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# Potential for Jobs and Economic Development from Offshore Wind in California


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California Ocean Renewable Energy Conference

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BOEM
Bureau of Ocean Energy Management

# Floating Offshore Wind in California: Gross Potential for Jobs and Economic Impacts from Two Future Scenarios

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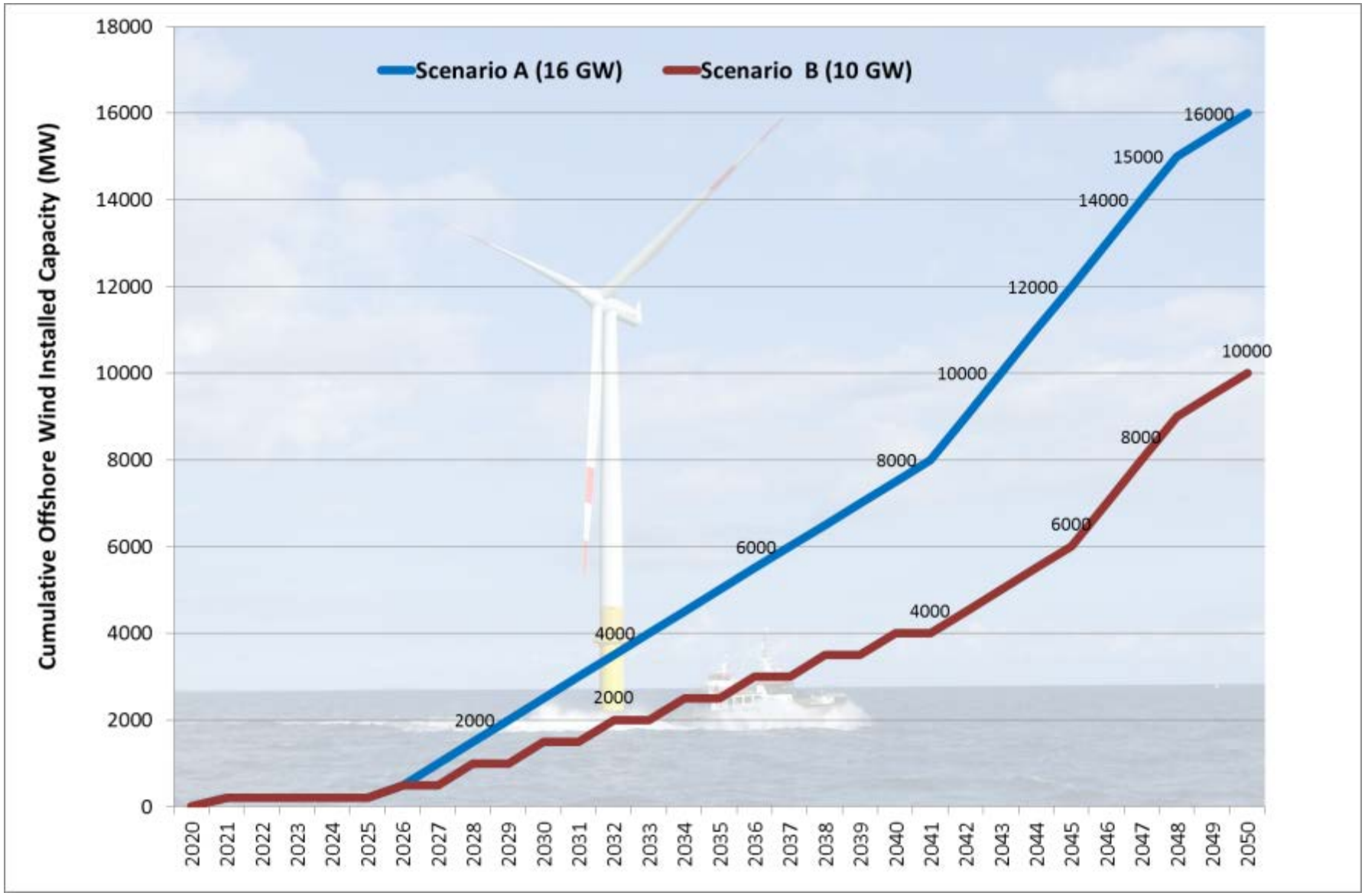
Suzanne Tegen

