Preliminary Analysis of the Jobs and Economic Impacts of Renewable Energy Projects Supported by the §1603 Treasury Grant Program

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Executive Summary

Historically, federal incentives for renewable energy development in the United States largely consisted of the investment and production tax credits (ITC and PTC) and the accelerated depreciation benefit for renewable energy property [the Modified Accelerated Cost Recovery System (MACRS) and the bonus depreciation]. Both the ITC and the PTC provide financial incentives for development of renewable energy projects in the form of tax credits that can be used to offset taxes paid on company profits. Given that many renewable energy companies are relatively nascent and small, their tax liability is often less than the value of the tax credits received; therefore, some project developers are unable to immediately recoup the value of these tax credits directly. Typically, these developers have relied on third-party tax equity investors to monetize the value of the main federal incentives for renewable energy project development. However, in the wake of the 2008/2009 financial crisis, the pool of tax equity investors dramatically decreased, limiting the ability of renewable energy project developers to recoup the value of these tax credits. In order to minimize any stagnation in the renewable energy industry as a result of the weakened tax equity market, the United States Congress created the §1603 Treasury grant program under the American Recovery and Reinvestment Act. This program offers renewable energy project developers a one-time cash payment—in lieu of the ITC and PTC and equal in value to the ITC (30% of total eligible costs of a project for most types of energy property)—thereby reducing the need for project developers to secure tax equity partners.

Although the primary intent of the §1603 program was to minimize the impact of the weakened tax equity market on renewable project development, as part of the Recovery Act, the program also had "the near term goal of creating and retaining jobs" in the renewable energy sector.[1] This analysis responds to a request from the Department of Energy Office of Energy Efficiency and Renewable Energy (DOE-EERE) to the National Renewable Energy Laboratory (NREL) to estimate the direct and indirect jobs and economic impacts of projects supported by the §1603 Treasury grant program. The analysis employs the Jobs and Economic Development Impacts (JEDI) models to estimate the *gross*[2] jobs, earnings, and economic output supported by the construction and operation of solar photovoltaic (PV) and large wind (greater than 1 MW) projects funded by the §1603 grant program.[3]

Through November 10, 2011, the §1603 grant program has provided approximately $9.0 billion in funds to over 23,000 PV and large wind projects, comprising 13.5 GW of electric generating capacity. This represents roughly 50% of total non-hydropower renewable capacity additions in

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[1] U.S. Department of Treasury. "Payments for Specified Energy Property in Lieu of Tax Credits under the American Recovery and Reinvestment Act of 2009 - Program Guidance," 2011; p. 2. http://www.treasury.gov/initiatives/recovery/Documents/B%20Guidance%203-29-11%20revised%20(2)%20clean.pdf. Accessed February 7, 2012.

[2] As a gross analysis, this analysis does not include impacts from displaced energy or associated jobs, earnings, and output related to existing or planned energy generation resources (e.g., jobs lost in the operation of natural gas or coal plants due to the need for less electricity production from these plants, given increased generation from wind) or increases or decreases in jobs related to changes in electric utility revenues and consumer energy bills, among other impacts.

[3] Additional renewable technologies are eligible to receive a §1603 grant including biomass, combined heat and power, fuel cells, geothermal, hydropower, landfill gas, marine hydrokinetic, microturbine, municipal solid waste, concentrated solar power, concentrated photovoltaic, solar thermal, and small wind technologies. This analysis focuses on the two technologies that make up the large majority of projects funded: PV and large wind.

2009–2011.[4] Total investment in these projects, which includes capital investments from all private, regional, state, and federal sources (including §1603 funds), is estimated to exceed $30 billion. These PV and large wind projects account for approximately 94% of the total generation capacity of projects funded under the §1603 program and represent 92% of total payments.

The estimated gross jobs, earnings, and economic output supported by the PV and large wind projects that received §1603 funds are summarized below and in Table ES-1:

- **Construction- and installation-related expenditures are estimated to have supported an average of 52,000–75,000 direct and indirect jobs per year over the program's operational period (2009–2011[5]).** This represents a total of 150,000–220,000 job-years. These expenditures are also estimated to have supported $9 billion–$14 billion in total earnings and $26 billion–$44 billion in economic output over this period. This represents an average of $3.2 billion–$4.9 billion per year in total earnings and $9 billion–$15 billion per year in output.

- **Indirect jobs, or jobs in the manufacturing and associated supply-chain sectors, account for a significantly larger share of the estimated jobs (43,000–66,000 jobs per year) than those directly supporting the design, development, and construction/installation of systems (9,400 per year).**

- **The annual operation and maintenance (O&M) of these PV and wind systems are estimated to support between 5,100 and 5,500 direct and indirect jobs per year on an ongoing basis over the 20- to 30-year estimated life of the systems.** Similar to the construction phase, the number of jobs directly supporting the O&M of the systems is significantly less than the number of jobs supporting manufacturing and associated supply chains (910 and 4,200–4,600 jobs per year, respectively).

The estimated ranges reported reflect uncertainty in the domestic content of a system and its components—the portion of total project expenditures spent on U.S.-manufactured equipment and materials such as turbines, towers, modules, or inverters. Based on a review of a number of studies specifically addressing domestic content for these types of systems, and recognizing the complexity and changing nature of solar and wind supply chains, a range for domestic content was applied in the analysis. This included a low of 30% to a high of 70% for both solar and wind systems, spanning the ranges observed in the literature. The lower end of the impact estimates noted above reflects the 30% domestic content assumption while the higher end reflects the 70% assumption. While this range reflects the implications of uncertainty in one key input to the economic impact estimates, it should not be construed as fully bounding uncertainty in the ultimate estimates of the economic impacts.

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[4] Gelman, R.; Gossett, S.; Buchanan. S. "2010 Renewable Energy Data Book." U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. Washington, DC: Ventyx Global Velocity Suite, 2011.
[5] Through November 10, 2011.

Table ES-1. Estimates of the Direct and Indirect Jobs, Earnings, and Economic Output Supported by PV and Large Wind Projects Funded Under the §1603 Grant Program

Summary Estimates of the Direct and Indirect Jobs, Earnings, and Output Supported			
	Average Jobs per year (FTE/year)	Total Earnings (Billions $)	Total Economic Output (Billions $)
During Construction Period (2009-2011)			
Large Wind	44,000-66,000	$7.7-$12.0	$23.0-$39.0
Photovoltaic	8,300-9,700	$1.5-$1.8	$3.5-$4.7
Total Direct + Indirect	52,000-75,000	$9.2-$14.0	$26.0-$44.0
During Operational Period (annual for system lifetime)			
Large Wind	4,500-4,900	$0.26-$0.29	$1.60-$1.70
Photovoltaic	610-630	$0.04	$0.09
Total Direct + Indirect	5,100-5,500	$0.3-$0.3	$1.7-$1.8

Note: In some cases, totals may not equal the sum of components due to independent rounding and preservation of significant figures. For a detailed breakdown of the direct and indirect shares of the total estimates presented here, see the main body of the report.

The results presented in this report cannot be attributed to the §1603 grant program alone. Some projects supported by a §1603 award may have progressed without the award, while others may have progressed only as a direct result of the program; therefore, the jobs and economic impact estimates can only be attributed to the total investment in the projects.

In addition, this effort represents a preliminary analysis of the gross impacts of the PV and large wind projects supported under the §1603 grant program rather than precise forecasts of the national economic and job-related impacts from these projects. Understanding the net employment and economic impacts of these projects would require a more detailed analysis of the types of jobs supported as a result of changes in the utilization of existing power plants and associated fuels, electric utility revenues, and household and business energy expenditures. Similarly, estimating jobs associated with possible alternative spending of federal funds used to support §1603 projects would require additional analysis.

Lastly, this analysis solely focuses on the jobs, earnings, and economic output supported by projects funded by the §1603 program. For a discussion of the impacts of the §1603 program on installed renewable generation capacity, project financing, and tax-equity markets, see Brown and Sherlock and Bolinger et al.[6]

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[6] Brown, P.; Sherlock, M. *ARRA Section 1603 Grants in Lieu of Tax Credits for Renewable Energy: Overview, Analysis, and Policy Options*. CRS-R41635. Washington, DC: Congressional Research Services, 2011. Bolinger, M.; Wiser, R.; Cory, K.; James, T. *PTC, ITC, or Cash Grant: An Analysis of the Choice Facing Renewable Power Projects in the United States*. LBNL-1642E. Berkeley, CA: Lawrence Berkeley National Laboratory, 2009.

