NREL
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Photo by Suzanne Tegen, NREL 41286

Wind Energy Workforce Development & Jobs

Suzanne Tegen, Ph.D.

Nebraska Wind and Solar Conference

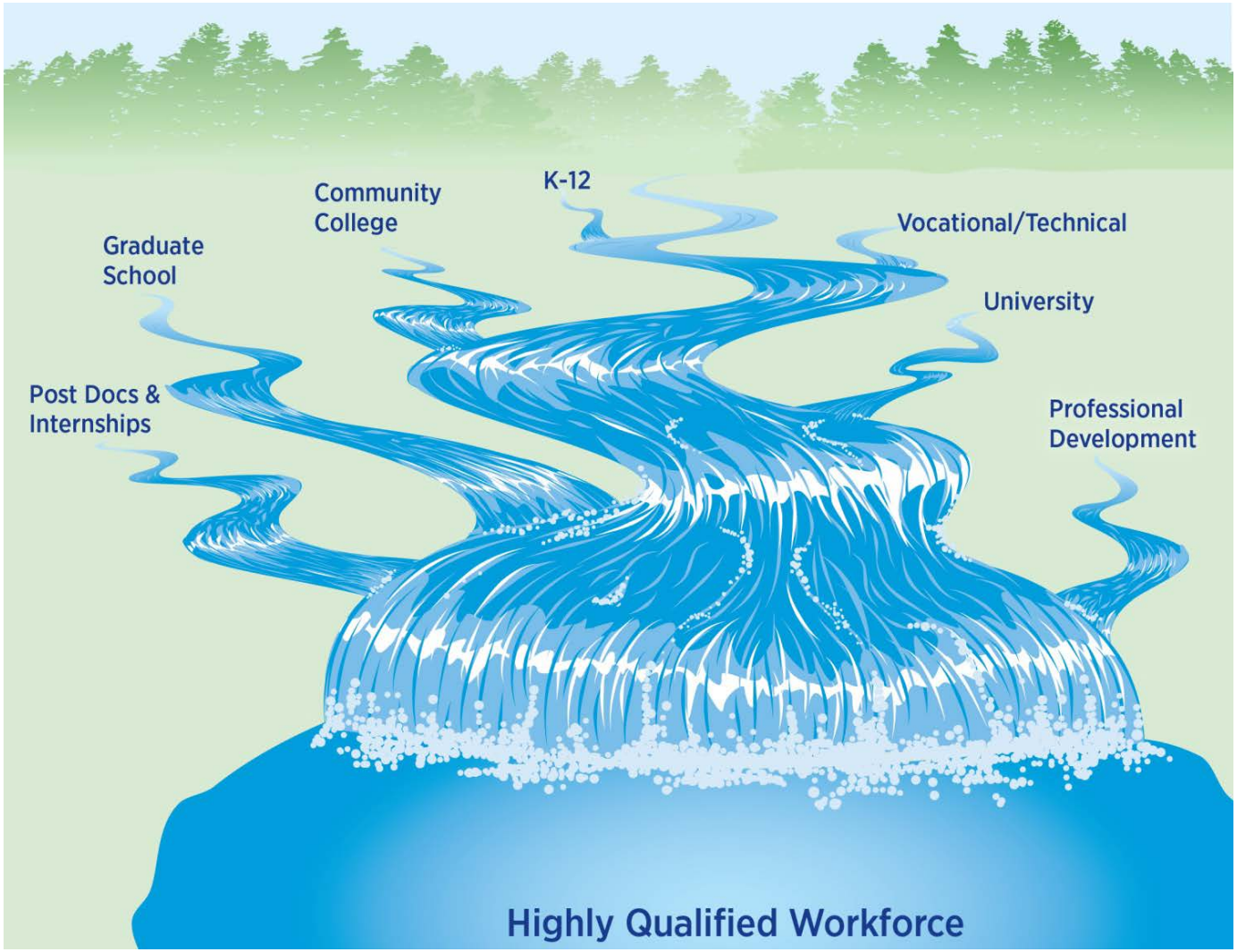
Lincoln, Nebraska

National Renewable Energy Laboratory

November 8, 2016

NREL/PR-5000-67377

The Wind Energy Workforce

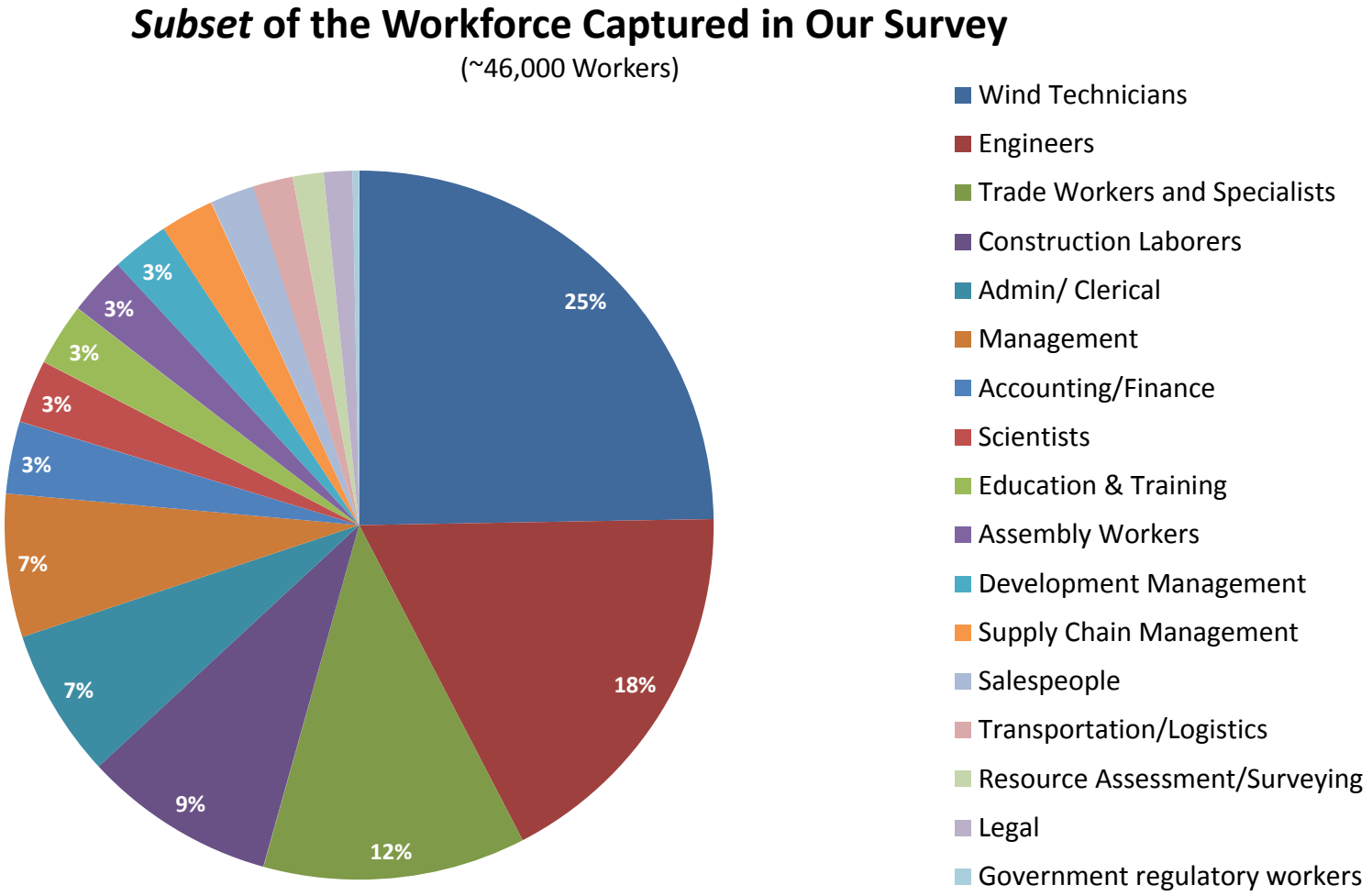


DOE/NREL Wind Energy Workforce Efforts

- WINDExchange
- Wind for Schools
- DOE Collegiate Wind Competition
- North American Wind Energy Academy
- NREL student internships
- Wind Career Map
- Research and reports.

Photo from Lindsey Hutterer, Pennsylvania State University, NREL 35638

One Segment of Jobs in the 2012 Wind Industry



Manufacturing jobs include some from the following categories: trade workers, assembly workers, supply chain management, salespeople, transportation, and some admin/clerical--approximately 25%.

Jobs Estimations Based on 2012 Industry Survey

Job	2015	2030	2050
Wind Energy Technician	21,250	95,000	150,000
Engineer	15,300	68,400	108,000
Trade Worker	10,200	45,600	72,000
Construction Labor	7,650	34,200	54,000
Admin/Clerical	5,950	26,600	42,000
Management	5,950	26,600	42,000
Accounting/Finance	2,550	11,400	18,000
Scientist	2,550	11,400	18,000
Education/Training	2,550	11,400	18,000
Assembly Worker	2,550	11,400	18,000
Development Management	2,550	11,400	18,000
Supply Chain Management	1,700	7,600	12,000
Salesperson	1,700	7,600	12,000
Transportation/Logistics	1,700	7,600	12,000
Resource Assessment/Surveyor	850	3,800	6,000
Legal Professionals	850	3,800	6,000

Jobs estimations are based on Leventhal and Tegen 2012 report, AWEA jobs data, and *DOE Wind Vision* scenarios for 2030 (380,000 total jobs) and 2050 (600,000 total jobs). Jobs are estimated based on percentages, which causes similar jobs numbers in different categories.