*National Renewable Energy Laboratory*

http://www.nrel.gov/docs/fy16osti/65352.pdf

# Potential Offshore Wind Energy Scenarios in California




Siemens turbine, Baltic Sea. *Photo by Walt Musial, NREL 26995*

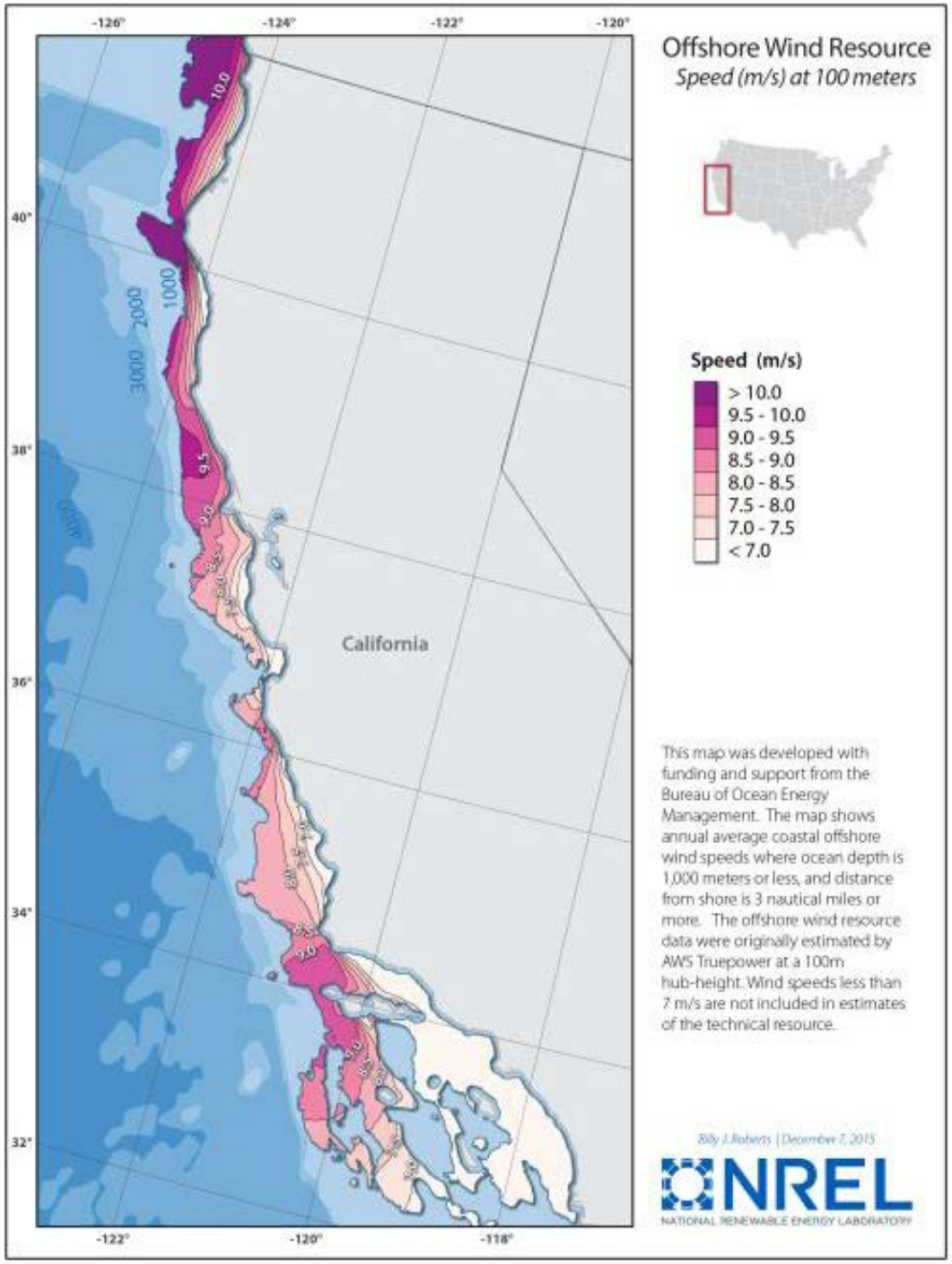
## Potential Offshore Wind Project Assumptions:

Projects must take into account coexistence with other uses for the same area, such as:

- Fishing
- Protected areas
- Endangered species
- Species of concern
- Military uses
- Cultural significance
- Tourism
- Others.

And must obtain all necessary approvals, including:

- Grid interconnection
- Environmental
- Federal and state agency
- Others.