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Introduction

On February 17, 2009, the United States Congress enacted the American Recovery and Reinvestment Act of 2009 (Public Law 111-5). Under section 1603 of the act's tax title (§1603), the American Recovery and Reinvestment Tax Act,[7] Congress created a program, operated by the Department of Treasury, that offers renewable energy project developers the option to select a cash grant in lieu of the production tax credit (PTC) and the investment tax credit (ITC) for energy property placed in service in or after 2009 for which construction began no later than 2011.[8] Payments to qualified applicants are in an amount generally equal to 10% or 30% of the total eligible cost basis[9] of the property (equivalent to the ITC), depending on the type of property. By receiving payments for property under §1603, applicants elect to forego tax credits under §45 (PTC) and §48 (ITC) of the Internal Revenue Code with respect to such property. Technologies eligible for the §1603 cash payment consist of thermal and electricity generating assets, including open- and closed-loop biomass, combined heat and power, fuel cells, geothermal, incremental hydropower, landfill gas, marine hydrokinetic, microturbine, municipal solid waste, solar, and wind.

Prior to enactment of the §1603 program, federal incentives for renewable energy development in the United States largely consisted of the PTC, ITC, and the accelerated depreciation benefit for renewable energy property. Both the PTC and the ITC provide financial incentives for development of renewable energy projects in the form of tax credits that can be used to offset taxes paid on company profits. Given that many renewable energy companies are relatively nascent and small, their tax liability is often less than the value of the tax credits received; therefore, some project developers are unable to immediately recoup the value of these tax credits directly. As an alternative to using the credits directly, project developers have traditionally relied on third-party tax equity investors (generally banks and large financial institutions willing to exchange capital for project ownership, tax credits, cash flows, and depreciation benefits) to monetize these credits. During the last recession, however, the number of tax equity investors (and the demand for tax credits) drastically declined,[10] making it difficult for many developers to recoup the value of their credits in the tax equity market. Congress thus passed the §1603 program as an alternative to the ITC or PTC to allow commercial project developers to select a one-time cash grant (equal in value to the ITC) in lieu of the ITC or PTC. This significantly reduced the need for developers to rely on tax equity investors.[11]

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[7] The §1603 program was originally set to expire at the end of 2010; however, the program was extended for one year (through the end of 2011) under Section 707 of the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 (Public Law 111-312).

[8] Projects placed in service after 2011 but under construction before the end of 2011 are also eligible for a §1603 grant. For further details, see:
http://www.treasury.gov/initiatives/recovery/Documents/FAQs%20for%20Begun%20Construction%20web4.pdf.

[9] Both "eligible cost basis" and "eligible basis" are used interchangeably within this text.

[10] Bolinger, M.; Wiser, R.; Cory, K.; James, T. *PTC, ITC, or Cash Grant: An Analysis of the Choice Facing Renewable Power Projects in the United States*. LBNL-1642E. Berkeley, CA: Lawrence Berkeley National Laboratory, 2009.
Schwabe, P.; Cory, K.; Newcomb, J. *Renewable Energy Project Financing: Impacts of the Financial Crisis and Federal Legislation*. NREL/TP-6A2-44930. Golden, CO: National Renewable Energy Laboratory, 2009.

[11] Tax equity investors are still needed to monetize the accelerated depreciation benefit. For further discussion of the §1603 program and the tax equity market, see:

Although the primary intent of the §1603 program was to minimize the impact of the weakened tax equity market on renewable project development, by providing project developers with an alternative way to recoup the value of the tax incentives, it ensured that development of renewable energy projects, and the jobs and economic benefits associated with those projects, were not hindered by weak tax equity markets. This analysis responds to a request from the Department of Energy Office of Energy Efficiency and Renewable Energy (DOE-EERE) to the National Renewable Energy Laboratory (NREL) to estimate the jobs and economic impacts resulting from the total investment in projects supported by the §1603 Treasury grant program.[12]

The jobs and economic impacts of investments are typically categorized into three groups: direct, indirect, and induced. For renewable generation facilities, direct jobs and economic activity are the jobs and economic activity associated with the design, development, management, construction/installation, and maintenance of generation facilities. Indirect jobs and economic activity are the jobs and activity associated with the manufacturing and supply of equipment, materials, and services for the generation facility, as well as the upstream suppliers that provide raw materials and services to these manufacturers. Induced jobs and economic activity include the jobs and economic activity that occur as a result of spending earnings by individuals directly and indirectly employed by the projects, which could include jobs at local grocery stores and restaurants, clothing retailers, hospitals, and schools. This analysis focuses on estimation of direct and indirect jobs and associated economic activity. However, given that the approach implemented also allows for the estimation of induced jobs and economic activity, induced impacts are included in the Appendix.

This analysis uses NREL's Jobs and Economic Development Impact (JEDI) models to estimate the gross[13] direct and indirect jobs, earnings, and economic output[14] associated with investment in photovoltaic (PV)[15] and large wind[16] projects funded by the §1603 grant program. Together, PV and large wind projects make up approximately 96% of all projects funded under the §1603 program, and grants for these projects represent approximately 92% of total §1603 funding.[17]

Brown, P.; Sherlock, M. *ARRA Section 1603 Grants in Lieu of Tax Credits for Renewable Energy: Overview, Analysis, and Policy Options*. CRS-R41635. Washington, DC: Congressional Research Services, 2011.

Bolinger, M.; Wiser, R.; Cory, K.; James, T. *PTC, ITC, or Cash Grant: An Analysis of the Choice Facing Renewable Power Projects in the United States*. LBNL-1642E. Berkeley, CA: Lawrence Berkeley National Laboratory, 2009.

Bolinger, M.; Wiser, R.; Darghouth, N. "Preliminary Evaluation of the Section 1603 Treasury Grant Program for Renewable Power Projects in the United States." *Energy Pol.;* Vol. 38, 2010; pp. 6804–6819.

[12] NREL benefits from the §1603 program as it receives compensation for reviewing applications on behalf of the Department of Treasury. No funds from such compensation were used to perform this analysis and no NREL staff involved in such application reviews contributed to this analysis.

[13] The JEDI models do not estimate the displaced energy or associated jobs, earnings, and output related to existing or planned energy generation resources (e.g., jobs lost in the operation of natural gas or coal plants due to the need for less electricity production from these plants, given increased generation from wind) or increases or decreases in jobs related to changes in electric utility revenues and consumer energy bills, among other impacts. Therefore, the estimates represent gross rather than net impacts.

[14] "Jobs" refers to the actual number of full-time equivalent jobs supported by the investments. "Earnings" refers to the total payroll costs, including wages, salary compensation, and benefits paid to workers. "Economic output" refers to economic activity (value of production for all industry sectors) resulting from the investments.

[15] PV projects less than 2 kW in capacity were excluded from the analysis.

[16] Large wind projects are considered wind systems with a capacity greater than 1 MW.

[17] Note that this represents funding from the program's inception through November 10, 2011.

Therefore, although we do not consider investment in other types of renewable generation projects funded (e.g., small wind, biomass, geothermal, and fuel cell), this analysis captures a large majority of the jobs, earnings, and output associated with the projects funded by the §1603 program.

The results presented in this analysis are estimates of the *gross* jobs, earnings, and economic activity supported by the *total investment* in PV and large wind projects funded by the §1603 program. As such, the results should not be attributed solely to the §1603 program itself. Some projects supported by §1603 awards may still have been implemented without the availability of the award, while others may have progressed only as a direct result of the program.[18] As discussed above, the §1603 program allows project developers to select a cash grant as an alternative to the PTC or ITC. Thus, in the absence of the §1603 program, these developers would still have had the option to seek the ITC or PTC. The question remains, however, as to how much renewable generation capacity that was built under the §1603 program would have been built if only the ITC or PTC were available. For some projects, additional project financing costs associated with monetizing these tax credits through the third-party tax equity market might have been incurred. As a consequence, in some of these cases it is possible that project return hurdle rates may not have been met and that the associated renewable generation capacity would not have been built.