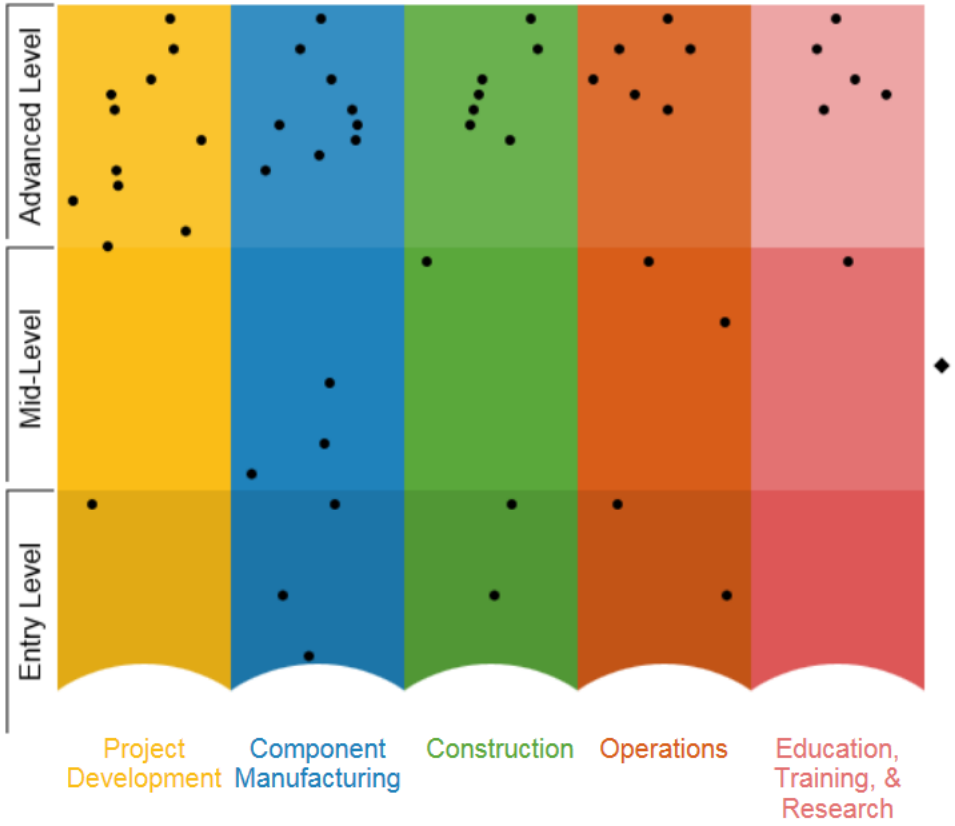
Wind Career Map

WIND CAREER MAP

- Wind Program Home
- About the Program
- Research & Development
- WINDExchange
- Financial Opportunities
- Information Resources
- News
- Events

This wind career map explores an expanding universe of wind energy occupations, describing diverse jobs across the industry, charting possible progression between them, and identifying the high-quality training necessary to do them well.

About this Mapping Tool



Wind Jobs

Mouse over the career map at the left to explore wind industry related jobs in Project Development; Component Manufacturing; Construction; Operations; and Education, Training, & Research. Or select a multi-sector career route below.

Selected Cross-Sector Routes

Reset

○ Technician >> Training Manager

FAQ

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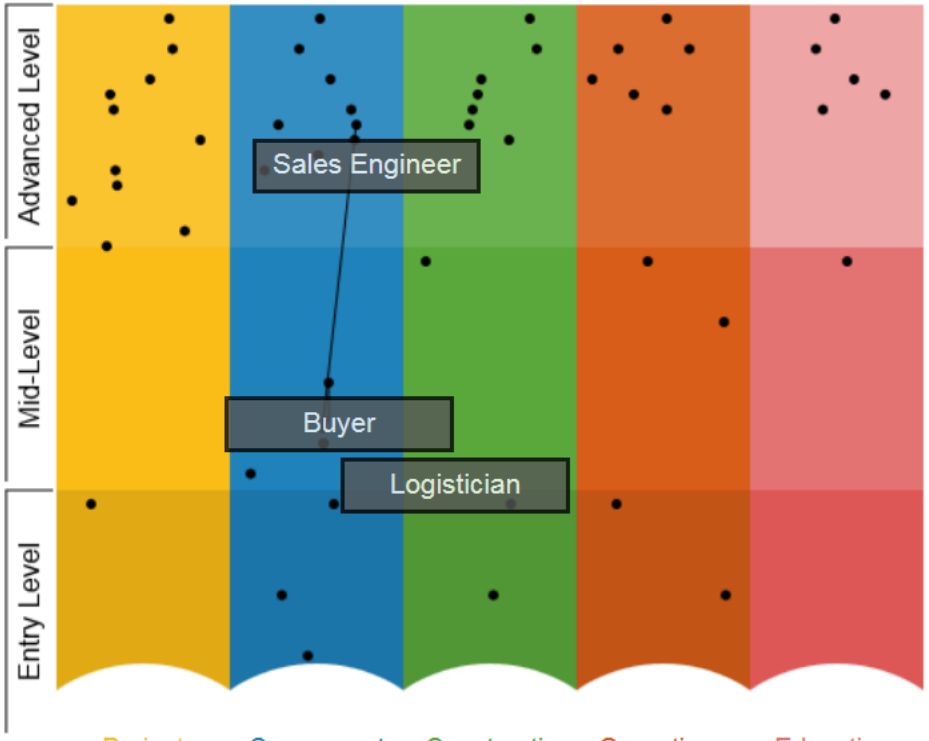


Logistician

Job Description: Logisticians analyze and coordinate an organization's supply chain—the system that moves a product from supplier to consumer. They manage the entire life cycle of a product, which includes how a product is acquired, distributed, allocated, and delivered.

Career transitions are related to experience and education. Although an associate's degree may be sufficient for some logistician jobs, a bachelor's degree is typically required for most positions. Industry certification and work experience in a related field can be helpful for jobseekers.