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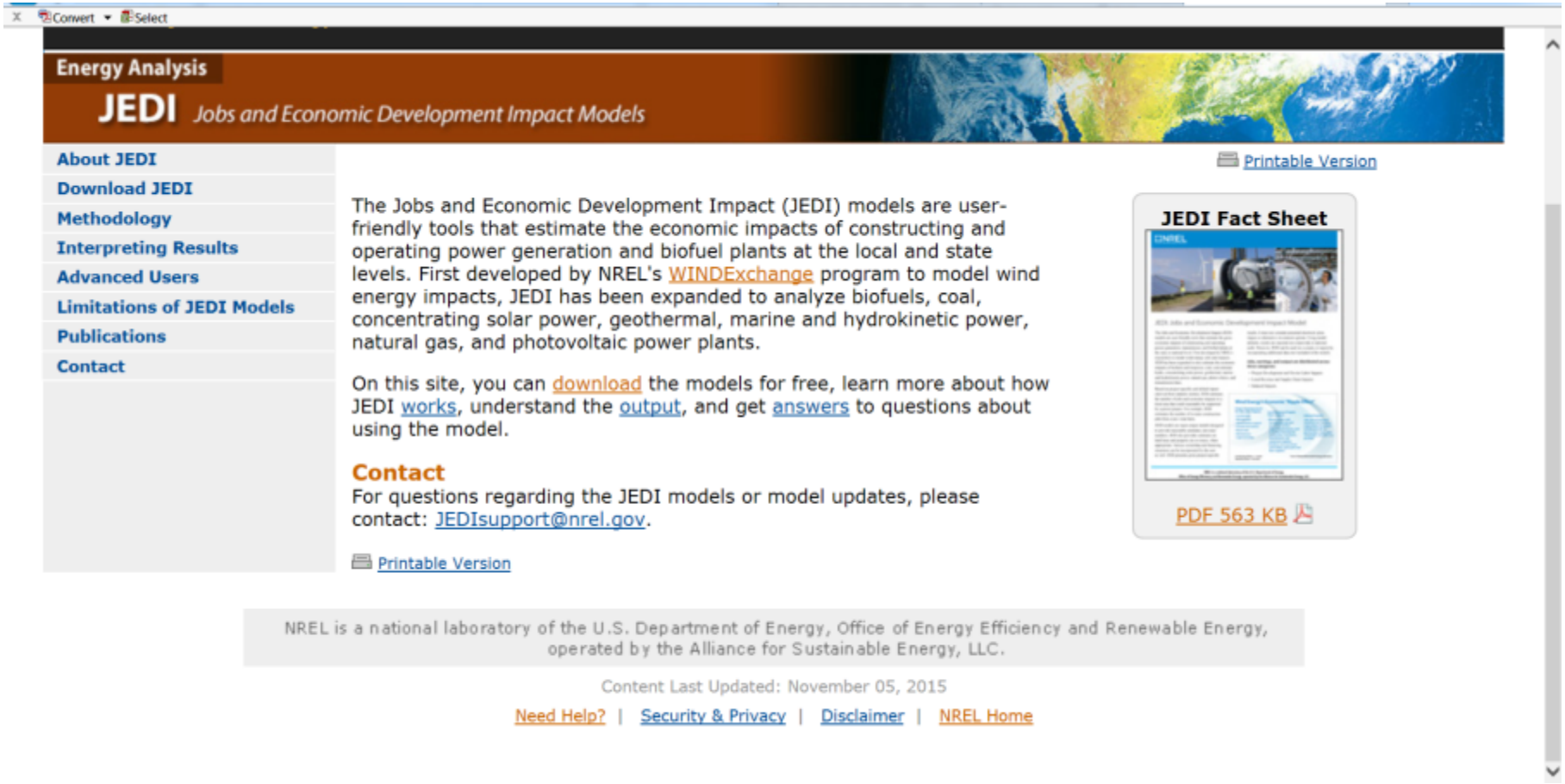
# The Jobs and Economic Development Impact Model

# Jobs and Economic Development Impacts




www.nrel.gov/analysis/jedi

# Many JEDI Models Available

JEDI Wind Energy Models
- JEDI Distributed Wind Model rel. DW6.2.15. (Excel 807 KB)
- JEDI Land-Based Wind Model rel. W07.08.15. (Excel 388 KB)
- JEDI Offshore Wind Model rel. OSW6.19.15. (Excel 4.2 MB)

JEDI Biofuels Models
- JEDI Biopower Model rel. B3.17.15. (Excel 409 KB)
- JEDI Cellulosic Model rel. C10.06.14. (Excel 432 KB)
- JEDI Corn Ethanol Model rel. CE10.06.14. (Excel 423 KB)
- JEDI Fast Pyrolysis Model rel.BFP02.17.15. (Excel 3.5 MB)

JEDI Solar Models
- JEDI CSP Trough Model rel. CSP3.24.14. (Excel 402 KB)
- JEDI Project PV Model rel PV3.24.14. (Excel 518 KB)

JEDI Natural Gas Model
- JEDI NGas Model rel. NG10.14.14. (Excel 352 KB)