In this analysis, no attempt was made to estimate the number of projects or amount of capacity that would have been built without a §1603 grant, which would be necessary in order to quantify the portion of the total jobs and associated economic impacts attributable to the §1603 program; thus, we report the estimated number of jobs, earnings, and economic output supported by total investment (§1603 investment and non-§1603 investment) in the projects examined. It is clear that some portion of the jobs, earnings, and economic output supported by these projects can be directly attributable to the §1603 program, but the authors make no attempt to estimate that portion in this analysis.

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[18] For a more detailed discussion, see: Bolinger, M.; Wiser, R.; Darghouth, N. "Preliminary Evaluation of the Section 1603 Treasury Grant Program for Renewable Power Projects in the United States." *Energy Pol.;* Vol. 38, 2010; pp. 6804–6819.

Status of the §1603 Program

As of November 10, 2011, the §1603 program had provided $9.7 billion in payments for 24,711 projects. Wind projects received approximately 79% of total §1603 funds and comprise almost 90% of the generation capacity funded by the program. Solar PV projects make up a much smaller portion of total funds and generation capacity (13% and 5%, respectively); however, solar PV projects are by far the most prevalent type of project funded, comprising 96% of all projects funded. In addition to wind and solar electric generation technologies, the §1603 program also funded renewable-based thermal production and mechanical energy production projects, such as solar hot water, geothermal heat, and combined heat and power systems; however, these projects represent a very small portion of the total number and value of awards received.

Table 1. §1603 Grant Program Project Summary Data[19]

Technology	Number of Projects	Nameplate Electric Capacity (MW)	Total §1603 Funds Awarded ($ Millions)	Total Eligible Cost Basis ($ Millions)
Wind - Large (>1 MW)	197	12,810	$ 7,680	$ 25,601
Wind - Small (<1 MW)	291	17	$ 24	$ 81
Solar - Photovoltaic (PV)	23,692	724	$ 1,305	$ 4,352
Solar - Thermal	287	0	$ 144	$ 482
Solar - Concentrated Solar Power (CSP)	11	216	$ 46	$ 154
Solar - Concentrated Photovoltaic (CPV)	13	5	$ 10	$ 32
Biomass	47	246	$ 172	$ 576
Geothermal Electric	13	229	$ 276	$ 960
Other	160	212	$ 114	$ 467
Total	24,711	14,458	$ 9,771	$ 32,706

The number and total capacity of wind projects receiving the §1603 grant has declined each year over the program's lifetime, while the number and capacity of PV projects has significantly increased. Given the effective date of the §1603 database used, a large number of PV projects placed in service in November and December 2011 are not included in this analysis. Inclusion of these projects would make up some of the gap between 2010 and 2011 totals shown in Figure 1. In addition, some projects placed in service prior to November 2011 that plan to elect the §1603 cash grant may not yet have applied for a grant.

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[19] Data reported reflects the §1603 program as of November 10, 2011.
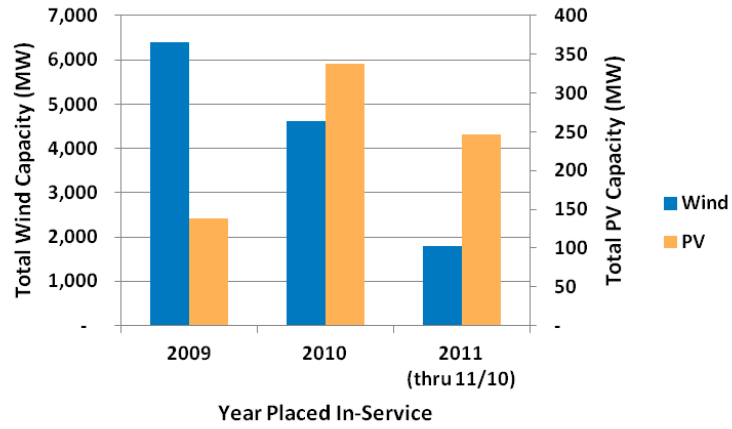
Figure 1. Total capacity of PV and large wind projects receiving §1603 grants

Data

Data used in this analysis were compiled from the Treasury database of applications for §1603 funds.[20] The database houses information on individual projects funded by the program, including the installed nameplate generation capacity, estimated annual electricity production, total eligible cost basis, and the total award amount. In the course of this analysis, reported capacity and electricity production were screened to ensure data quality, as these self-reported values can be incorrectly entered and may not be updated in the course of the application review. For this analysis, inconsistencies or errors were identified and corrected when possible; when no information was available to correct an entry, it was excluded from the analysis.

The §1603 application requires applicants to estimate the number of direct full- and part-time jobs supported by the project. However, the §1603 program does not provide guidance on the types of jobs that should be included or the methodology applicants should employ to estimate the number of jobs. As a result, these figures are not suitable reference points for this analysis. This analysis therefore uses other methods of estimating job and economic impacts, which are applied consistently to all projects.

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[20] NREL. "Application for Section 1603 – Payments for Specified Renewable Energy Property in Lieu of Tax Credits." https://treas1603.nrel.gov/index.cfm. Accessed November 12, 2011.

Methodology

This analysis uses the JEDI-Wind and JEDI-PV models to estimate the gross national employment and economic impacts of large wind and PV projects funded by the §1603 program from the program's inception in 2009 through November 10, 2011. The JEDI-Wind and JEDI-PV models are flexible input-output (I/O) modeling tools designed to estimate the economic impacts of expenditures during the construction and operation of wind and solar PV generation facilities.[21] The JEDI models have previously been used to estimate the economic impacts of individual generation projects,[22] as well as the impacts of broader investment in renewables.[23] The models have been used by the U.S. Department of Energy, the U.S. Department of Agriculture, NREL, and the Lawrence Berkeley National Laboratory, as well as a number of universities.[24]

Like other I/O models, the JEDI models represent the entire economy as a system of interactions or linkages between subsectors of the economy. Within the models, the linkages between each subsector are represented by multipliers that determine how expenditures during the construction and operation of PV or wind facilities impact employment, earnings, and output in all other sectors of the economy.[25] For example, JEDI calculates how purchases of PV project materials, such as modules, inverters, racking equipment, and construction materials, not only impact module and inverter manufacturers but also the metal fabrication industry, the construction material industry, and other industries that supply goods and services required for project development.

At a basic level, the models use project-specific data as inputs, including the installed project cost ($/kW), system capacity (kW), operation and maintenance (O&M) costs ($/kW), location, and the domestic content (or local share) of labor and materials. Based on these inputs, the JEDI models estimate and report the gross jobs [measured in full-time equivalents (FTEs),[26] or job-years], earnings (wage and salary compensation), and economic output supported by expenditures during the construction and operational phases of the project. As gross impact models, the JEDI models do not account for the displacement of jobs or economic activity related to changes in the utilization of existing power plants, electric utility revenues, and

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[21] Detailed information on the JEDI models is available at http://www.nrel.gov/analysis/jedi/ and JEDI-related publications at http://www.nrel.gov/analysis/jedi/publications.html.
[22] See Slattery, M.; Lantz, E.; Johnson, L. "State and Local Economic Impacts from Wind Energy Projects: Texas Case Study." *Energy Policy;* Vol. 39, Issue 12, 2011; pp. 7930–7940.
[23] DOE-EERE. *20% Wind Energy by 2030 – Increasing Wind Energy's Contribution to U.S. Electricity Supply*. Washington, DC: DOE-EERE, 2008. http://www.nrel.gov/docs/fy08osti/41869.pdf. Accessed March 28, 2012.
[24] The JEDI models are tested and validated during their development through interviews with industry representatives and analysts and by comparison with values from current literature. Prior to release, the models are peer reviewed internally and externally by experts in the field, including project developers and other industry participants familiar with project costs and other key project development and operating parameters.
[25] Industry-specific multipliers used in this analysis were derived from the Impact Analysis for Planning (IMPLAN) model. IMPLAN is a social accounting and impact analysis software that identifies interactions between all sectors of the economy. See Minnesota IMPLAN Group at www.implan.com.
[26] For this analysis, one FTE job (or job-year) is full-time employment for one person for the duration of a year. Three FTEs could therefore be made up of either one full-time job for three years or three full-time jobs for one year.

household and business energy expenditures. Similarly, the jobs and economic impacts associated with possible alternative spending of the federal funds used to support §1603 projects were not estimated in this study. Therefore, results presented in this paper should be interpreted as gross rather than net estimates.

