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Job and Economic Development Impact (JEDI) Model: A User-Friendly Tool to Calculate Economic Impacts from Wind Projects

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JOB AND ECONOMIC DEVELOPMENT IMPACT (JEDI) MODEL: A USER-FRIENDLY TOOL TO CALCULATE ECONOMIC IMPACTS FROM WIND PROJECTS

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Abstract

The U.S. Department of Energy/National Renewable Energy Laboratory (DOE/NREL) has developed a spreadsheet-based wind model (Jobs and Economic Development Impact (JEDI)) that incorporates economic multipliers for jobs, income, and output. Originally developed with state-specific parameters, it can also be used to conduct county and regional analyses.

NREL has enlisted the Wind Powering America (WPA) State Wind Working Groups (SWWGs) to conduct county-specific economic impact analyses, and has encouraged them to use JEDI if they do not have their own economic model. The objective of the analyses is to identify counties within WPA target states, and preferably counties with a significant agricultural sector, that could economically benefit from wind development. These counties could then explore opportunities to tap into the United States Department of Agriculture (USDA) Farm Bill Section 9006 grants and loans to stimulate wind development.

This paper describes the JEDI model and how it can be used. We will also summarize a series of analyses that were completed to fulfill a General Accounting Office (GAO) request to provide estimates of the economic development benefits of wind power.

Introduction

As energy prices rise and the threat of environmental degradation looms on the horizon, our use of fossil fuels and nuclear power continues to grow. Yet many policy makers, renewable energy advocates, and citizens across the country question our reliance on these conventional energy sources and look toward renewable resources as a win-win situation for the environment and local economies. Unfortunately, few have the knowledge or resources to quickly and easily analyze the benefits associated with developing renewable power sources such as wind turbines. The JEDI model, designed to demonstrate the economic benefits associated with developing wind power plants in the United States, now provides a tool to help meet this need.[1]

The primary goal in developing the initial model was a) to provide a tool for wind developers, renewable energy advocates, government officials, decision makers, and other potential users who might not have the resources to develop their own economic development model, and b) to easily identify the local economic impacts associated with constructing and operating wind power plants. The second goal was to facilitate broad access and usage of the model by making it electronically available through NREL.

To accommodate a potentially broad user base with varying experience with economic development modeling, a strong emphasis was placed on designing JEDI in a user-friendly format that could be easily modified — accommodating varying levels of project-specific information. This insures the greatest flexibility for inexperienced spreadsheet users, those unfamiliar with economic impact analysis, and more experienced and knowledgeable users who need this type of analysis.

Methodology

Basic information about a wind project (at minimum the project's state, county, or region; the year of construction; and the size of the facility), the model calculates the project cost (i.e., specific expenditures) as well as the number of jobs, income (i.e., wages and salary), and economic activity that will accrue to the state, county, or region being analyzed.[2] To evaluate these impacts, input-output or multiplier analysis is used.

Input-output models were originally developed to trace supply linkages in the economy. For example, they show how purchases of wind turbines not only benefit turbine manufacturers, but also the fabricated metal industries and others businesses supplying inputs to those manufacturers. The benefits that are ultimately generated by expenditures for wind plants depend on the extent to which those expenditures are spent locally and the structure of the local economy. Consistent with the spending pattern and location-specific economic structure (state, county, or region), different expenditures support a different level of employment, income, and output.

Input-output analysis is a method of evaluating and summing the impacts of a series of effects generated by an expenditure (i.e., input). To determine the total effect of developing a wind power plant, three impacts are examined for each expenditure. These include direct effect, indirect effect, and induced effect.

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1 Marshall Goldberg, of MRG & ASSOCIATES, designed the model under contract to the National Renewable Energy Laboratory (NREL).

2 Although JEDI was originally designed to provide state level analysis, the model also includes a "User Add-in Location" feature. This feature allows users to import specific county or region level multipliers and personal expenditure patterns to localize the analysis to a location other than the state level.

Direct effect: Direct effects are the on-site or immediate effects created by an expenditure. In constructing a wind plant, it refers to the on-site jobs of the contractors and crews hired to construct the plant. It also includes the jobs at the turbine manufacturing plants and the jobs at the tower and blade factories.