JEDI Coal Model
- JEDI Coal Model rel. C10.13.14. (Excel 341 KB)

JEDI Water Power Models
- JEDI Hydropower Model rel.CH11.03.14. (Excel 436 KB)
- JEDI Marine Hydrokinetic Model rel.MH10.06.14. (Excel 414 KB)

JEDI Geothermal Model
- JEDI Geothermal Model rel. GT11.03.14. (Excel 1023 KB)

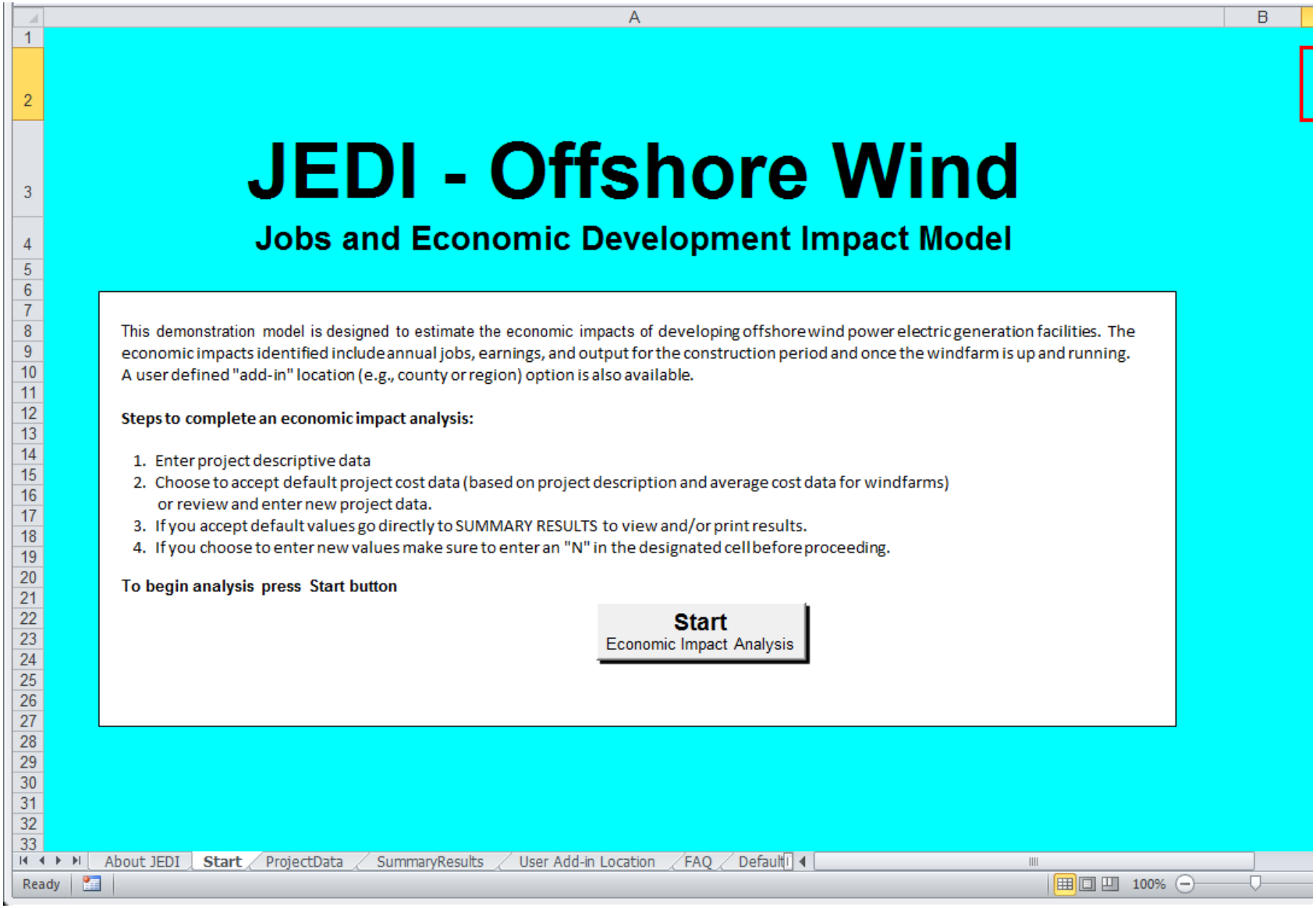
JEDI Petroleum Model
- JEDI Petroleum Model rel. P11.04.14. (Excel 4.3 MB)

JEDI Transmission Line Model
- JEDI Transmission Line Model rel. TL11.03.14. (Excel 461 KB)