Expenditures during the construction and operational phases of a generation system have direct (onsite), indirect (supply chain), and induced impacts on jobs, earnings, and economic output. The JEDI models estimate each type of impact separately. The definitions of direct, indirect, and induced vary by study and are defined below as used here:

- **Direct (project development and onsite labor)** jobs, earnings, and output are the jobs and economic activity associated with the design, development, management, construction/installation, and maintenance of generation facilities. For example, in installing a PV or large wind system, the direct impacts include the jobs, earnings, and output associated with the specialty contractors, construction workers, clean-up crews, truck drivers, and other specialists hired to permit, design, and install the system. It also includes management and support staff.

- **Indirect (supply-chain labor and local revenue)** jobs, earnings, and output are the jobs and economic activity associated with the manufacturing of equipment and materials used for the facility, the supply chain that provides raw materials and services to these manufacturers, and the finance and banking sectors that provide services for the construction and operation of a facility. For example, for a wind facility, this would include jobs at wind turbine manufacturing plants and jobs at other manufacturing facilities that fabricate structural hardware, foundations, and electrical components for the wind facility's systems. It also includes the banker who finances the construction contractor, the accountant who keeps the contractor's books, and the jobs at steel mills and other suppliers that provide the necessary materials.

- **Induced** jobs, earnings, and output refer to the jobs, earnings, and economic output that occur (or are induced) through spending of earnings by persons directly and indirectly employed by the projects (workers in the first two categories). For example, during the construction phase of a facility, jobs are induced when the workers hired to install a PV system spend their earnings to purchase food at grocery stores and restaurants, pay rent or mortgages on their homes, and purchase clothes or other goods to meet their needs.

The sum of these three effects determines the total economic and employment effects (or impacts) that result from expenditures for the construction and operation of a wind or solar plant. However, as stated earlier, the focus of this report is on estimation of direct and indirect effects. Induced effects are presented in the Appendix.

The JEDI models were originally designed to analyze individual projects at the local or regional level. To estimate the national impacts of more than 23,000 PV and large wind projects funded by the §1603 program, two key modifications were made. First, national multipliers were incorporated into the models[27] in order to calculate the total gross U.S. domestic jobs and

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[27] The 2009 IMPLAN national data (the most current available at the time of this study) was adapted for this analysis.

economic impacts of the individual projects. Second, rather than analyzing each of the more than 23,000 projects (23,381 PV and 197 wind) individually, projects were aggregated into a set of model or representative projects based on their characteristics, and the impacts were estimated based on these representative plants. For each year that the §1603 program was in operation (2009, 2010, and 2011), the projects were grouped by type (PV or wind) and capacity, and representative projects for each type and size category were derived. Each representative project was given a capacity equal to the average capacity of all projects within the group. The installed cost of each representative project was exogenously specified based on the project's size (capacity) and year placed in-service. The installed cost assumptions are shown in Table 2 and discussed below. Impacts of the total expenditures on these representative projects were estimated using the JEDI-PV and JEDI-Wind models. For each year, the gross national impacts of all projects within a capacity category were subsequently calculated as the product of the representative plant impacts and the total number of projects within the associated category. The total estimated gross national impacts for all projects are the sum of the impacts of all capacity groups. Figure 2 illustrates the general methodology employed.
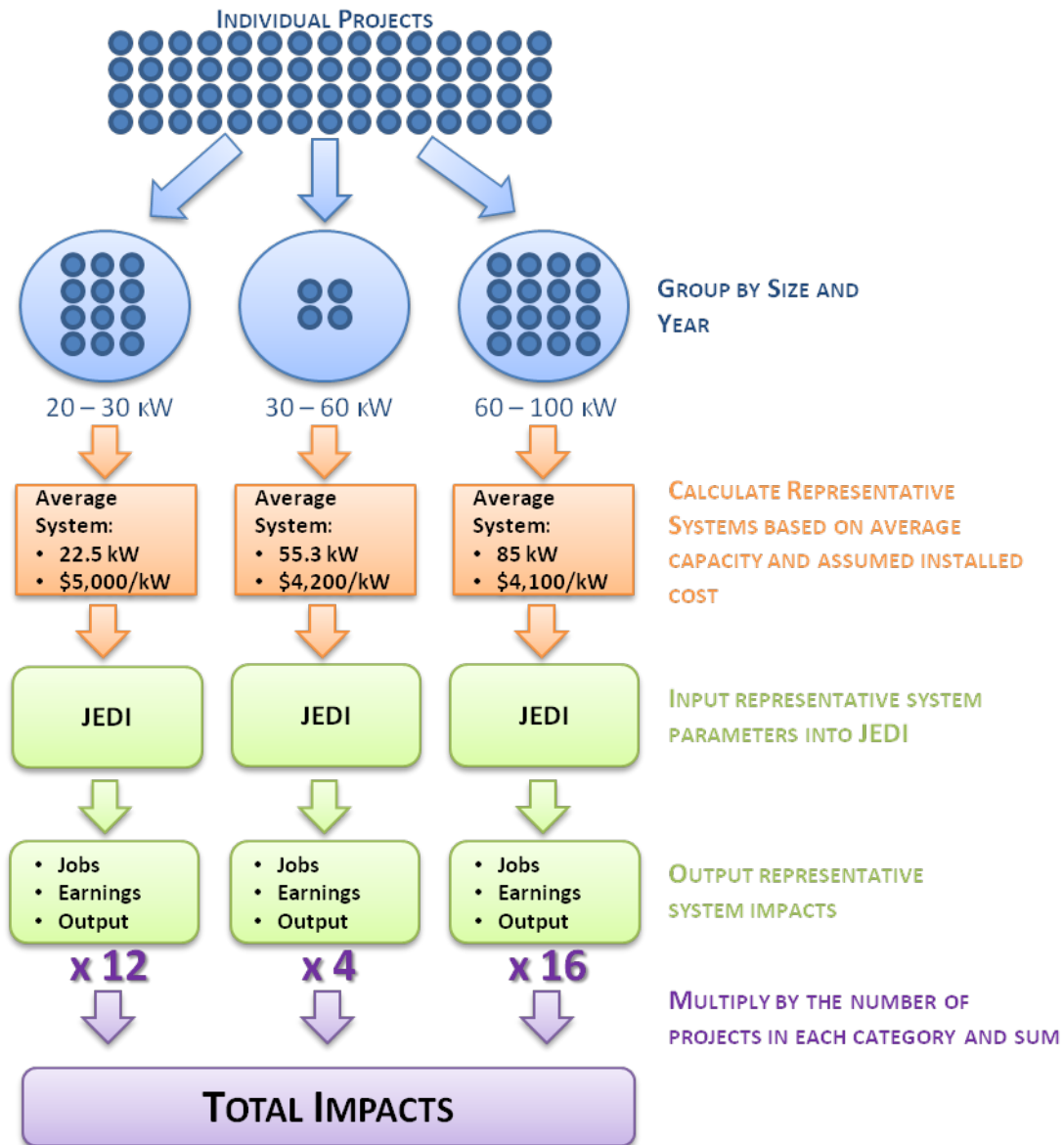
Figure 2. Illustrative flowchart of methodology

Note: Capacity and cost values and number of projects shown are for illustration purposes only and do not reflect capacity categories or averages used in the analysis.

Given that the national multipliers do not capture regional variation in costs of labor and standard costs of living, use of the national multipliers may introduce some uncertainty in the estimates of the employment and economic impacts. However, this concern mainly relates to the estimates of the direct onsite labor impacts, as these impacts are concentrated in the region where a facility is under construction or operating. In contrast, the majority of the indirect supply-chain and induced impacts are generally outside of the region where a facility is located, and therefore, use of the national multipliers to calculate the indirect and induced impacts is required in order to capture out-of-state or out-of-region impacts, which would otherwise be excluded with the use of regional multipliers. The direction and magnitude of this effect depends on the geographic distribution of investment and how the regional- or state-level multipliers in the high-investment

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regions compare to the national-level multipliers. While it would be more robust to estimate the gross onsite impacts of each project separately using regional- or state-level multipliers, given the large number of projects and the amount of time required to implement this project-by-project approach, this aggregated method was adopted.

