,217	$7,671,892
Induced	189	$10,160,599	$17,759,229	$32,431,817
Total	326	$31,752,395	$71,016,667	$94,225,742

Scenario B: Annualized Solar Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	586	$109,151,032	$282,776,806	$310,748,974
Indirect	205	$14,821,184	$23,007,978	$44,049,202
Induced	1,082	$58,338,450	$101,967,012	$186,211,660
Total	1,873	$182,310,667	$407,751,797	$541,009,836

Scenario B: Annualized Solar Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	2,158	$402,215,546	$1,042,016,969	$1,145,092,866
Indirect	756	$54,615,249	$84,783,134	$162,318,887
Induced	3,988	$214,973,978	$375,742,827	$686,179,719
Total	6,904	$671,804,773	$1,502,542,930	$1,993,591,472

Scenario B: Annualized Solar Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	2,410	$449,243,200	$1,163,851,181	$1,278,978,869
Indirect	845	$61,000,947	$94,696,107	$181,297,458
Induced	4,455	$240,109,064	$419,675,251	$766,408,897
Total	7,711	$750,353,211	$1,678,222,539	$2,226,685,224

Table 45

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	318	$52,777,388	$210,872,199	$527,652,146
Indirect	1,283	$124,331,673	$223,707,843	$420,180,136
Induced	1,560	$84,170,584	$147,082,563	$268,721,654
Total	3,161	$261,279,646	$581,662,605	$1,216,553,936

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	12	$1,954,319	$7,808,488	$19,538,684
Indirect	48	$4,603,937	$8,283,785	$15,559,052
Induced	58	$3,116,793	$5,446,391	$9,950,623
Total	117	$9,675,049	$21,538,664	$45,048,359

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	108	$17,962,785	$71,770,355	$179,586,414
Indirect	437	$42,316,286	$76,138,967	$143,008,314
Induced	531	$28,647,459	$50,059,552	$91,459,418
Total	1,076	$88,926,530	$197,968,874	$414,054,146

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	242	$40,199,232	$160,616,140	$401,899,593
Indirect	977	$94,700,361	$170,392,733	$320,040,820
Induced	1,188	$64,110,653	$112,029,152	$204,678,639
Total	2,407	$199,010,246	$443,038,024	$926,619,052

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	46	$7,681,006	$30,689,479	$76,792,339
Indirect	187	$18,094,724	$32,557,526	$61,151,301
Induced	227	$12,249,843	$21,405,796	$39,108,652
Total	460	$38,025,573	$84,652,801	$177,052,293

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	16	$2,703,775	$10,802,942	$27,031,518
Indirect	66	$6,369,488	$11,460,510	$21,525,747
Induced	80	$4,312,043	$7,535,011	$13,766,559
Total	162	$13,385,306	$29,798,463	$62,323,824

Scenario B: Annualized Natural Gas-Fueled Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	10	$1,579,274	$6,309,996	$15,789,102
Indirect	38	$3,720,416	$6,694,081	$12,573,183
Induced	47	$2,518,663	$4,401,198	$8,041,043
Total	95	$7,818,354	$17,405,274	$36,403,329

Table 46

Scenario B: Annualized Net Transmission Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	27	$4,029,030	$15,662,118	$41,579,907
Indirect	65	$7,412,498	$19,522,496	$39,747,876
Induced	79	$4,283,467	$7,483,742	$13,677,457
Total	171	$15,724,995	$42,668,355	$95,005,239

Scenario B: Annualized Net Transmission Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	38	$5,640,642	$21,926,965	$58,211,869
Indirect	91	$10,377,497	$27,331,494	$55,647,026
Induced	111	$5,996,853	$10,477,238	$19,148,440
Total	240	$22,014,992	$59,735,697	$133,007,335

Scenario B: Annualized Net Transmission Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	44	$6,446,448	$25,059,388	$66,527,850
Indirect	104	$11,859,997	$31,235,994	$63,596,601
Induced	127	$6,853,546	$11,973,986	$21,883,931
Total	274	$25,159,991	$68,269,368	$152,008,382

Scenario B: Annualized Net Transmission Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	44	$6,446,448	$25,059,388	$66,527,850
Indirect	104	$11,859,997	$31,235,994	$63,596,601
Induced	127	$6,853,546	$11,973,986	$21,883,931
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Scenario B: Annualized Net Transmission Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
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Induced	127	$6,853,546	$11,973,986	$21,883,931
Total	274	$25,159,991	$68,269,368	$152,008,382