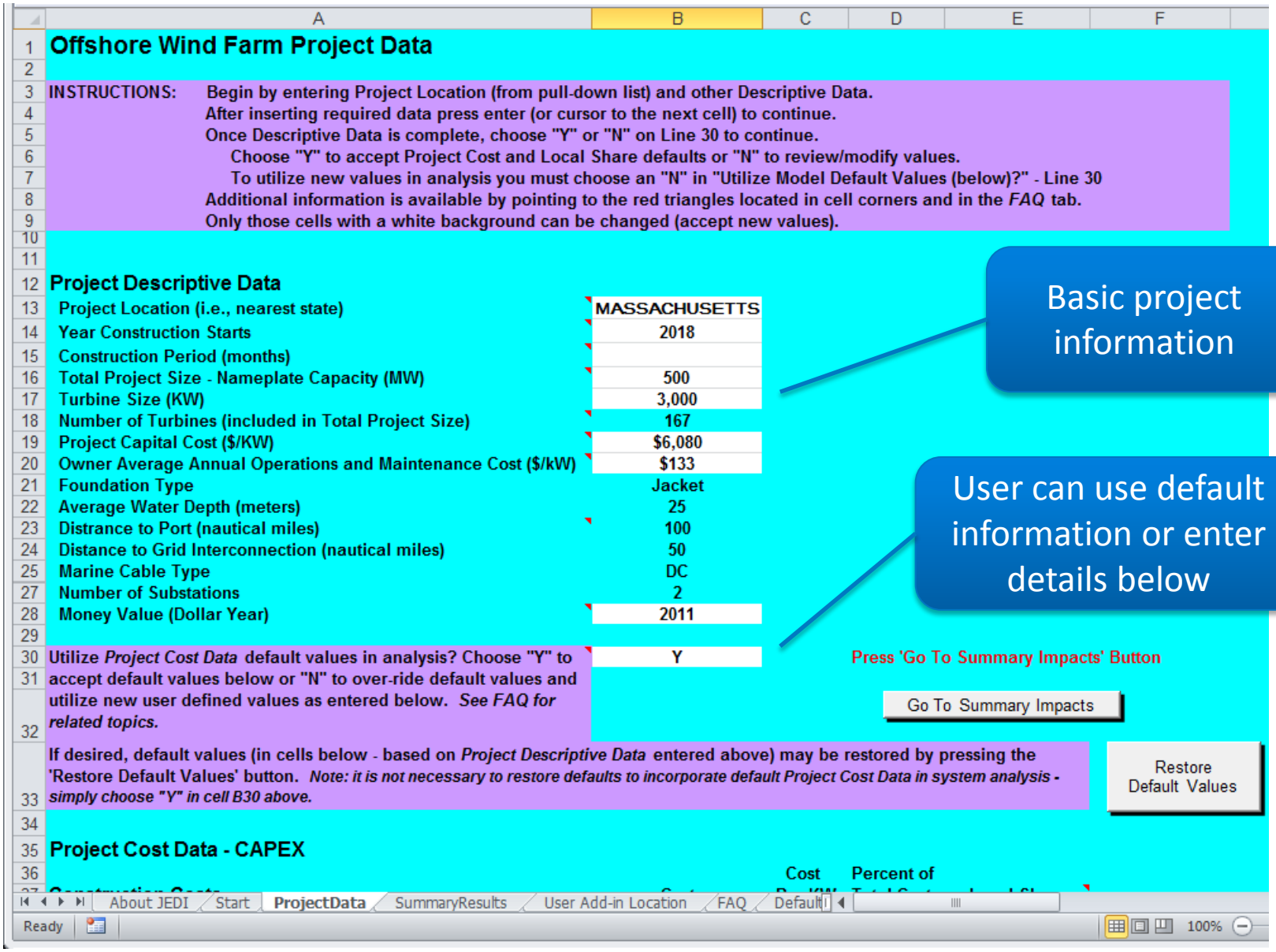
JEDI International (Others available)
- JEDI Intl Zambia 040815 Public. (Excel 337 KB)

*Photo from Siemens AG, NREL 27880*

# The JEDI Model



# Project Scenario



## Offshore Wind Farm Project Data

INSTRUCTIONS: Begin by entering Project Location (from pull-down list) and other Descriptive Data.
After inserting required data press enter (or cursor to the next cell) to continue.
Once Descriptive Data is complete, choose "Y" or "N" on Line 30 to continue.
Choose "Y" to accept Project Cost and Local Share defaults or "N" to review/modify values.
To utilize new values in analysis you must choose an "N" in "Utilize Model Default Values (below)?" - Line 30
Additional information is available by pointing to the red triangles located in cell corners and in the *FAQ* tab.
Only those cells with a white background can be changed (accept new values).