The minimum inputs required to run an analysis using the JEDI models are the nameplate generation capacity (MW), location (United States), year of construction, and installed system costs ($/kW) for individual projects. JEDI provides default values for more detailed cost breakouts, financial parameters, O&M costs, and other assumptions when not specified by the user.[28] The capacity, location, and year of construction (approximated as the year placed in service) are all directly reported by §1603 applicants and are therefore available for this analysis. For installed system costs, the following values were assumed for PV and wind systems.[29]

Table 2. Installed Costs Assumed in this Analysis

Cost Assumptions							
Wind				PV			
Capacity Category	Placed In-Service 2009	Placed In-Service 2010	Placed In-Service 2011	Capacity Category	Placed In-Service 2009	Placed In-Service 2010	Placed In-Service 2011
1-20 MW	$ 2,144	$ 2,155	$ 2,024	2-10 kW	$ 6,800	$ 5,700	$ 4,400
20-50 MW	$ 2,144	$ 2,155	$ 2,024	10-100 kW	$ 6,500	$ 5,400	$ 4,200
50-100 MW	$ 2,144	$ 2,155	$ 2,024	100-500 kW	$ 5,600	$ 4,700	$ 3,500
100-200 MW	$ 2,144	$ 2,155	$ 2,024	500-1,000 kW	$ 5,200	$ 4,300	$ 3,100
>200 MW	$ 2,144	$ 2,155	$ 2,024	> 1,000 kW	$ 5,100	$ 4,300	$ 3,000

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[28] The default detailed cost breakouts represent average costs derived from industry sources and reporting of system installation and operating costs. They include specific equipment and component costs, labor costs, services, and other typical expenditures and are benchmarked to the year 2010.

[29] §1603 applicants report the total eligible cost basis of a project, which reflects the dollar amount upon which the §1603 award is calculated and generally reflects "the cost of the property and may also include the capitalized portion of certain other costs related to buying or producing the property (e.g., permitting, engineering, and interest during construction)." See "Evaluating Cost Basis for Solar Photovoltaic Properties" (http://www.treasury.gov/initiatives/recovery/Documents/N%20Evaluating_Cost_Basis_for_Solar_PV_Properties%20final.pdf). The eligible basis is a tax concept and its value and composition may differ, for any given project, from the total project component and installation costs typically used as inputs to JEDI. For example, while many utility-scale renewable energy projects require substantial investment in establishing interconnections with the grid, under tax law, some of these investments that occur "outside the fence" for a project are not incorporated in the eligible basis, thus the eligible basis may be an under-representation of the total investment for a project. Alternatively, for third-party owned systems, property owners may choose to assign the rights to a §1603 payment (or underlying investment tax credit) to a lessee, who can claim the payment based on the property's "fair market value" (FMV)—or the price at which a property would sell in a transaction between a willing buyer and seller. If the owner was able to build the property at a cost below that FMV, then the claimed basis may exceed the owner's actual cost by the difference between the owner's actual acquisition costs and the FMV price at which the owner could have sold the property to the lessee (or any other party). In this case, the eligible basis may be greater than the actual costs incurred to build the project. In light of the difference between the definition of eligible basis for purposes of §1603 administration and the concept and scope of costs used in the JEDI model, we chose to use representative cost estimates for each type of system.

The installed costs for wind projects are derived from the Department of Energy's "2010 Wind Technologies Market Report."[30] The report estimates average installed wind power project cost by year and size. The results show no clear economies of scale across the range of wind projects examined; thus, for this study, the assumed annual average installed costs for wind systems do not vary across capacity categories, but only by year.[31] The installed costs for solar are based on a bottom-up model of PV system prices developed by NREL[32] and represent an average unsubsidized cash-purchase price for a typical system within each size category. Currently, the literature shows a range of estimates for the historical and current installed costs for PV systems. The PV costs assumed in this analysis are in the lower end of the range of estimates found in the literature[33] and thus provide a conservative estimate of the total investment in PV projects (and therefore the resulting jobs and economic impact estimates).

Table 3 shows a summary of the large wind facilities included in the analysis. A total of 197 large wind projects were identified, which represented over 12,810 MW of capacity and an estimated $27 billion in total investment.

Table 3. Summary of Large Wind Projects Included in the Analysis

Large Wind Projects Placed In-Service (2009-2011)			
	Number of Projects	Average Project Size (MW)	Total Capacity (MW)	Estimated Total Investment (Millions $)
1-20 MW	69	6.6	455	$ 954
20-50 MW	39	33.4	1,303	$ 2,737
50-100 MW	34	76.2	2,590	$ 5,541
100-200 MW	42	131.5	5,522	$ 11,804
>200 MW	13	226.1	2,940	$ 6,264
All	197	65.0	12,810	$ 27,299

Note: The table summarizes projects for all years (2009, 2010, and 2011 to November 10). Estimated total investment in these projects is based on assumed system costs described above.

Table 4 shows a summary of the PV projects included in the analysis. A total of 23,380 PV systems ranging in size from 2 kW to 24,000 kW were included in the analysis (PV systems under 2 kW were excluded).[34] This represents a total of 728 MW of capacity and an estimated

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[30] Wiser, R.; Bolinger, M. "2010 Wind Technologies Market Report." DOE-EERE, June 2011. http://www1.eere.energy.gov/wind/pdfs/51783.pdf. Accessed March 28, 2012.
[31] Note that the 2011 installed cost estimate from the "2010 Wind Technologies Market Report" is a preliminary estimate given that data on 2011 projects was relatively limited when the analysis was completed.
[32] Goodrich, A.; James, T.; Woodhouse, M. *Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities*. NREL/TP-6A20-5334. Golden, CO: National Renewable Energy Laboratory, 2012.
[33] See, for example:
- Barbose, G.; Darghouth, N; Wiser, R.; Seel, J. *Tracking the Sun IV: The Installed Cost of Photovoltaics in the U.S. from 1998-2010*. Berkeley, CA: Lawrence Berkeley National Laboratory, 2011.
- Bromley, H. "California Versus German Solar Prices: Same Dope, Twice as High." New York, NY: Bloomberg New Energy Finance, 2012.
[34] Although not specifically noted in the §1603 program database, all system sizes are assumed to be direct-current (DC) capacity.

$3.3 billion in investment. The estimated investment in PV systems shown here is lower than the eligible basis of the funded PV projects. This is likely due to the reasons described in footnote 29 detailing how the basis may differ from the installed costs typically used as inputs to JEDI and the fact that the installed cost assumptions used for PV systems represent the lower range of estimates found in the literature. Again, the cost assumptions adopted in this analysis will therefore lead to more conservative estimates of jobs and economic impacts associated with these projects.

Table 4. Summary of PV Projects Included in the Analysis

PV Projects Placed in Service (2009-2011)				
	Number of Projects	Average Project Size (kW)	Total Capacity (MW)	Estimated Total Investment (Millions $)
2-10 kW	18,251	6	103	$ 532
10-100 kW	4,052	31	124	$ 619
100-500 kW	851	207	176	$ 770
500-1,000 kW	138	660	91	$ 366
> 1,000 kW	88	2,659	234	$ 1,014
Total	23,380	31	728	$ 3,302

Note: The table summarizes projects for all years (2009, 2010, and 2011 to November 10). Estimated total investment in these projects is based on assumed system costs described above.

Additional Methodological Assumptions

In addition to project cost and capacity, a range of additional project parameters must be specified as inputs, including the domestic content of installed equipment and materials, O&M costs, financial parameters (including percent of total costs financed, interest rate carried on loans, and tax expenditures), and land-use costs, among others.

The domestic content of a system is the portion of total project expenditures that are spent on goods produced within the United States. This applies to both the construction phase and the operating phase, which were modeled separately for each technology. Consistent with recent trade data, only a portion of the total project expenditures was considered domestically sourced.[35] As a result, non-domestic expenditures are not reflected in the U.S. job or economic impacts.