Routes To Advancement:
Buyer - This advance typically

Reset

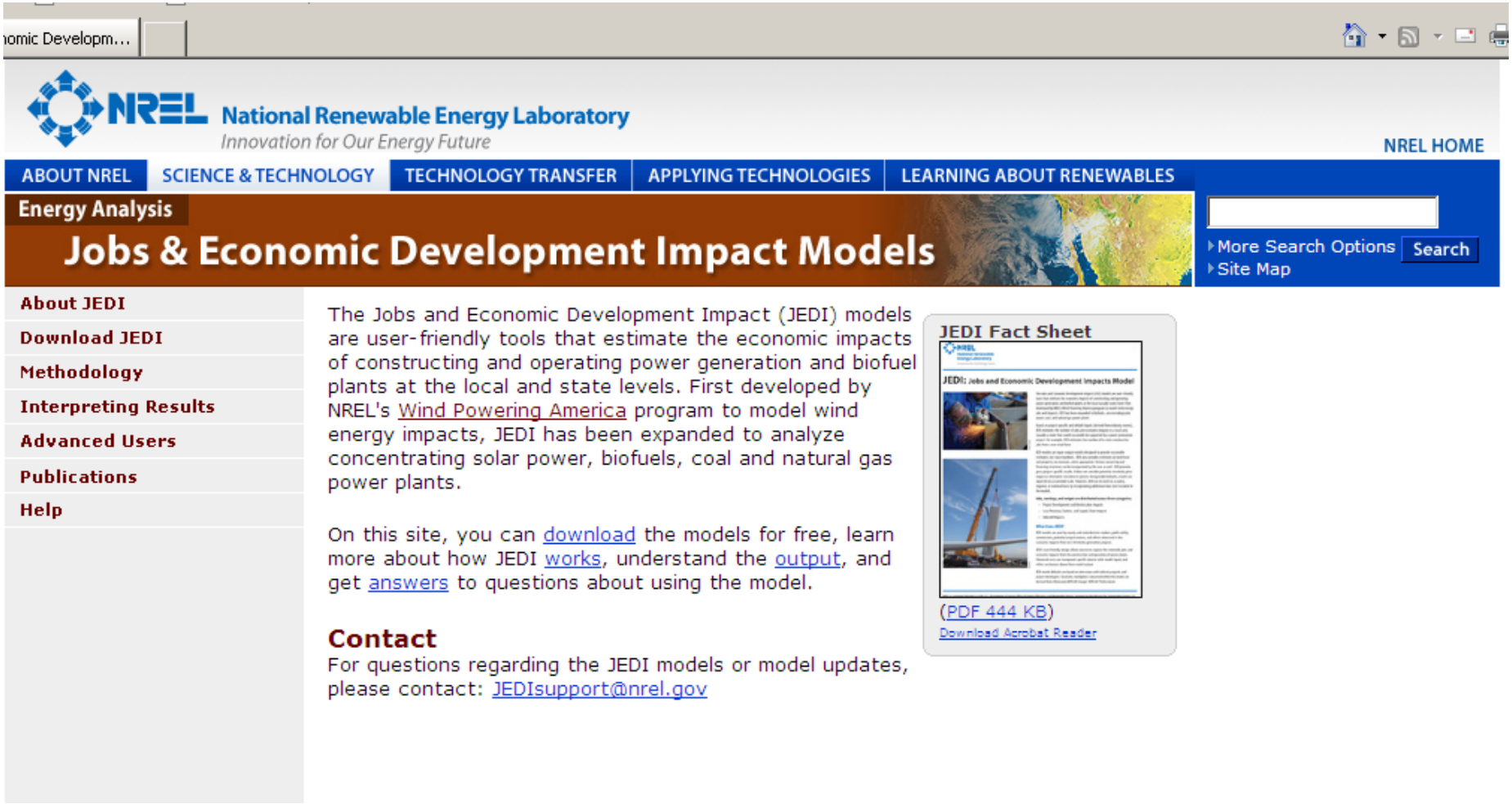
Job Details | FAQ

Jobs & Economic Development Impacts (JEDI)

- No cost, input-output tool to estimate gross employment and economic impacts that result from new power generation
- JEDI default inputs are from developers and industry experts, based on existing projects
- User input can be minimal with defaults or be very detailed for more precise results.

Photo from Todd Spink, NREL 14809

Downloading the JEDI Model



www.nrel.gov/analysis/jedi

Which Technologies Have JEDI Models?

- Land-based wind
- Distributed wind
- Offshore wind
- Natural gas (combined cycle)
- Coal (pulverized coal)
- Marine and hydrokinetic
- Concentrating solar power
- Dry mill corn ethanol
- Lignocellulosic ethanol
- Solar photovoltaic
- Hydropower
- Transmission
- Geothermal
- Biopower
- Petroleum refining.

Photo from Sally Wright, Renewable Energy Research Lab - Umass, NREL 15160

Wind Power Sizes & Applications

Photo from Bergey Windpower Co. Inc., NREL 02102

Small (≤100 kW)

Homes

Farms

Remote applications (e.g., water pumping, telecom sites, ice making)

Distributed power

Photo from Tjaden Farms, NREL 13764

Mid-scale (100–1,000 kW)

Village power

Hybrid systems

Distributed power

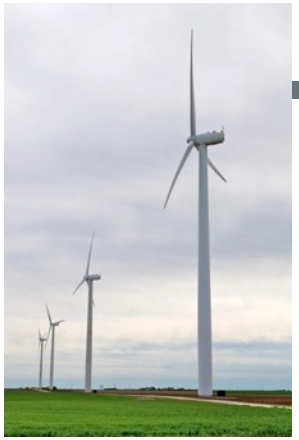


Photo from Native Energy Inc., NREL 7593

Large, land-based (1–3 MW)

Utility-scale wind farms

Large distributed power

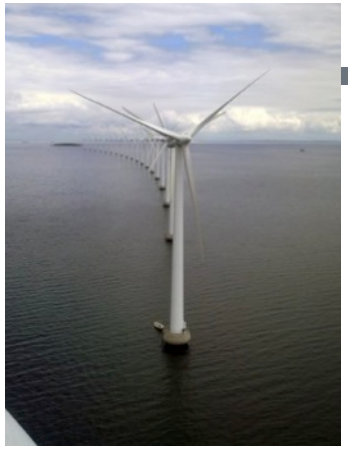


Photo from HC Sorensen, NREL 17855

Large, offshore (3–7 MW)

Utility-scale wind farms, shallow coastal waters

One U.S. installation

Between 2013-2015, 14,300 kW of distributed wind were installed in Nebraska.