### Project Descriptive Data

| | |
|---|---|
| Project Location (i.e., nearest state) | MASSACHUSETTS |
| Year Construction Starts | 2018 |
| Construction Period (months) | |
| Total Project Size - Nameplate Capacity (MW) | 500 |
| Turbine Size (KW) | 3,000 |
| Number of Turbines (included in Total Project Size) | 167 |
| Project Capital Cost ($/KW) | $6,080 |
| Owner Average Annual Operations and Maintenance Cost ($/kW) | $133 |
| Foundation Type | Jacket |
| Average Water Depth (meters) | 25 |
| Distrance to Port (nautical miles) | 100 |
| Distance to Grid Interconnection (nautical miles) | 50 |
| Marine Cable Type | DC |
| Number of Substations | 2 |
| Money Value (Dollar Year) | 2011 |

Utilize *Project Cost Data* default values in analysis? Choose "Y" to accept default values below or "N" to over-ride default values and utilize new user defined values as entered below. *See FAQ for related topics.* — Y

Press 'Go To Summary Impacts' Button

Go To Summary Impacts

If desired, default values (in cells below - based on *Project Descriptive Data* entered above) may be restored by pressing the 'Restore Default Values' button. *Note: it is not necessary to restore defaults to incorporate default Project Cost Data in system analysis - simply choose "Y" in cell B30 above.*

Restore Default Values

### Project Cost Data - CAPEX

Cost Percent of

About JEDI | Start | ProjectData | SummaryResults | User Add-in Location | FAQ | Default