A review of the most recent available studies of the domestic content, including analysis from the U.S. Trade Commission, demonstrated large variation in estimates of the domestic content of PV and wind installations. Estimates of the domestic content of wind installations ranged from 48% to 66% of total investment,[36] and estimates for PV ranged from 42% to 71% of total

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[35] Note that the "Buy American" provision of the Recovery Act does not apply to the §1603 program.
[36] IHS-CERA. "U.S. Wind Industry Overview: A Baseline Snapshot of U.S. Wind Manufacturing." Cambridge, MA: HIS-CERA, 2010.
Bolinger, M.; Wiser, R.; Darghouth, N. "Preliminary Evaluation of the Section 1603 Treasury Grant Program for Renewable Power Projects in the United States." *Energy Pol.;* Vol. 38, 2010; pp. 6804–6819.
David, A.S. "Impact of Wind Energy Installations on Domestic Manufacturing and Trade." Washington, DC: U.S. International Trade Commission, Office of Industries, 2010.

investment.[37] These studies reflect the difficulty in determining domestic content and the complexity and breadth of the supply chains for PV and wind systems. Furthermore, the domestic content for new systems changes over time in response to demand, market development, and availability of resources, among other factors. Given the high uncertainty in these values, rather than use a single estimate for the domestic content, we performed a range of sensitivities where the domestic content assumption was varied from 30%–70% for both solar and wind. Clearly, there is no one domestic content for all systems, and as such, we do not suggest a specific value but rather suggest that it falls within the range explored. A higher domestic share increases the number of jobs, amount of earnings, and output associated with each §1603 project.

The job and economic impacts during the operational phase of a project are directly driven by expenditures during that period, including labor and material costs for the O&M of a system and interest payments paid on debt. Applicants are not required to report O&M costs, thus for this analysis O&M expenditures are estimated using the O&M default costs[38] within JEDI. For large wind systems, O&M cost is assumed to be $20/kW per year. For PV systems, the O&M costs vary by system size: for 2 kW–10 kW systems, O&M cost is assumed to be $33/kW per year; for 10 kW–100 kW systems, O&M is assumed to be $24/kW per year; and for systems greater than 100 kW, O&M is assumed to be $20/kW per year.

The project finance structure, including the debt/equity ratio and the rates of return on debt and equity, also directly affects the job and economic impact estimates. The financing structure for individual projects is highly project specific and can depend on a range of factors including the technology type, project size, current economic conditions, and the financial strength of the developer. Given the number of projects analyzed for this study, it was not feasible to specify financial parameters for each project, thus assumptions were made for the general financing parameters for PV and wind systems. The JEDI-Wind model allows the user to specify the percent of total cost financed through debt and the percent of total cost financed through equity, as well as the rates of return on both. For wind systems we assumed that the non-§1603 portion of the total cost (i.e., 70% of the total cost) was 60% equity financed and 40% debt financed. Debt was assumed to carry a nominal interest rate of 6.5% over 15 years and equity was assumed to have a nominal rate of 11.5% over 20 years. The JEDI-PV model does not break out debt and equity. Instead, it allows the user to specify the portion of total costs that were financed and the terms of the financed portion. Therefore, it was assumed that 70% of the total system cost (i.e., the non-§1603 portion) was financed over 15 years with a nominal weighted-average cost of

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[37] EIA. *Solar Photovoltaic Cell/Module Manufacturing Activities 2009.* Washington, DC: EIA, 2011. IHS-CERA. "U.S. Solar Industry Overview: A Baseline Snapshot of U.S. Solar Photovoltaic Manufacturing." Cambridge, MA: IHS-CERA, 2010.
Greentech Media. "U.S. Solar Energy Trade Assessment 2010: Trade Flows and Domestic Content for Solar Energy-Related Goods and Services in the United States," 2010. http://www.seia.org/galleries/default-file/Solar_Trade_Assessment.pdf. Accessed March 28, 2012.
[38] As described earlier, these default costs represent average O&M costs reported by industry and are collected during the development and validation of JEDI.

capital of 9%. No parameters were established to account for changes in interest rates over the project's operational phase.[39]

Any changes to the financial assumptions that would cause an increase in the overall financing costs would increase the annual interest payments made on debt/equity and thus result in greater numbers of finance sector and induced jobs, earnings, and output supported during the operational phase.[40]

Given the large variation in sales tax rates and exemptions throughout the United States, and to simplify the analysis, no additional sales tax was assumed or included as a separate expenditure within the analysis.

Revenue from property taxes was excluded from the analysis. Exclusion of this revenue stream provides a downward bias to the results (or a decrease in gross jobs, earnings, and output estimated). Therefore, exclusion of these taxes represents a conservative assumption.

For the wind analysis we assumed an annual land lease cost of $3,000 per 1 MW turbine.[41] Land lease costs vary significantly throughout the United States, and although an increase or decrease in land lease costs will only have a small impact on national results, it can significantly alter local economic impacts. For an increase in land lease costs, there is a proportional increase in the impacts. For example, for a cost of $6,000 per turbine for a wind project, there are 0.025 jobs supported per $1 million of project developer cost. At $12,000 per turbine, there are 0.05 jobs supported per $1 million of project developer cost.

Although varying the assumptions outlined above will affect the results of this analysis, the sensitivity of the results to these assumptions is small in comparison to the domestic content factor. Therefore, we have explored the sensitivity to the domestic content assumptions in greater detail. Sensitivity to the assumptions outlined above is well within the range of estimates reported.

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[39] For any given project, the debt/equity ratio and rates of return on debt and equity can vary significantly from the values assumed. These assumptions are intended to represent typical values seen in the market.

[40] The identified implication of an increase in the interest payments does not consider the potential impacts a higher rate could have on project owner profitability, nor does it consider the project's anticipated cash flows that might cause the project owner to not proceed with a loan. Rather, the financing assumptions are used purely to estimate the annual capital that is paid out as a result of financing.

[41] This value represents an average cost for the United States and is based on information collected from project developers and county commissioners working in regions where wind plants are being developed.

Results

In this section, estimated gross direct and indirect jobs, earnings, and economic output supported by the construction and operation of PV and large wind generation facilities funded by the §1603 program are presented. Job estimates are expressed as FTEs, or job-years, as well as average annual jobs per year. One FTE job (or job-year) is full-time employment for one person for the duration of a year. Three FTEs could therefore be made up of either one full-time job for three years or three full-time jobs for one year. FTEs and job-years are used interchangeably in this report. In addition to FTEs we also present the average annual jobs per year supported by projects funded by the §1603 program. These values should be interpreted as the average number of jobs *sustained* during the construction of projects placed in service 2009–2011.

Earnings are the total payroll costs, including wages, salary compensation, and benefits paid to workers. The estimated total earnings impact over the operational period of the §1603 program (2009 through November 10, 2011) is reported.

Economic output is the sum of all economic activity (value of production for all industry sectors) resulting from the investments in the solar and wind generation facilities. The estimated total economic output impact over the operational period of the §1603 program (2009 through November 10, 2011) is reported.

All dollar amounts are reported as billions of year-2009 dollars.

In the following sections, the estimates of the jobs, earnings, and output supported during the construction period of the systems analyzed (2009–2011) are presented, followed by estimates of the jobs, earnings, and output supported during the operational period of the systems. Results are presented as ranges reflecting a domestic content of 30%–70%.

Construction Period Jobs, Earnings, and Economic Output

Construction period jobs are considered short-term jobs; that is, they occur during the construction/installation period only. Table 5 provides a summary of the estimates of the gross jobs, earnings, and economic output supported by investments (§1603 and non-§1603 funding) in PV and large wind projects funded by the §1603 grant program from 2009 to 2011.

Construction-related expenditures for these projects were estimated to support an average of 52,000–75,000 direct and indirect jobs per year (or 150,000–220,000 job-years from 2009–2011); this represents 4.9–7.2 job-years per million dollars of total investment or 11–16 job-years per megawatt of installed capacity. Large wind projects accounted for approximately 85% of the jobs (44,000–66,000 jobs per year), and PV projects accounted for approximately 15% (8,300–9,700 jobs per year). Total wages paid to workers during the construction period were estimated to be $9 billion–$14 billion (or $3.1 billion–$4.9 billion per year) and total economic output was estimated to be $26 billion–$44 billion (or $9.1 billion–$15.4 billion per year).