Indirect effect: Indirect effects refer to the increase in economic activity that occurs when a contractor, vendor or manufacturer receives payment for goods or services and in turn is able to pay others who support their business. For instance, this impact includes the banker who finances the contractor; the accountant who keeps the contractor's books; and the steel mills and electrical manufacturers and other suppliers that provide the necessary materials.

Induced effect: Induced effects refer to the change in wealth and income that is induced by the spending of those persons directly and indirectly employed by the project. This would include spending on food, clothing, or day care by those directly or indirectly employed by the project, retail services, public transit, utilities, cars, oil, property & income taxes, medical services, and insurance, for example.

The sum of these three effects yields a total effect that results from a single expenditure. To accomplish this analysis at the state level, state-specific multipliers and personal expenditure patterns are used to derive the results. These state-by-state multipliers for employment, wage and salary income and output (economic activity), and personal expenditure patterns were adapted from the IMPLAN Professional model using year 2000 data, the most current data available last year.[3] The changes in expenditures from investments in developing wind power plants are matched with their appropriate multipliers for each sector affected by the change in expenditure.

Consistent with an analysis of this type and scope, the assumptions play an important role in influencing the results. Thus, to accommodate the greatest level of flexibility in user skill level and availability of specific detailed project information, the model is designed to incorporate model default values or new values entered by the user. The default values represent a reasonable expenditure pattern for constructing and operating a wind power plant in the United States and the share of expenditures spent locally. The default expenditure pattern is based on a review of numerous wind resource studies.

Currently, not every project will follow this exact "default" pattern for expenditures. Project size, location, financing arrangements, and numerous site-specific factors influence the construction and operating costs. Similarly, the availability of local resources (including skilled labor and materials) and the availability of locally manufactured power plant components will have a significant effect on the costs and the economic benefits that accrue to the state or local region. To the extent the user has and can incorporate project-specific data and the share of spending that is expected to occur locally, the more localized the impact analysis will be.

Analyses

An early version of JEDI was used by the Union of Concerned Scientists to conduct economic impact analyses in Arizona, Idaho, and Washington. A presentation of these analyses is available at NREL's Wind Powering American web page.[4]

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3 See Minnesota IMPLAN Group (MIG, Inc), Stillwater, Minnesota, 651/439-4421, www.IMPLAN.com. IMPLAN (**Impact Analysis for PLANning**) Professional is a social accounting and impact analysis tool.

4 Go to http://www.eere.energy.gov/windpoweringamerica/pdfs/econ_clemmer.pdf for February 2003 presentation by Steve Clemmer,

In 2003, the GAO requested that NREL conduct economic impact analyses of projects in 11 counties from a total of 5 different states. These include: Alameda and Solano in California; Weld in Colorado; Buena Vista, Cherokee, and Dickinson in Iowa; Pipestone and Rock in Minnesota; and Crockett, Pecos, and Upton in Texas. For each of these counties, three wind project scenarios were analyzed. The scenarios included analysis of a 150 MW plant, a 40 MW plant, and twenty 2 MW plants. Table 1 summarizes the scenario results.

Although each of the plants has a similar expenditure pattern (construction and annual O&M costs), the share of local spending varies depending upon the project location and availability of skilled labor and local businesses to meet project needs. In addition to these parameters, the analysis assumes the 150 MW and 40 MW plants are developed (owned) by non-local investors, are financed by non-local lenders and include land lease payments to local landowners (estimated at $4,000 per 1.5 MW turbine). The twenty 2 MW plants are assumed to be developed by local residents (landowners), equity payments are made to local residents, all financing is by local lending institutions and no land lease payments are made. The local ownership and local financing result in more dollars remaining in the local economy (i.e., more local spending and fewer monetary leakages) when compared with a project of similar size not locally owned or financed.

In addition to the GAO scenarios, economic impact analyses are being conducted in conjunction with NREL in Colorado, Montana, Oregon, and Virginia. Other states, including Arizona, Idaho, Michigan, and Nevada, are in various stages of conducting these analyses.

Important Considerations

Three important points should be considered when using JEDI. First, JEDI is intended to construct a reasonable profile of investments (i.e., wind power plant construction and operating costs) and demonstrate the economic impacts that will likely result, assuming a project occurs during the stated period of analysis. Given future changes in wind power plant costs and potential changes in industry and personal consumption patterns in the economy, the analysis is not intended to provide a precise forecast, but rather an approximate estimate of overall impacts.