Ready 100%

Basic project information

User can use default information or enter details below

# Detailed Costs

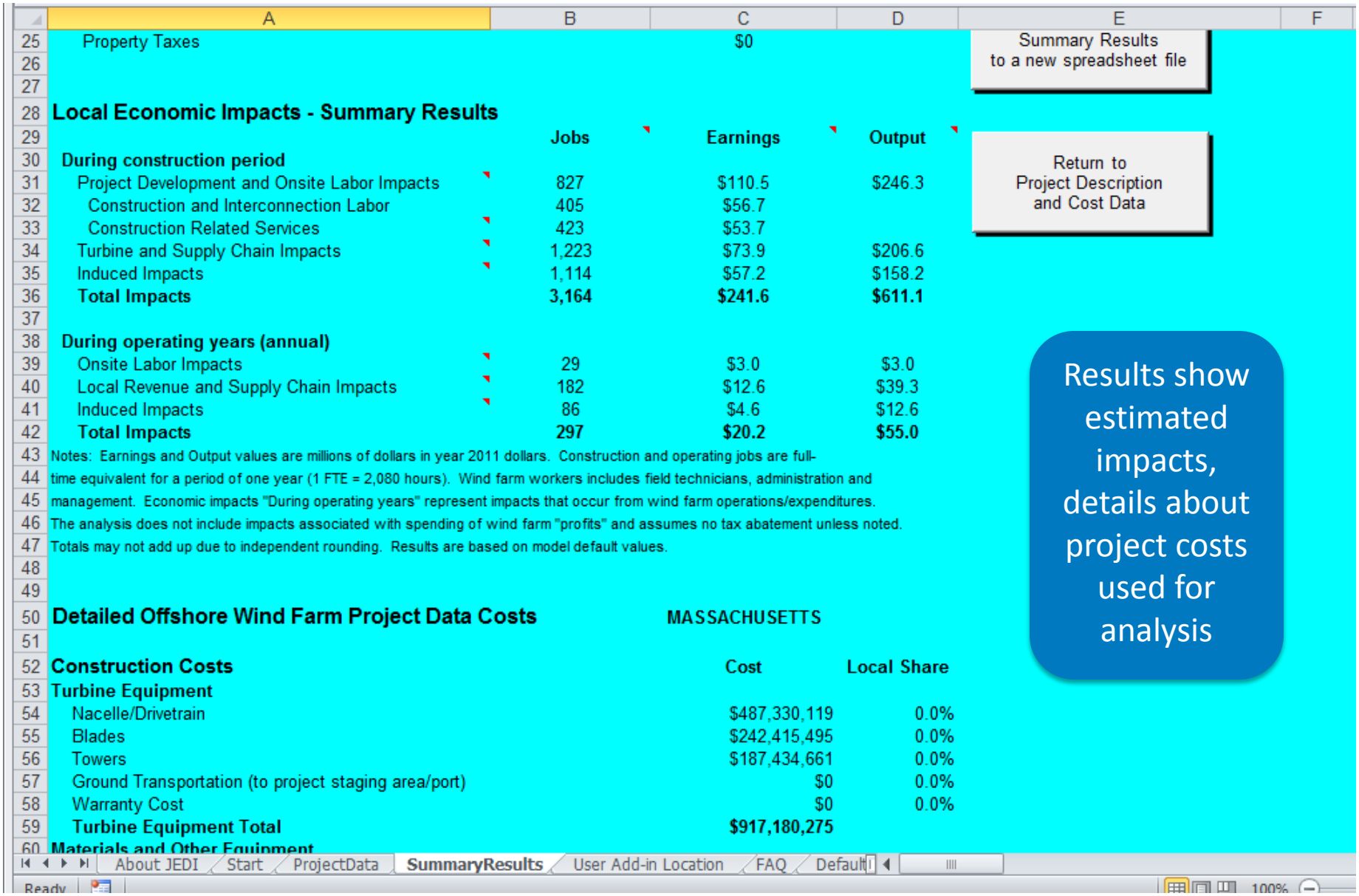
| | A | B | C | D | E |
|---|---|---|---|---|---|
| 37 | **Construction Costs** | **Cost** | **Per KW** | **Total Cost** | **Local Share** |
| 38 | **Turbine Equipment** | | | | |
| 39 | Nacelle/Drivetrain | $487,330,119 | $975 | 15.7% | 0% |
| 40 | Blades | $242,415,495 | $485 | 7.8% | 0% |
| 41 | Towers | $187,434,661 | $375 | 6.0% | 0% |
| 42 | Ground Transportation (to project staging area/port) | $0 | $0 | 0.0% | 0% |
| 43 | Warranty Cost | $0 | $0 | 0.0% | 0% |
| 44 | Turbine Equipment Total | $917,180,275 | $1,834 | 29.5% | |
| 45 | **Materials and Other Equipment** | | | | |
| 46 | Basic Construction (concrete, rebar, gravel, etc.) | $4,498,431 | $9 | 0.1% | 100% |
| 47 | Foundation (including alternatives for different types) | $86,769,751 | $174 | 2.8% | 5% |
| 48 | Substructure (including alternatives for different types) | $58,179,718 | $116 | 1.9% | 0% |
| 49 | Project Collection System | $78,462,648 | $157 | 2.5% | 0% |
| 50 | HV Cable (project site to point of grid interconnection) | $133,953,304 | $268 | 4.3% | 0% |
| 51 | Converter Stations (for DC line to land) | $199,930,305 | $400 | 6.4% | 5% |
| 52 | Substation (including transportation) | $131,204,264 | $262 | 4.2% | 5% |
| 53 | Materials and Other Equipment Total | $692,998,420 | $1,386 | 22.3% | |
| 54 | **Labor Installation** | | | | |
| 55 | Foundation | $326,972,640 | $654 | 10.5% | 0% |
| 56 | Substructure | $183,922,110 | $368 | 5.9% | 0% |
| 60 | Management/Supervision | $8,500,000 | $17 | 0.3% | 100% |
| 61 | Labor Installation Total | $519,394,750 | $1,039 | 16.7% | |
| 62 | **Insurance During Construction** | | | | |
| 63 | CAR/Third Party liability/business interuption, etc. | $66,976,653 | $134 | 2.2% | 0% |
| 64 | **Development Services/Other** | | | | |
| 65 | Engineering | $14,994,773 | $30 | 0.5% | 100% |
| 66 | Legal Services | $2,998,956 | $6 | 0.1% | 100% |
| 67 | Public Relations | $899,687 | $2 | 0.0% | 100% |
| 68 | Ports and Staging | $124,956,442 | $250 | 4.0% | 100% |
| 69 | Site Certificate/Permitting | $9,996,516 | $20 | 0.3% | 100% |
| 70 | Air Transportation (personnel or materials) | $8,187,145 | $16 | 0.3% | 100% |
| 71 | Marine Transportation (personnel or materials) | $21,557,736 | $43 | 0.7% | 100% |
| 72 | Erection/Installation (equipment services) | $189,165,657 | $378 | 6.1% | 25% |
| 73 | Decomissioning Bonding | $99,965,152 | $200 | 3.2% | 0% |
| 74 | Development Services/Other Total | $472,722,064 | $945 | 15.2% | |

About JEDI | Start | **ProjectData** | SummaryResults | User Add-in Location | FAQ | Default