Photo from Trudy Forsyth, NREL 11996

Why Economic Impact Modeling?

- People care about jobs!
- Evaluate potential scenarios – current or future
- Inform communities, decision-makers
- Assist businesses
  - Evaluate economic development efforts
- Assist government
  - Representing public interest
  - Planning and evaluating
  - Community development.

Photo from First Wind, NREL 16738

Who Uses the JEDI Models?

- Governments
  - Public utility commissions
  - State or governors' energy offices
  - Many federal agencies, including BLM, Treasury, DOE, USDA
  - National laboratories
- State, county, domestic and international analysts
- Developers and others in industry
- Universities/students
- Consultants
- Stakeholders
- Economic development groups
- Consumer advocates.

Project Development & Onsite Labor Impacts

Sample job types

- Truck driving
- Crane operation, hoisting, rigging
- Earth moving
- Pouring cement
- Management, support
- Siting.

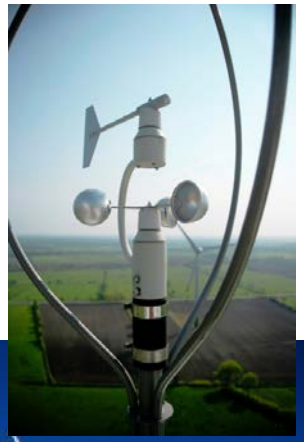


Photo from iStock 947687

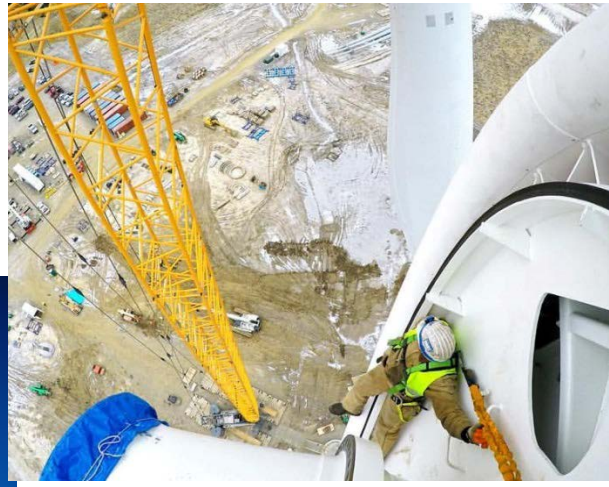


Photo by Jessica Makolin, NREL 40804

Photo from Cross Island Farms, NREL 19923

Photo from Stephanie Lively, Boise State University, NREL 16147

Photo from Northern Power Systems, NREL 13853

Local Revenues, Turbine, Module, & Supply Chain Impacts


NREL 11074


Photo from iStock 5676592


Photo by Jim Green, NREL 16178

- Steel mill jobs, parts, services
- Equipment manufacturing and sales
- Blade and tower manufacturers
- Property taxes, financing, banking, accounting.


Photo from iStock 4088468

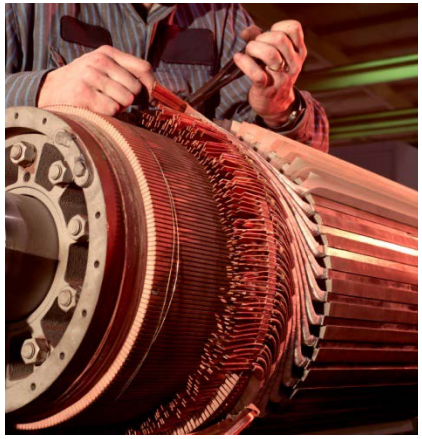


Photo from iStock 8433850


Photo from iStock 7792082


Photo from iStock 8384987

Induced Impacts

Photo from iStock 9774681

Photo from iStock 8783332

Photo from iStock 4363756

Money spent in the local area on goods and services from increased revenue, including: *hotels, sandwich shops, grocery stores, clothing, other retail, public transit, cars, restaurants, and medical services.*

Photo from iStock 3275965

Photo from iStock 8007815

Photo from National Park Service, NREL 11598-C

Typical Results from a 100-MW Wind Project

Onsite Jobs
60-80 construction jobs*
5-7 operations & maintenance jobs*
Increased Local Revenues
Land lease payments: 3%-6% of gross project revenue (occasionally higher based on region)
Local property tax revenue: $500,000 - $1+million per year
Local Benefits
Stimulate local industry (concrete, roads, environmental, siting, legal)
Stimulate local manufacturing in some cases

*Jobs are listed as full-time equivalents

JEDI Strengths & Weaknesses

- Strengths
  - Widely accepted
  - Utilized and trusted by private companies, international organizations, and government agencies in the United States at the federal, state, and local levels
  - Can use available data from many different sources
  - Can give detailed sector-specific impact information.
- Weaknesses
  - Only gross, not net; What about coal mining jobs that could be lost if new natural gas plant comes online?
  - Assumes infinite supply of inputs and successful project
  - Assumes fixed prices; does not consider changes in electric rates, wages, or taxes.