Scenario B: Annualized Net Transmission Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	44	$6,446,448	$25,059,388	$66,527,850
Indirect	104	$11,859,997	$31,235,994	$63,596,601
Induced	127	$6,853,546	$11,973,986	$21,883,931
Total	274	$25,159,991	$68,269,368	$152,008,382

Scenario B: Annualized Net Transmission Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	44	$6,446,448	$25,059,388	$66,527,850
Indirect	104	$11,859,997	$31,235,994	$63,596,601
Induced	127	$6,853,546	$11,973,986	$21,883,931
Total	274	$25,159,991	$68,269,368	$152,008,382

Scenario B: Annualized Net Transmission Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	44	$6,446,448	$25,059,388	$66,527,850
Indirect	104	$11,859,997	$31,235,994	$63,596,601
Induced	127	$6,853,546	$11,973,986	$21,883,931
Total	274	$25,159,991	$68,269,368	$152,008,382

Table 47

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2025 and 2026

	Jobs	Labor Income	Value Added	Output
Direct	720	$118,643,508	$913,287,222	$1,414,622,730
Indirect	2,537	$217,295,149	$376,073,358	$712,500,220
Induced	2,935	$158,396,276	$276,789,671	$505,689,384
Total	6,193	$494,334,933	$1,566,150,251	$2,632,812,334

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2027 and 2028

	Jobs	Labor Income	Value Added	Output
Direct	879	$146,471,710	$1,410,201,844	$1,770,595,525
Indirect	2,480	$183,396,589	$297,128,177	$568,469,212
Induced	2,870	$154,851,714	$270,603,183	$494,361,407
Total	6,229	$484,720,013	$1,977,933,204	$2,833,426,145

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2029 and 2030

	Jobs	Labor Income	Value Added	Output
Direct	972	$159,634,629	$1,598,621,537	$2,094,815,261
Indirect	3,141	$241,259,229	$397,876,178	$758,930,020
Induced	3,493	$188,450,718	$329,311,692	$601,634,695
Total	7,606	$589,344,576	$2,325,809,407	$3,455,379,975

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2031 and 2032

	Jobs	Labor Income	Value Added	Output
Direct	1,032	$169,734,188	$1,552,676,970	$2,151,201,940
Indirect	3,448	$276,852,044	$466,056,582	$886,389,679
Induced	3,895	$210,186,213	$367,292,270	$671,028,292
Total	8,376	$656,772,445	$2,386,025,821	$3,708,619,910

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2033 and 2034

	Jobs	Labor Income	Value Added	Output
Direct	944	$154,964,753	$1,619,865,573	$2,068,742,958
Indirect	2,999	$224,801,678	$366,350,644	$699,994,703
Induced	3,306	$178,400,572	$311,750,078	$569,548,200
Total	7,250	$558,167,003	$2,297,966,295	$3,338,285,861

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2035 and 2036

	Jobs	Labor Income	Value Added	Output
Direct	1,308	$227,589,267	$1,532,374,455	$1,898,412,719
Indirect	2,477	$184,249,510	$300,485,088	$575,555,990
Induced	3,580	$193,116,693	$337,487,934	$616,495,050
Total	7,366	$604,955,470	$2,170,347,476	$3,090,463,759

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2037 and 2038

	Jobs	Labor Income	Value Added	Output
Direct	2,320	$428,140,954	$1,272,177,422	$1,472,121,004
Indirect	1,243	$94,959,693	$161,166,639	$311,599,537
Induced	4,537	$244,592,028	$427,497,423	$780,739,458
Total	8,101	$767,692,675	$1,860,841,485	$2,564,459,998

Scenario B: Annualized Energy and Transmission Operations Impacts in Years 2039 and 2040

	Jobs	Labor Income	Value Added	Output
Direct	2,478	$459,687,871	$1,233,314,200	$1,400,167,451
Indirect	1,025	$78,392,444	$134,521,380	$261,224,712
Induced	4,665	$251,484,890	$439,551,878	$802,730,188
Total	8,170	$789,565,205	$1,807,387,458	$2,464,122,351

Table 48 and Figure 7 illustrate the cumulative job gains that would align with all the energy capacity and transmission investments supposed under Scenario B.