Table 5. Estimates of the Construction Period Gross Direct and Indirect Jobs, Earnings, and Economic Output Supported by PV and Large Wind Projects Funded Under the §1603 Grant Program

		Total Job-years (FTE)	Average Jobs per year (FTE/year)	Total Earnings (Billions $)	Total Economic Output (Billions $)
		Construction Period: Jobs, Earnings, and Output Supported by the §1603 Program (2009-2011)			
Large Wind	Direct	16,000	5,500	$1.2	$1.4
	Indirect	110,000-170,000	38,000-60,000	$6.5-$11.0	$21.0-$38.0
	SUBTOTAL	130,000-190,000	44,000-66,000	$7.7-$12.0	$23.0-$39.0
Solar	Direct	11,000	3,900	$0.7	$1.0
	Indirect	13,000-17,000	4,400-5,800	$0.8-$1.1	$2.4-$3.7
	SUBTOTAL	24,000-28,000	8,300-9,700	$1.5-$1.8	$3.5-$4.7
TOTALS	Total Direct	27,000	9,400	$1.9	$2.4
	Total Indirect	120,000-190,000	43,000-66,000	$7.3-$12.0	$24.0-$42.0
	TOTAL DIRECT & INDIRECT	150,000-220,000	52,000-75,000	$9.2-$14.0	$26.0-$44.0

Notes: As described above, the ranges shown are the result of varying the domestic content assumption within the JEDI models from a low of 30% to a high of 70%.
Earnings and economic output values are billions of dollars in year-2009 dollars. Jobs are reported as FTEs for a period of one year (1 FTE = 2,080 hours).
In some cases, totals may not equal the sum of components due to independent rounding and preservation of significant figures.

Investment in large wind projects during the construction period was estimated to support an average of 44,000–66,000 jobs per year, $2.7 billion–$4.2 billion per year in earnings or wages, and $8 billion–$14 billion per year in economic output. Total estimated earnings and output over the duration of the §1603 program's existence were $7.7 billion–$12.0 billion and $23 billion–$39 billion, respectively. Each million dollars of total project investment was estimated to have supported 4.8–7.0 job-years. This represents 10–15 job-years per megawatt of installed wind capacity.

Direct jobs, or jobs supporting the design, development, construction, and installation of wind facilities, were estimated to account for 5,500 jobs per year over the construction phase. These include construction crews, foundation workers, heavy equipment operators, electricians, crane operators, engineers, and other construction-related workers. Indirect jobs, or jobs in the manufacturing and the associated supply-chain sectors, account for a much larger share of jobs and were estimated to account for 38,000–60,000 jobs per year during the construction phase of projects (2009–2011).[42] These include jobs in the manufacturing plants that produce the turbines, towers, blades, and other components, as well as jobs in the industries that supply goods and services to the turbine manufacturing companies and construction companies installing the systems.[43]

Investment in PV projects during the construction period was estimated to support an average of 8,300–9,700 jobs per year, $0.5 billion–$0.6 billion per year in earnings, and $1.2 billion–

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[42] To simplify the analysis, manufacturing of turbines and production and supply of materials for manufacturing were assumed to occur in the same year that a facility was placed in service. This was clearly not the case for some facilities.

[43] These estimated impacts are highly sensitive to domestic content assumptions, and therefore, it is crucial to consider the range of impacts presented.

$1.6 billion per year in output. Total earnings and output over the program's existence were estimated to be $1.5 billion–$1.8 billion and $3.5 billion–$4.7 billion, respectively. Each million dollars of total project investment was estimated to support between 7.3 and 8.5 job-years during the construction period, representing 33–39 job-years per megawatt of installed solar capacity.

Jobs supporting the design, development, construction, and installation of the PV projects analyzed were estimated to account for an average of 3,900 jobs per year. Jobs in the cell/module manufacturing and associated supply-chain sectors were estimated to account for an additional 4,400–5,800 jobs per year.

Operational Period Jobs, Earnings, and Economic Output

Operational period jobs, earnings, and economic output are associated with the O&M of the systems and include the impacts from purchasing equipment and materials and services necessary to keep the installed systems operating as well as spending related to ongoing local revenues. These annual job and economic impacts, shown in Table 6, are expected to be sustained over the lifetime of the systems (20–30 years).

The annual O&M of the new PV and large wind systems are estimated to continue to support 5,100–5,500 jobs per year for the life of the systems; this represents approximately 0.4 jobs per megawatt of installed capacity. These jobs and the associated spending are projected to account for approximately $0.3 billion in earnings and $1.7 billion–$1.8 billion in economic activity each year for the next 20–30 years.[44]

Table 6. Estimates of the Operational Period Gross Direct and Indirect Jobs, Earnings, and Economic Output Supported by PV and Large Wind Projects Funded Under the §1603 Grant Program

		Average Jobs per year (FTE/year)	Total Earnings (Billions $)	Total Economic Output (Billions $)
Large Wind	Direct	770	$0.05	$0.05
	Indirect	3,700-4,100	$0.21-$0.23	$1.55-$1.64
	SUBTOTAL	*4,500-4,900*	*$0.26-$0.29*	*$1.60-$1.70*
Solar	Direct	150	$0.01	$0.01
	Indirect	460-480	$0.03	$0.08
	SUBTOTAL	*610-630*	*$0.04*	*$0.09*
TOTALS	**Total Direct**	910	$0.1	$0.1
	Total Indirect	4,200-4,600	$0.2-$0.3	$1.6-$1.7
	TOTAL DIRECT & INDIRECT	*5,100-5,500*	*$0.3*	*$1.7-$1.8*

Operational Period: Jobs, Earnings, and Output Supported by the §1603 Program (2009-2011)

Notes: As described above, the ranges shown are the result of varying the domestic content assumption within the JEDI models from a low of 30% to a high of 70%.

Earnings and economic output values are billions of dollars in year-2009 dollars. Jobs are reported as FTEs for a period of one year (1 FTE = 2,080 hours).

In some cases, totals may not equal the sum of components due to independent rounding and preservation of significant figures.

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[44] This assumes that project lifetimes are 20–30 years and that expenditures in different economic sectors as a result of O&M of systems remain constant over time. No attempt was made to model potential structural changes in the economy that might impact these amounts over time.

Similar to the construction phase, during the O&M phase of the projects, the majority of jobs supported are indirect jobs or jobs related to purchasing of equipment and materials, as well as the services necessary to keep the systems operating. These indirect jobs account for approximately 4,200–4,600 jobs per year for the lifetime of the systems. Onsite jobs directly supporting the service and maintenance of systems (as well as the associated management and administration) account for approximately 910 jobs annually for the lifetime of the systems.

Comparison with Previous Analyses of the §1603 Program

A number of recent studies estimate the impacts of the §1603 program on jobs in the renewable energy sector. These studies focus on either solar or wind technologies and generally estimate the gross number of direct, indirect, and induced jobs supported. In this section we focus solely on the estimates of direct and indirect jobs. With the exception of Bolinger et al.,[45] none of the studies provide significant detail on the methods used to estimate jobs values. No studies to date attempt to estimate the net job impacts of the §1603 program.

Similar to this analysis, Bolinger et al. used the JEDI-Wind model to estimate the number of gross jobs supported by all wind power projects built in 2009 that elected the §1603 cash grant in lieu of the ITC or PTC. This represents 71 projects accounting for 6,202 MW of capacity—approximately 59% of the total wind capacity analyzed in this paper. Bolinger et al. estimate that these 71 projects resulted in 74,000 gross direct and indirect jobs during the construction phase and approximately 3,900 jobs annually during the operational phase. This represents approximately 12.0 jobs per megawatt of installed wind capacity during the construction phase and 0.6 jobs per megawatt of installed capacity during the operational phase. Bolinger et al.'s estimates for jobs intensity (jobs per megawatt installed) during the construction phase fall within the range estimated in this study, while estimates for the operational phase are somewhat higher than the estimate in this study. This observed difference is likely due to the use of updated industry multipliers in the analysis presented here[46] and differences in the treatment of property taxes and financing assumptions.

More recently, EuPD Research, in an analysis prepared for the Solar Energy Industries Association (SEIA), provided an estimate of the gross number of jobs that would be supported by a one-year extension (through 2012) of the §1603 program.[47] The EuPD analysis estimates that a one-year extension would drive additional installation of approximately 370 MW of PV and 130 MW of concentrated solar power (CSP) capacity and support approximately 18,000 direct and indirect jobs during the construction and installation period. This represents 36 jobs per megawatt of installed PV and CSP capacity. Given that the EuPD analysis includes the contribution of jobs supported by some CSP capacity, it is not directly comparable to the results presented in this study; however, the jobs intensity does fall within the range estimated in this study.