Photo by Jonathan Keller, NREL 36528

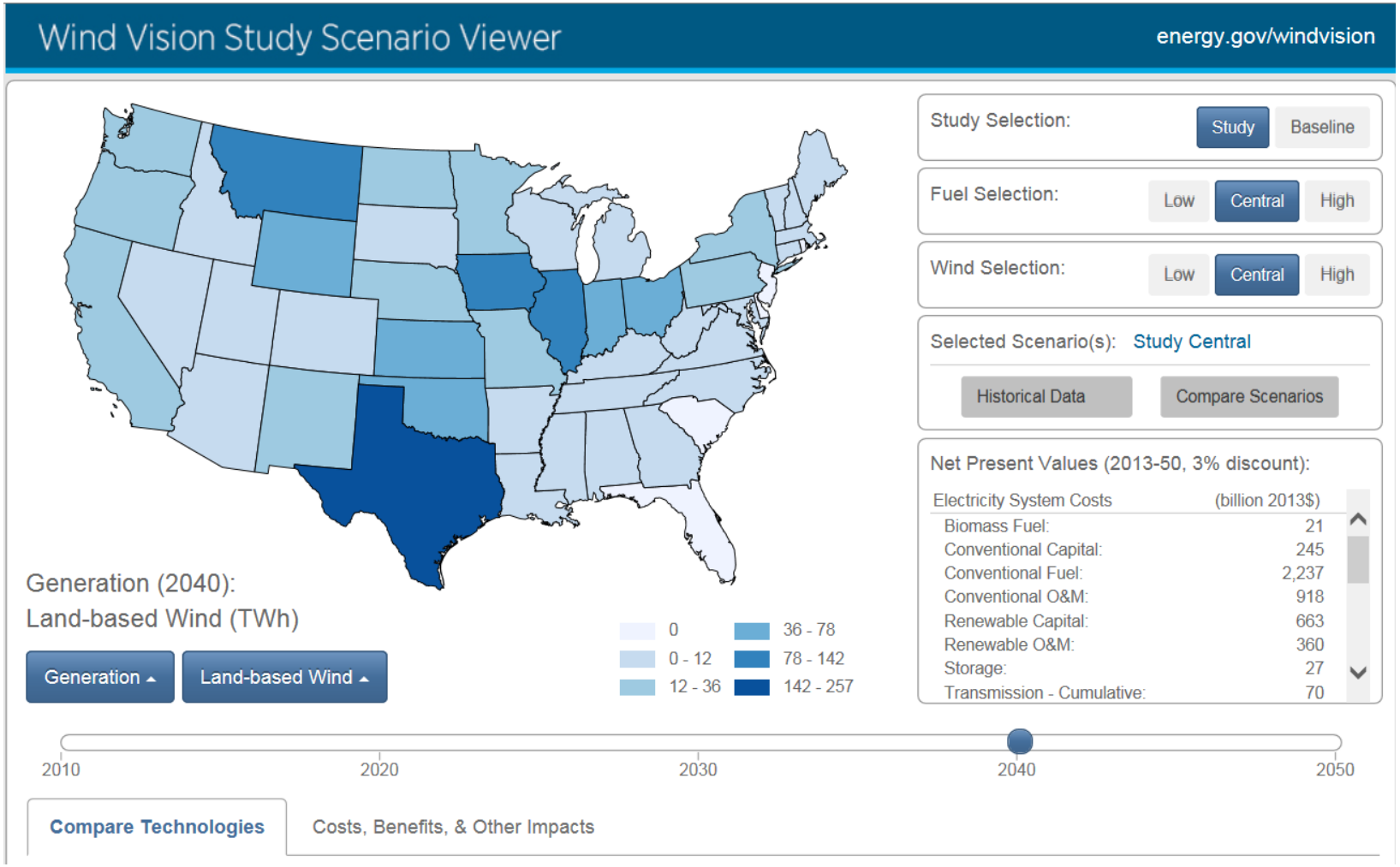
The Wind Vision Report

Key Findings

- **Wind energy is available nationwide.** The *Wind Vision Report* shows that wind can be a viable source of renewable electricity in all 50 states by 2050.
- **Wind energy supports a strong domestic supply chain.** Wind has the potential to support more than 600,000 jobs in manufacturing, installation, maintenance, and supporting services by 2050.
- **Wind energy is affordable.** As wind generation agreements typically provide 20-year fixed pricing, the electric utility sector is anticipated to be less sensitive to volatility in natural gas and coal fuel prices with more wind. By reducing national vulnerability to price spikes and supply disruptions with long-term pricing, wind is anticipated to save consumers $280 billion by 2050.
- **Wind energy preserves water resources.** By 2050, wind energy can save 260 billion gallons of water—the equivalent to roughly 400,000 Olympic-size swimming pools—that would have been used by the electric power sector.
- **Wind energy deployment increases community revenues.** Local communities will be able to collect additional tax revenue from land lease payments and property taxes, reaching $3.2 billion annually by 2050.
- **Wind energy reduces air pollution.** In 2013, operating wind energy capacity avoided the emission of more than 250,000 metric tons of air pollutants, which include sulfur dioxide, nitric oxide, nitrogen dioxide, and particulate matter. By 2050, wind energy could avoid the emission of 12.3 gigatonnes of greenhouse gases.

http://energy.gov/eere/wind/wind-vision

Wind Vision Scenario Tool



http://en.openei.org/apps/wv_viewer/

Wind Vision Scenario Benefits, Costs, Impacts

The Potential of 35% of the Country's Electricity Coming from Wind Energy by 2050