Table 48

Scenario B: Cumulative Operations Jobs Impacts, 2025 through 2030

	Wind	Solar	Natural Gas	Transmission	Total
2025	2,861		3,161	171	6,193
2026	5,722		6,321	343	12,386
2027	11,267	326	6,438	583	18,614
2028	16,812	653	6,555	823	24,843
2029	23,068	653	7,631	1,097	32,449
2030	29,324	653	8,706	1,372	40,055
2031	35,019	653	11,114	1,646	48,431
2032	40,713	653	13,521	1,920	56,807
2033	47,229	653	13,981	2,195	64,057
2034	53,745	653	14,441	2,469	71,307
2035	58,801	2,526	14,603	2,743	78,673
2036	63,857	4,400	14,765	3,018	86,039
2037	64,685	11,303	14,859	3,292	94,139
2038	65,513	18,207	14,954	3,566	102,240
2039	65,698	25,918	14,954	3,840	110,410
2040	65,883	33,629	14,954	4,115	118,581
After 2040 …	*65,883*	*33,629*	*14,954*	*4,115*	*118,581*

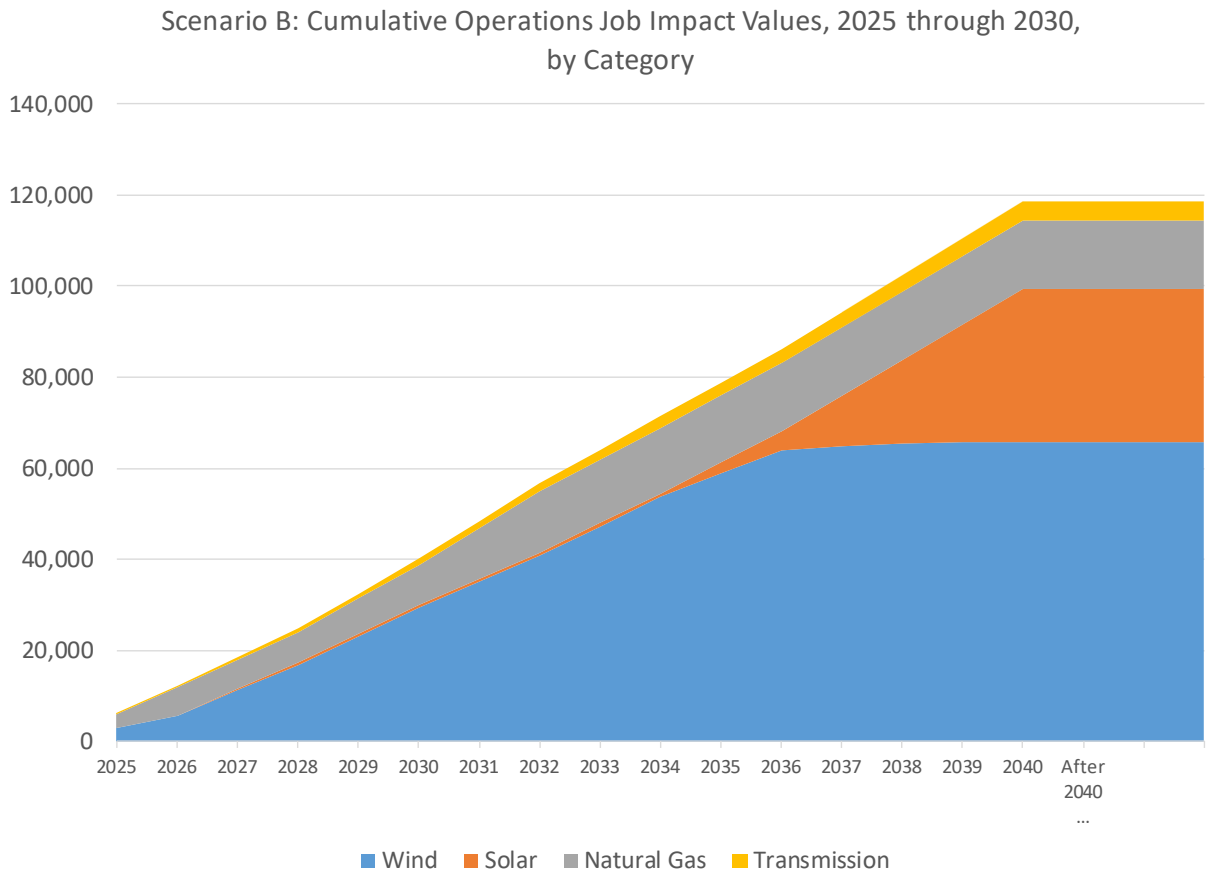

Figure 7

Table 49 displays all of the power generation and transmission operational effects once all of the investments are fully operational by 2040. These values hold so long as all of the energy investments remain in service.