Second, the analysis is specific to developing a wind power plant and thus is considered a gross analysis. That is, it doesn't reflect net impacts associated with alternate spending of the money (such as constructing and operating other types of electricity-generating power plants) or replacement of existing power generation resources.

Third, the analysis does not account for changes in electricity prices or end-user electricity bills that could result from developing wind power plants versus other types of power plants.

Fourth, the analysis assumes the output from the power plant and the specific terms of the power purchase agreement generate sufficient revenues to accommodate the equity and debt repayment and annual operating expenditures. To the extent additional revenues (i.e., profits and/or tax advantages above actual costs) accrue to the project owner, there will be additional benefits. If the project owner is local, these additional benefits will contribute to the local share, however these benefits are not included in the analysis.

Union of Concerned Scientists.

TABLE 1. GAO WIND PROJECT SCENARIOS – JEDI ANALYSES

Site Location (county)	Project Size	Number of Turbines	Local Construction Cost Spending (millions)	Local Annual O&M Spending (millions)	Total Jobs (Direct, Indirect, Induced) Impacts (During Construction)	Total Jobs (Direct, Indirect, Induced) Impacts (During Operating Years)
California						
Alameda	40 MW	54 – 750kW	$ 5.1	$ 0.8	84	17
Alameda	20 – 2MW*		$ 5.1	$ 6.7	84	38
Alameda	150 MW	100 – 1500kW	$ 19.1	$ 3.1	314	65
Solano	40 MW	27 – 1500kW	$ 5.1	$ 0.8	86	17
Solano	20 – 2MW*		$ 5.1	$ 6.7	86	34
Solano	150 MW	100 – 1500kW	$ 19.1	$ 3.1	321	64
Colorado						
Weld	40 MW	27 – 1500kW	$ 5.1	$ 0.8	103	20
Weld	20 – 2MW*		$ 5.1	$ 6.7	103	46
Weld	150 MW	100 – 1500kW	$ 17.5	$ 3.1	349	76
Iowa						
Buena Vista	40 MW	54 – 750kW	$ 0.5	$ 1.3	13	23
Buena Vista	20 – 2MW*		$ 0.5	$ 7.2	13	48
Buena Vista	150 MW	200 – 750kW	$ 1.9	$ 4.9	47	86
Cherokee	40 MW	27 – 1500kW	$ 0.3	$ 1.3	9	25
Cherokee	20 – 2MW*		$ 0.3	$ 7.2	9	52
Cherokee	150 MW	100 – 1500kW	$ 1.3	$ 4.9	33	93
Dickinson	40 MW	54 – 750kW	$ 0.5	$ 1.3	11	22
Dickinson	20 – 2MW*		$ 0.5	$ 7.2	11	48
Dickinson	150 MW	200 – 750kW	$ 1.9	$ 4.9	40	81
Minnesota						
Pipestone	40 MW	27 – 1500kW	$ 0.3	$ 0.3	7	12
Pipestone	20 – 2MW*		$ 0.3	$ 6.2	7	36
Pipestone	150 MW	100 – 1500kW	$ 1.3	$ 1.3	28	45
Rock	40 MW	27 – 1500kW	$ 0.3	$ 0.3	7	12
Rock	20 – 2MW*		$ 0.3	$ 6.2	7	38
Rock	150 MW	100 – 1500kW	$ 1.3	$ 1.3	27	45
Texas						
Crockett	40 MW	27 – 1500kW	$ 0.3	$ 1.2	6	16
Crockett	20 – 2MW*		$ 0.3	$ 7.1	6	37
Crockett	150 MW	100 – 1500kW	$ 1.3	$ 4.6	21	60
Pecos	40 MW	54 – 750kW	$ 0.5	$ 1.2	10	18
Pecos	20 – 2MW*		$ 0.5	$ 7.1	10	39
Pecos	150 MW	200 – 750kW	$ 1.9	$ 4.7	36	67
Upton	40 MW	27 – 1500kW	$ 0.3	$ 1.2	6	13
Upton	20 – 2MW*		$ 0.3	$ 7.1	6	32
Upton	150 MW	100 – 1500kW	$ 1.3	$ 4.6	22	47

* Scenario includes no land lease payments due to landowner development.