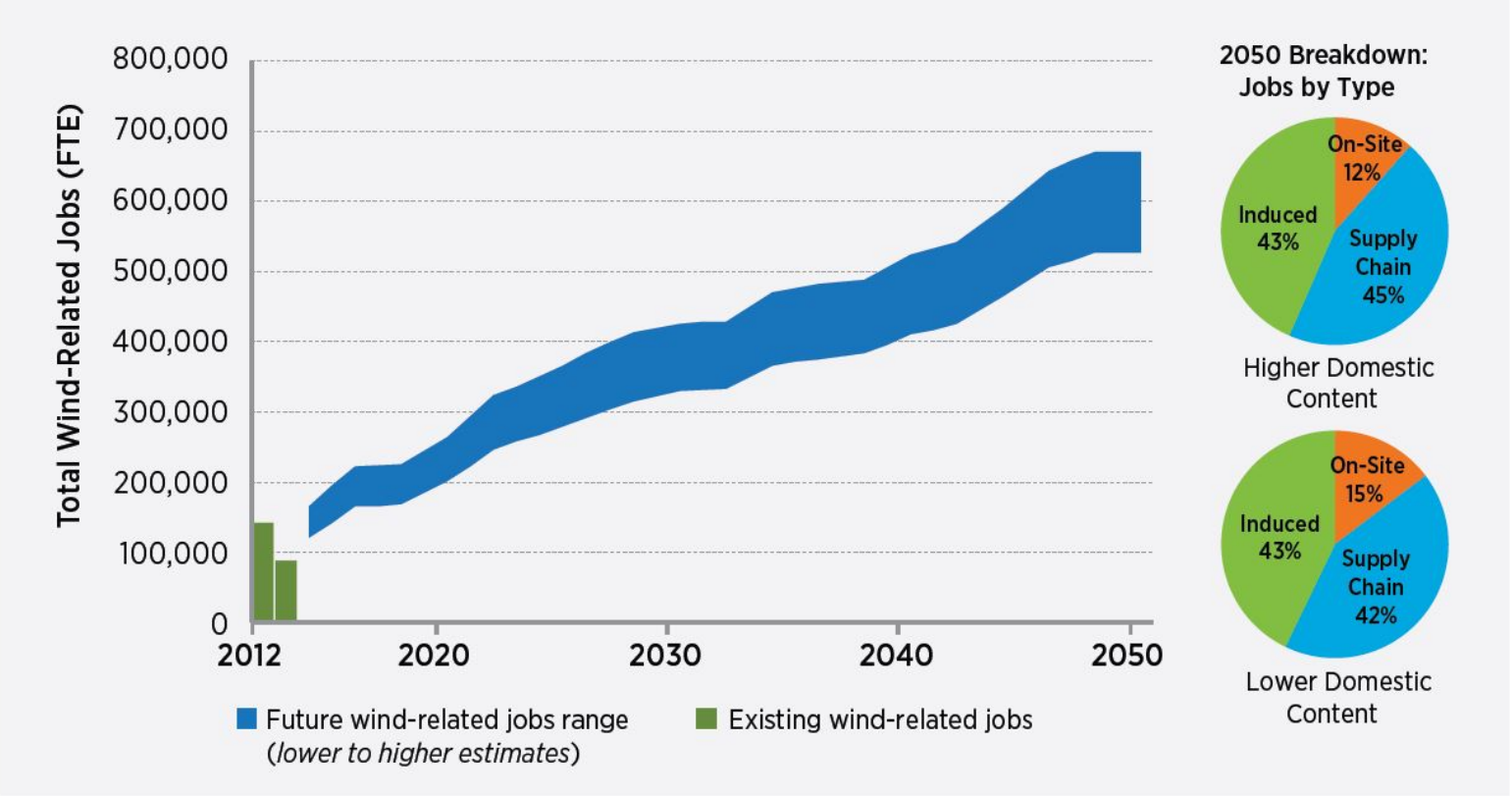
Costs	Benefits		
$	GHG	Air Pollution	H_2O
$149 Billion [3%] savings	GHG: 14% less GHG; $400 Billion savings	$ 108 Billion savings; 22,000 lives saved	260 Billion gallons [23%] less consumption

Additional Impacts

Energy Diversity	Jobs	Local Revenues	Land Use	Public Acceptance and Wildlife
Electricity prices 20% less sensitive	~ 600,000 gross jobs	$1.0 Billion/year in land leases $3.2 Billion/year in tax payments	1.5% area of contiguous US Less than 1/3 area occupied by golf courses in US today	Responsible siting; Optimizing coexistence

The Wind Vision Study Scenario results in modest increases in electricity cost in the near- and mid-term (<1% price increase), but in the long term electricity costs savings of 2% are achieved by 2050

Jobs from the Wind Vision Scenario



Note: Existing job estimates for 2012 and 2013 utilized American Wind Energy Association data for on-site and supply chain jobs and then the JEDI model to estimate the additional induced jobs.