Table 49

Scenario B: Energy and Transmission Operations Annual Impacts 2040 and Thereafter

	Jobs	Labor Income	Value Added	Output
Direct	21,309	$3,729,733,759	$22,265,038,444	$28,541,359,175
Indirect	38,702	$3,002,412,675	$4,999,316,090	$9,549,328,143
Induced	58,565	$3,158,958,205	$5,520,568,258	$10,084,453,349
Total	118,581	$9,891,104,639	$32,784,922,792	$48,175,140,667

Table 50 contrasts the operational job gains reported in Table 48 with job losses assumed under corresponding power generation retirements under Scenario B. As was the situation in Scenario A, the retirement of fossil fuel generation has strong job impacts when contrasted with the new energy and transmission investments. Net energy systems operations jobs decline by 3,917 in 2025 and the decline

maximum is 12,594 jobs by 2028. Eventually the new investments offset the declines producing 3,082 net new jobs by 2040 and thereafter.

Table 50

Scenario B: Operations Net Cumulative Jobs Considering Capacity Additions and Retirements

	New Investment Addtions	Losses Due to Retirements	Net Change
2025	6,193	(10,110)	(3,917)
2026	12,386	(20,220)	(7,834)
2027	18,614	(28,828)	(10,214)
2028	24,843	(37,437)	(12,594)
2029	32,449	(43,400)	(10,951)
2030	40,055	(49,363)	(9,308)
2031	48,431	(55,885)	(7,454)
2032	56,807	(62,407)	(5,599)
2033	64,057	(69,031)	(4,973)
2034	71,307	(75,654)	(4,347)
2035	78,673	(81,700)	(3,027)
2036	86,039	(87,746)	(1,707)
2037	94,139	(92,798)	1,342
2038	102,240	(97,849)	4,391
2039	110,410	(106,674)	3,737
2040	118,581	(115,498)	3,082

Appendix – Methodological Notes

All data on electricity generation additions and investments plus transmission costs were provided by the Interconnection Seam Study team. No modifications were made to those data for this analysis.

The IMPLAN Model

The IMPLAN input-output modeling system was used to project resulting economic outcomes for construction activity and for ongoing operations using the national economy as the study region. IMPLAN is an inter-industrial accounting model that has been in use mainly by academics in land grant universities and in federal and state governments since the early 1980s. It is the most widely used impact assessment tool, and coupled with its associated annually-updated region-specific data sets, it is thoroughly modifiable, transparent, flexible, and it has high industrial detail. The model used for this assessment has 536 industrial sectors.

The study author has conducted an extensive number and wide array of analyses using the IMPLAN system over the past 25 years, and has been a technical consultant to the IMPLAN, Inc., organization as well as having conducted a large number of workshops over the years in the proper use of IMPLAN for evaluating, as examples, renewable energy from crops, local foods, and university economic impacts. The author has also taught a graduate course on economic impact and benefit cost analysis in the School of Urban and Regional Planning at the University of Iowa for the past 15 years.

Investment Spending Allocations and the Economic Impact Process

Coefficients for allocating construction spending were obtained from current NREL resources, including JEDI for wind, natural gas, and transmission. However useful and necessary those coefficients are, the spending patterns associated with all of the technologies are highly aggregated and represent broad summaries of spending by type. The bill of goods approach used in this study to estimate construction-related economic impacts improves proportionally to the number of sectors utilized. In short, more sectoral detail will yield better estimations of the amount and the variation of economic effects associated with each category of investment.

The bill of goods procedure used in this study for all energy generation and transmission analyses followed these steps:

- An initial allocation of spending for each energy and transmission category was obtained from NREL sources
- Resulting spending amounts by type were entered into the appropriate IMPLAN industrial sector separately for each category of investment
- National-level inputs purchase probabilities were set to the national average for each industrial type except when logic suggested over-riding the default values

- The IMPLAN models were then run to discern the total supply chain impacts for each category of energy generation and transmission spending
- Separate runs were made for construction labor income amounts for each energy group and transmission, which produced the induced effects resulting from spending those incomes.
- The supply sector and the labor income runs were combined.
- Finally, construction labor jobs, labor income, and other elements of value added (e.g., sales taxes) were manually added to the results to complete the estimation.

For the operational impacts:

- A table of U.S. employment per 100 MWs of electricity generation was constructed using IMPLAN and Department of Energy data
- MW additions by category and by year were multiplied times the employment requirements per unit of electricity generation
- The IMPLAN model was then "shocked" by the new direct job requirements associated with capacity additions in each sector analyzed
- This produced conventional impact results itemizing direct, indirect, induced, and total economic effects.
- The exact same procedures were used to calculate the energy retirements, primarily from the fossil fuel sector.
- The fossil fuel sector was divided into a coal-fired sector and a natural gas-fueled sector in the IMPLAN model. Each sector was linked solely to its primary feed stock sources. This means that there were different operational impacts from natural gas additions than there were from all other fossil fuel plant retirements.
- Last, the operational effects of new transmission systems were estimated using both JEDI data and IMPLAN. In the transmission JEDI model, the ratio of expected annual operational spending per total construction investment was used as the operational output multiplier times transmission spending (as annualized for reporting purposes). The transmission (and distribution) sector of the IMPLAN model presumes increments to energy supply. In this analysis, those presumptions were offset because energy additions had already been compiled. This prevented operational impact double counting for the transmission sector.