Entering Data and Running the Model

The JEDI model is designed for all levels of users, requiring no experience with spreadsheets or background in economic modeling. The model includes on-line instructions on how to proceed with entering data for analysis, as well as detailed information (comments) to assist users in understanding the type of data required in specific cells. A documentation file is also included with the model.

For those users with little or no experience with wind power plants or economic impact analysis, minimal inputs are required, such as the state in which the wind plant will be built, the year the plant will be built, and the size of the plant. The user can then choose to accept all project defaults (or review and edit the defaults) and go directly to Summary Impacts to view the results of the analysis.

For those users with more experience with wind power plants and/or economic impact analysis (i.e., those with more project-specific information on costs and expenditures, financing, taxes, and local share of spending, among others), project-specific values can be entered to override the default values.

Once the analysis is complete, the user has several options for saving the data and results including printing the results, saving the model (using a different name), or copying the results into a spreadsheet format.

Interpreting the Results

Regardless of the amount of project-specific data entered by the user, JEDI provides sufficient information to help users better understand the economic impacts associated with the project being analyzed. The model provides basic project information to identify the magnitude of the construction-related spending and ongoing operating and maintenance (O&M) expenditures, as well as the portion of local spending. As noted earlier, these outputs should not be interpreted as precise values. Instead, they should be used as an indication of the magnitude of the potential economic development impacts. The "local share" values — default or user modified — are determined in the model for each of the expenditures. Similarly, the model identifies local spending on debt and equity payments, property taxes and land lease payments.

In addition to the basic project information, the model provides analysis (divided into direct, indirect and induced impacts) of the local jobs, earnings, and output (economic activity) generated as a result of the project. This includes the one-time impacts from the construction phase, as well as the annual or ongoing impacts from the annual operations.

For example, JEDI can be used to quickly and easily find the economic impacts from a 100-megawatt (MW) wind power plant in Colorado to be built in the year 2004 using 1.5-MW turbines at a cost of $1000 per kW. Figure 1 shows the results of such an analysis. By entering this information into the model and accepting the model defaults, we find that the construction of the plant will support just over 220 local jobs (full-time equivalent for a year) and generate almost $12 million in local economic activity during the construction period. Of the total jobs, 85 are directly attributable to the construction sector.

Once this project is operational, it continues to benefit the state by providing 40 full-time equivalent jobs each year of operation (20 directly employed by the wind plant). Total annual local spending from the ongoing operations is approximately $1.3 million.

Wind Plant - Project Data Summary			
Year of Construction		2004	
Project Location		COLORADO	
Project Size - Nameplate Capacity (MW)		100.0	
Turbine Size (KW)		1500	
Number of Turbines		67	
Construction Cost ($/KW)		$1,000	
Annual Direct O&M Cost ($/KW)		$12.50	
Money Value (Dollar Year)		2004	
Project Construction Cost		$100,000,000	
Local Spending		$11,692,658	
Total Annual Operational Expenses		$16,841,333	
Direct Operating and Maintenance Costs		$1,250,000	
Local Spending		$781,623	
Other Annual Costs		$15,591,333	
Local Spending		$551,333	
Debt and Equity Payments		$0	
Property Taxes		$283,333	
Land Lease		$268,000	
Local Economic Impacts - Summary Results			
	Jobs	**Earnings**	**Output**
During construction period			
Direct Impacts	92	$3.02	$11.43
Construction Sector Only	85	$2.79	$10.71
Indirect Impacts	58	$2.14	$6.87
Induced Impacts	71	$2.19	$6.60
Total Impacts (Direct, Indirect, Induced)	**222**	**$7.36**	**$24.90**
During operating years (annual)			
Direct Impacts	26	$0.80	$1.33
Plant Workers Only	20	$0.62	$0.62
Indirect Impacts	4	$0.14	$0.50
Induced Impacts	10	$0.31	$0.94
Total Impacts (Direct, Indirect, Induced)	**40**	**$1.26**	**$2.77**
Totals may not add up due to independent rounding.			

FIGURE 1. LOCAL ECONOMIC IMPACTS FROM 100-MW COLORADO WIND FARM EXAMPLE USING JEDI

User Add-In Location Feature

The initial JEDI model design provided for state-level impact analysis. After its introduction, it was apparent many potential users might also wish to perform a similar level of analysis for a smaller or more localized region (such as an individual county or group of counties) or for a larger region (such as a group of neighboring states) to better capture the regional benefits. The high cost of including multiplier and expenditure data in the model for every county in the United States and the complexities associated with designing the model to analyze the endless number of possibilities for combining counties and states made this impractical.