While a few additional studies provide estimates of the impacts of extensions to the §1603 program, they do not provide detail on underlying analysis and assumptions and, therefore, are not included in the comparison here.[48]

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[45] Bolinger, M.; Wiser, R.; Darghouth, N. "Preliminary Evaluation of the Section 1603 Treasury Grant Program for Renewable Power Projects in the United States." *Energy Pol.;* Vol. 38, 2010; pp. 6804–6819.

[46] The analysis presented here uses the 2009 rather than the 2006 IMPLAN multipliers.

[47] EuPD Research, prepared for SEIA. "Economic Impact of Extending the Section 1603 Treasury Program," 2011. http://www.novoco.com/energy/resource_files/reports/seia_economic-impact-extending-section-1603_101211.pdf. Accessed March 28, 2012.

[48] For example, see AWEA. "Renewable Trade Groups Call for Tax Credit Extension," 7 December 2010. http://www.awea.org/blog/index.cfm?customel_dataPageID_1699=5796. Accessed March 28, 2012.

Conclusions

This analysis uses the NREL JEDI-PV and JEDI-Wind models to estimate the gross jobs, earnings, and economic output resulting from the total investment in PV and large wind projects funded by the §1603 cash grant program through November 10, 2011. It is estimated that expenditures on these projects supported between 52,000 and 75,000 direct and indirect jobs annually (a total of 150,000–220,000 FTEs, or job-years, over the period) during the design, development, construction, and installation of the systems. The results equate to 5–7 job-years per million dollars of total investment, or 11–16 jobs-years per megawatt of installed capacity. In addition, it is estimated that these projects supported $3.1 billion–$4.9 billion per year in earnings and $9.1 billion–$15.4 billion per year in economic output. During the operational phase, these projects are estimated to continue to support 5,100–5,500 direct and indirect jobs, approximately $0.3 billion in earnings, and $1.7 billion–$1.8 billion in economic output annually for the lifetime of the projects (generally 20–30 years). These operational period jobs represent approximately 0.4 jobs per megawatt of installed capacity. The estimates vary with the assumed domestic content of a system, which were bounded between 30% and 70%.

Consistent with the share of total project investment, wind projects account for the largest share of jobs during both the construction and operational periods, accounting for approximately 85%–90% of the jobs supported in the construction and operation periods. However, the higher installed cost ($/kW) assumed for PV systems drives higher jobs intensity for PV projects on a per-kilowatt basis.

Indirect manufacturing and supply-chain jobs make up the large majority of the jobs supported by investment in the PV and large wind projects analyzed and account for approximately 80%–85% of the total direct and indirect jobs supported. Jobs directly for the design, construction, and operation are estimated to make up approximately 10%–15% of the total jobs supported.

In terms of total jobs, earnings, and economic output supported, the largest impact of investment in the PV and wind projects analyzed here is during the construction and installation phase. This is due to the fact that PV and wind facilities are capital-intensive and require a large workforce to install. O&M of the facilities does not require a large workforce, and thus the total jobs, earnings, and economic output supported by these facilities during their regular operation is significantly lower than the total supported during construction. Although the number of jobs and associated economic activity is greatly reduced during the operational phase of the projects, these jobs and associated earnings and economic output are expected to last throughout the projects' lifetimes (estimated to be 20–30 years).

This analysis estimates the gross jobs and economic impacts of projects funded by §1603; it is not an impact assessment of the §1603 program itself, and as such, the estimated impacts cannot be attributed solely to the §1603 program. The number of jobs and amount of earnings and economic output directly attributable to the §1603 program will likely be lower than the estimates reported here to the extent that some supported projects may have gone forward even in the absence of the §1603 program. Furthermore, the results presented in this report are not intended to be precise forecasts of the national economic and job-related impacts from these projects but rather estimates of overall impacts. These aggregate national results are consistent with prior published job estimates for similar systems. This effort represents only a preliminary

analysis of the *gross* impacts of these projects, and additional analysis would be necessary to examine the *net* employment and economic impacts of these projects, including more detailed analysis of the types of jobs supported. Lastly, while the results presented offer reasonable insights into the national impacts associated with these investments in these projects, the results are sensitive to changes in the assumptions.

Appendix

As stated in the Introduction to this report, this analysis responds to a request from the DOE-EERE to estimate the direct and indirect jobs and economic activity supported by total investment in projects receiving §1603 cash grants. This analysis employs the NREL JEDI-PV and JEDI-Wind models to estimate the direct and indirect jobs, earnings, and economic output supported by §1603 projects. The JEDI models also have the capability of estimating induced jobs and economic activity, or the jobs and economic activity that results from expenditures of earnings or wages by individuals directly or indirectly employed by the projects/facilities analyzed. These induced jobs are part of the broader economy and should not necessarily be considered renewable energy jobs. This appendix presents estimates of the induced jobs, earnings, and economic output supported by investment in the PV and large wind projects receiving awards from the §1603 program. Estimates for both the construction and installation period, as well as the operational period of the projects, are included. Direct and indirect jobs, earnings, and output are also included in Tables A-1 and A-2—note these are the same estimates as those presented in the main body of the report.

Table A-1. Estimates of the Construction Period Gross Direct, Indirect, and Induced Jobs, Earnings, and Economic Output Supported by PV and Large Wind Projects Funded Under the §1603 Grant Program

		Total Job-years (FTE)	Average Jobs per year (FTE/year)	Total Earnings (Billions $)	Total Economic Output (Billions $)
		Construction Period: Jobs, Earnings, and Output Supported by the §1603 Program (2009-2011)			
Wind	Direct	16,000	5,500	$1.2	$1.4
	Indirect	110,000-170,000	38,000-60,000	$6.5-$11.0	$21.0-$38.0
	Induced	77,000-120,000	27,000-43,000	$3.8-$6.1	$12.0-$19.0
	SUBTOTAL	*200,000-310,000*	*71,000-110,000*	*$12.0-$18.0*	*$35.0-$58.0*
Solar	Direct	11,000	3,900	$0.7	$1.0
	Indirect	13,000-17,000	4,400-5,800	$0.8-$1.1	$2.4-$3.7
	Induced	14,000-18,000	4,900-6,100	$0.7-$0.9	$2.2-$2.7
	SUBTOTAL	*38,000-45,000*	*13,000-16,000*	*$2.2-$2.7*	*$5.7-$7.5*
TOTALS	Total Direct	27,000	9,400	$1.9	$2.4
	Total Indirect	120,000-190,000	43,000-66,000	$7.3-$12.0	$24.0-$42.0
	Total Induced	91,000-140,000	32,000-49,000	$4.5-$7.0	$14.0-$22.0
	TOTAL	*240,000-360,000*	*84,000-120,000*	*$14.0-$21.0*	*$40.0-$66.0*

Table A-2. Estimates of the Operational Period Gross Direct, Indirect, and Induced Jobs, Earnings, and Economic Output Supported by PV and Large Wind Projects Funded Under the §1603 Grant Program

Operational Period: Jobs, Earnings, and Output Supported by the §1603 Program (2009-2011)				
		Average Jobs per year (FTE/year)	Total Earnings (Billions $)	Total Economic Output (Billions $)
Wind	Direct	770	$0.05	$0.05
	Indirect	3,700-4,100	$0.21-$0.23	$1.55-$1.64
	Induced	3,900-4,200	$0.19-$0.21	$0.61-$0.65
	SUBTOTAL	*8,400-9,000*	*$0.46-$0.49*	*$2.21-$2.35*
Solar	Direct	150	$0.01	$0.01
	Indirect	460-480	$0.03	$0.08-$0.09
	Induced	680-690	$0.03	$0.10
	SUBTOTAL	*1,300*	*$0.07*	*$0.19-$0.20*
TOTALS	Total Direct	910	$0.1	$0.1
	Total Indirect	4,200-4,600	$0.2-$0.3	$1.6-$1.7
	Total Induced	4,600-4,900	$0.2	$0.7-$0.8
	TOTAL	*9,700-10,000*	*$0.5-$0.6*	*$2.4-$2.5*