Annualizing the Results

Economic impact results for construction and for the operational outcomes have been annualized. Input-output models are designed to reflect economic values as they would be accounted for over a one year period at a time. The biennial investment data were halved to reflect the amount of spending and economic activity that would have accrued in each capital development or operational year.

To be clear, the Interconnection Seam Study assumes a 15 year funding cycle. That cycle, however, needs to be translated so that it makes sense from an economic impact analysis and data presentation perspective. In this analysis, then, the eight periods of spending result, for economic development purposes, in 16 periods of economic activity (assuming a year 1 and a year 2 for each investment boost).

Similarly, the operations data assumes operations must lag construction – in this study, that is just for one year.

Biennial investment declarations are not the ideal input structure for economic impact assessment. The actual spending by type of spending during each year of capital formation provides the best data foundation so that the economic impacts, both construction-based and operational, are measured in the actual years in which the activity takes place. This evaluation merely annualizes the biennial data as a device for smoothing the effects over time and displaying them in a manner that is consistent with impact analysis protocols. This allows for a big picture assessment, but for analyzing particular projects for particular regions, it is better to have high spending detail that is temporally specific.

Cautions When Using National-Level Models

As the U.S. was used as the model territory, the resulting economic impacts are large. And it can be argued that the amount of investment coupled with the territory involved justify a national model. The Interconnection Seam Study presentation material, however, indicates that the new transmission and energy generation activity would be highly regionalized. Accordingly, were this study replicated using subsets of generation technologies (i.e., solar only in specific regions), these multi-state regions would yield lower economic impacts per million dollars of investment as higher fractions of technical and service input requirements would leak out of the smaller study regions.

Importantly and consequentially, the results presented here should be expressed as national totals and they should not be prorated to specific sub-regions of the U.S. based on regionalized levels of energy generation or transmission investments.

Discounting Financial Data / Per MW Cost Reductions Over Time

All financial data in this study were expressed in 2024 constant amounts. The assumptions used by the Interconnection Seam Study Team to discount future values to 2024 can be found in their study material. The IMPLAN model was set to 2024 as the base year for the data analysis (the inputs year) and for the reporting of the data.

The Interconnection Seam Study assumes that costs per MW for all electric and transmission technologies decline over time. Wind energy expansions, for example, occur earlier in the investment horizon, so their costs per installed capacity are higher, comparatively, than would be the case with solar investments which occur much later and presume significant cost-per-MW reductions over time.

Operational Maintenance Retirements

Overall, U.S. jobs in private sector electric power generation were 34 percent less in 2017 than in 2009. The simple fact is that as the nation adds generation capacity, it requires, simultaneously, fewer workers at generation facilities.

As indicated in the text, retiring fossil fuel electricity generation results in very strong job impacts. For a significant period of time, these retirements when compared to energy generation additions result in a projected reduction in jobs in the nation's energy generation and transmission sector.

Older power generation had very strong linkages to fossil fuel extraction and to transportations systems. These robust supply sectors, in turn, had very strong linkages to their own respective supply chains. Accordingly, retiring large fractions of old generation technology will yield very high multiplier effects.

Newer technology, like wind and solar, has different supply chain needs. Their inputs, wind and solar, are essentially labor free, but they have more technical inputs and maintenance needs, and their generating systems must be replaced or upgraded more frequently. The extent of linkages associated with ongoing operations and maintenance of new energy generation are extensive, but new energy generators are not as labor intensive as would have been the case historically: Over time, new increments to the nation's energy generation grid will require fewer total multiplied-through jobs per unit of energy produced. This outcome is clearly evident in direct employment in the electricity producing sectors as jobs decline while both capacity increases as does the mix of renewable energy.

Again, a caution is in order: we are using a model that is based on employment characteristics in 2015 to project potential economic outcomes for a period that is in the near future and extends for 15 years. The kinds of jobs linked to energy production in the 2015 base model will likely be significantly different than would be the case for a projection model based on 2024 data, the first year of investment. The modeling process is consistent with regard to energy generation additions and retirements. Nonetheless, it is probable that both projected retirements job impacts and new energy generation impacts are larger than will in fact eventuate. The assumption is that the net gains are, however, reasonable.