Figure 3-45. Wind-related gross employment estimates, including on-site, supply chain, and induced jobs: 2012–2050

JEDI www.nrel.gov/analysis/jedi

DOE Wind Vision http://energy.gov/eere/wind/wind-vision

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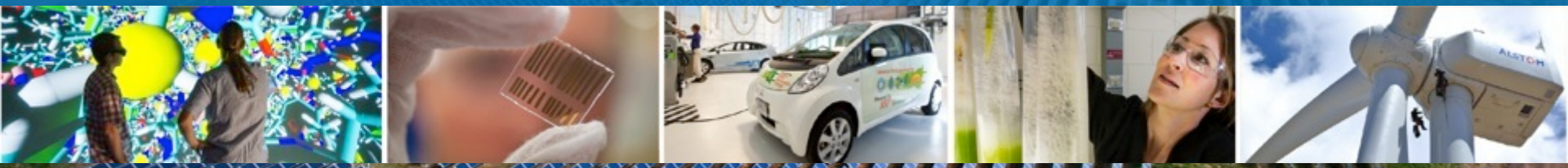


For more information, please visit our website at

www.nrel.gov

Additional Information

JEDI Phases

Results presented over two phases:

- Construction
  - Result is calculated over construction period, regardless of how long it takes to build the project
  - Example: JEDI reports an impact of 600 jobs. This is an annual average of 300 if it takes 2 years to build the project
- Operating
  - Annual, ongoing results
  - Example: JEDI reports 25 jobs. This means that year after year, there will be 25 FTE jobs supporting the project.

JEDI Results Are Reported in Three Categories

- Jobs (FTEs)
  - Number of people working the equivalent of 40-hour weeks, 2080 hours/year
- Earnings
  - Income from work
  - Includes wages, salaries, employer-provided supplements (retirement, health)
- Gross output
  - Measure of total economic activity
  - Revenue plus expenditures on inputs
  - Not the same as GDP

Interpreting Results & Model Limitations

- JEDI results are gross, not net.
- JEDI does not factor in far-reaching impacts from development such as changes in utility rates, greenhouse gas emissions, property values, or public health.
- Input-output models cannot estimate impacts from supply-side changes such as technological improvements, price changes, or changes in taxes/subsidies.
- JEDI doesn't evaluate a project's feasibility or profitability.
- NREL is not responsible for how the model is used or applied or how the results are interpreted.

JEDI Model Approach

- Build project development and operation scenarios
  - Scenarios contain project parameters, expenditures, and other characteristics.
  - Scenarios can be based on default data, or a model user can supply detailed project information.
- Feed project scenario in to an input-output model to estimate impacts
  - We use the IMPLAN model.
  - User has ability to change I-O data to represent different geographies or models such as RIMS II.

Input-Output Models

- Snapshot of the relationships between sectors of an economy at a single point in time:
  - Industries, labor, households, capital, investments, government, imports/exports
- Expenditures in an economy
  - Inputs: goods/services from other industries; payments for labor, capital, taxes, imports
  - Outputs: goods/services to other industries, households, and governments, exports
- Captures feedback within a region; i.e., an increase in demand for electricity might increase demand for locally manufactured turbines, which will further increase demand for electricity.

Explaining Variability in Economic Development Impacts

- Size and cost of the project
  - Higher costs often result in increased impact for construction and O&M
- Size and diversity of the local economy
  - Level of analysis
  - Multiplier effect
- Developer preferences
  - Local share/local purchase coefficient
- Magnitude and allocation of project revenues
  - E.g., community wind.

Photo from Forbes Park LLC, NREL 16116

Validating the JEDI Models

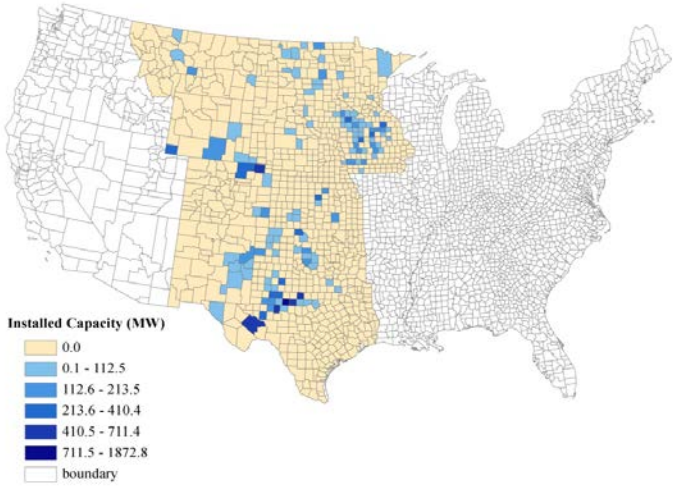
Various studies have validated the JEDI model outputs. One example: USDA and DOE worked together on an econometric study.

Economic Development from Wind Power: An Empirical Analysis of Impacts to Counties

The findings of this work indicate that, on average, there is an approximately $36,000-per-megawatt impact on county-level personal income resulting from wind power installations between 2000 and 2008. For this sample, this translates to a median increase in total personal income of 0.65% for those counties with wind power development (with an increase of 0.1% and 2.6% at the 25th and 75th percentiles, respectively) when compared to initial income levels in 2000.

Total Installed Wind Power Capacity from 2000 to 2008 in the Counties in the 12 State Study Area

Source: Jason Brown (USDA) et al. 2011.



Summary of the JEDI Model

- The JEDI tool provides a user-friendly, free platform to carry out economic impacts analysis for renewable energy projects.
- Acquiring as much project-specific information as possible is critical–the more accurate the inputs, the better the outputs.
- Individual projects vary in key aspects that affect economic development to state and local regions.
  - In extreme cases (i.e., local turbine manufacturing), impacts to a state or local region may be 5 to 10 times different.
- Analyzing jobs and economic impacts is an important task, especially in today's economic and political climate.
  - It is not, however, the sole metric upon which we can/should evaluate renewable energy projects.
- General questions: *jedisupport@nrel.gov*