To accommodate those users who desire this level of analysis, a User Add-In Location feature is provided. This feature allows users with the capability to derive or obtain the necessary data inputs to complete analysis for a specific region of interest other than the state level included with the base model. The necessary inputs include direct, indirect, and induced multipliers for employment, earnings and output (per million dollars change in final demand) and personal consumption expenditures (i.e., average consumer expenditures on goods and services — calculated as a percentage for each industry — totaling 100 percent combined), for the 14 aggregated industries analyzed in the model. More detail on the sectors contained in each industry can be found as an appendix to the model, which is made available to all JEDI users.

The aggregated industries include:

1. Agriculture
2. Construction
3. Electrical Equipment
4. Fabricated Metals
5. Finance, Insurance, and Real Estate
6. Government
7. Machinery
8. Mining
9. Other Manufacturing
10. Other Services
11. Professional Services
12. Retail Trade
13. Transportation, Communication and Public Utilities
14. Wholesale Trade

Once the user's new location data are entered into JEDI, the user need only identify the location of the wind plant (in the project description section of the ProjectData worksheet) as MyCounty or MyRegion (depending on where the data are entered in the User Add-In Location worksheet) and proceed with the analysis.

Data Sources

Analyzing the economic impacts of constructing and operating wind power plants requires a large amount of project-specific data, state-specific input-output multipliers and personal expenditure patterns, and price deflators. The project-specific data include a bill of goods (costs associated with actual construction of the facility, roads, etc., as well as costs for equipment and other services and fees), annual operating and maintenance costs and data on the portion of expenditures spent locally, financing terms, and tax rates. More specifically, the model requires the following project inputs:

- Construction Costs (materials and labor)
- Equipment Costs (turbines, rotors, towers, etc.)
- Other Costs (utility interconnection, engineering, land easements, permitting, etc.)
- Annual Operating and Maintenance Costs (personnel, materials and services)
- Other Parameters (financial: debt and equity, taxes, and land lease)

Unfortunately, many developers consider this type of information proprietary due to competitive forces in the marketplace. Similarly, project-specific differences can and do significantly impact costs. As a result, it is nearly impossible to identify a one-price-fits-all situation. Nevertheless, the model provides reasonable default values for each of the inputs noted above and all of those necessary for the analysis. These values represent average costs and spending patterns derived from a number of sources (project specific data contained in reports and studies) and research and analysis of renewable resources undertaken by the model developer during the past 10 years. Among other sources (including personal communications and anecdotal evidence gathered to complete previous renewable studies), the model incorporates specific project-related data derived from the following sources:

BBC Research and Consulting. *Potential Economic Benefits from Commercial Wind Power Facilities in Quay County.* New Mexico Energy, Minerals and Natural Resources Department, Santa Fe, New Mexico. July 15, 2000.

DanMar and Associates. *Economic Impact Analysis of WINDPOWER DEVELOPMENT in Southwest Minnesota.* Southwest Regional Development Commission, Slayton, Minnesota. September 1996.

Office of Utility Technologies, Energy Efficiency and Renewable Energy. *Renewable Energy Technology Characterizations.* Electric Power Research Institute and U.S. Department of Energy. December 1997. TR-109496.

Wind, Thomas A. *Wind Farm Feasibility Study.* Iowa Association of Municipal Utilities, Ankeny, Iowa. April 1996.

Personal communications with Dan Juhl, a wind project developer in Minnesota, 2003.

Personal communications with Steve Clemmer, Research Director, Clean Energy Program, Union of Concerned Scientists, Cambridge, Massachusetts, 2003.

The state-by-state input-output multipliers and household commodity demand/personal consumption expenditure patterns were derived from IMPLAN Professional™ Version 2.0, using 2000 state data files for the respective states. Minnesota IMPLAN Group, Inc., Stillwater, Minnesota.

The U.S. price deflators were derived from Current Dollar and "Real" Gross Domestic Product data downloaded from the Bureau of Economic Analysis Web site, http://www.bea.doc.gov, December 2002.

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13. ABSTRACT *(Maximum 200 words)*

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