Ready

User specifies cost, portion procured or produced within the region of analysis

# Results



| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 25 | Property Taxes | | $0 | | Summary Results to a new spreadsheet file | |
| 26 | | | | | | |
| 27 | | | | | | |
| 28 | **Local Economic Impacts - Summary Results** | | | | | |
| 29 | | **Jobs** | **Earnings** | **Output** | Return to Project Description and Cost Data | |
| 30 | **During construction period** | | | | | |
| 31 | Project Development and Onsite Labor Impacts | 827 | $110.5 | $246.3 | | |
| 32 | Construction and Interconnection Labor | 405 | $56.7 | | | |
| 33 | Construction Related Services | 423 | $53.7 | | | |
| 34 | Turbine and Supply Chain Impacts | 1,223 | $73.9 | $206.6 | | |
| 35 | Induced Impacts | 1,114 | $57.2 | $158.2 | | |
| 36 | **Total Impacts** | **3,164** | **$241.6** | **$611.1** | | |
| 37 | | | | | | |
| 38 | **During operating years (annual)** | | | | | |
| 39 | Onsite Labor Impacts | 29 | $3.0 | $3.0 | | |
| 40 | Local Revenue and Supply Chain Impacts | 182 | $12.6 | $39.3 | | |
| 41 | Induced Impacts | 86 | $4.6 | $12.6 | | |
| 42 | **Total Impacts** | **297** | **$20.2** | **$55.0** | | |
| 43 | Notes: Earnings and Output values are millions of dollars in year 2011 dollars. Construction and operating jobs are full- | | | | | |
| 44 | time equivalent for a period of one year (1 FTE = 2,080 hours). Wind farm workers includes field technicians, administration and | | | | | |
| 45 | management. Economic impacts "During operating years" represent impacts that occur from wind farm operations/expenditures. | | | | | |
| 46 | The analysis does not include impacts associated with spending of wind farm "profits" and assumes no tax abatement unless noted. | | | | | |
| 47 | Totals may not add up due to independent rounding. Results are based on model default values. | | | | | |
| 48 | | | | | | |
| 49 | | | | | | |
| 50 | **Detailed Offshore Wind Farm Project Data Costs** | | MASSACHUSETTS | | | |
| 51 | | | | | | |
| 52 | **Construction Costs** | | **Cost** | **Local Share** | | |
| 53 | **Turbine Equipment** | | | | | |
| 54 | Nacelle/Drivetrain | | $487,330,119 | 0.0% | | |
| 55 | Blades | | $242,415,495 | 0.0% | | |
| 56 | Towers | | $187,434,661 | 0.0% | | |
| 57 | Ground Transportation (to project staging area/port) | | $0 | 0.0% | | |
| 58 | Warranty Cost | | $0 | 0.0% | | |
| 59 | **Turbine Equipment Total** | | **$917,180,275** | | | |
| 60 | **Materials and Other Equipment** | | | | | |

About JEDI | Start | ProjectData | SummaryResults | User Add-in Location | FAQ | Default

Ready

Results show estimated impacts, details about project costs used for analysis

# JEDI Ripple Effect and Sample Jobs

## Wind energy's economic "ripple effect"

### *Project Development & On-site Labor Impacts*

- Construction workers
- Cement truck drivers
- Vessel operators
- Maintenance workers
- Legal and siting
- Management
- Administrative support

### *Local Revenue, Turbine, & Supply Chain Impacts*

- Blades, towers, gearboxes
  - Platforms, crane & truck operators, gas and gas station workers;
  - Supporting businesses, such as bankers financing the construction, contractors, manufacturers, and equipment suppliers;
  - Utilities;
- Hardware store purchases and workers, spare parts and their suppliers

### *Induced Impacts*

Jobs and earnings that result from the spending supported by the project workers, including benefits to grocery store clerks, retail salespeople, and restaurant workers

**Construction Phase = 1-2 years**
**Operational Phase = 20-30 years**

**Source: National Renewable Energy Laboratory**

# Local Revenues, Turbine, Module, and Supply Chain Impacts


Photo by David Parsons, NREL 05204


Photo from iStock 5676592


Photo from Jim Green, NREL 16178

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


Photo from iStock 4088468


Photo from iStock 8433850


Photo from iStock 7792082


Photo from iStock/8384987

# Project Development & Onsite Labor Impacts

**Sample job types**

- Vessel operation
- Siting
- Crane operation, hoisting, rigging
- Truck driving
- Helicopter pilots
- Management, support.

*Photo from Cross Island Farms, NREL/PIX 19923*

*Photo from istock 947687*

*Photo by Soren Kjeldgaard, NREL 27866*

# 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 wages paid, including: *hotels, sandwich shops, grocery stores, clothing, child care, other retail, public transit, cars, restaurants, and medical services.*

Photo from iStock 3275965

Photo from iStock 8007815

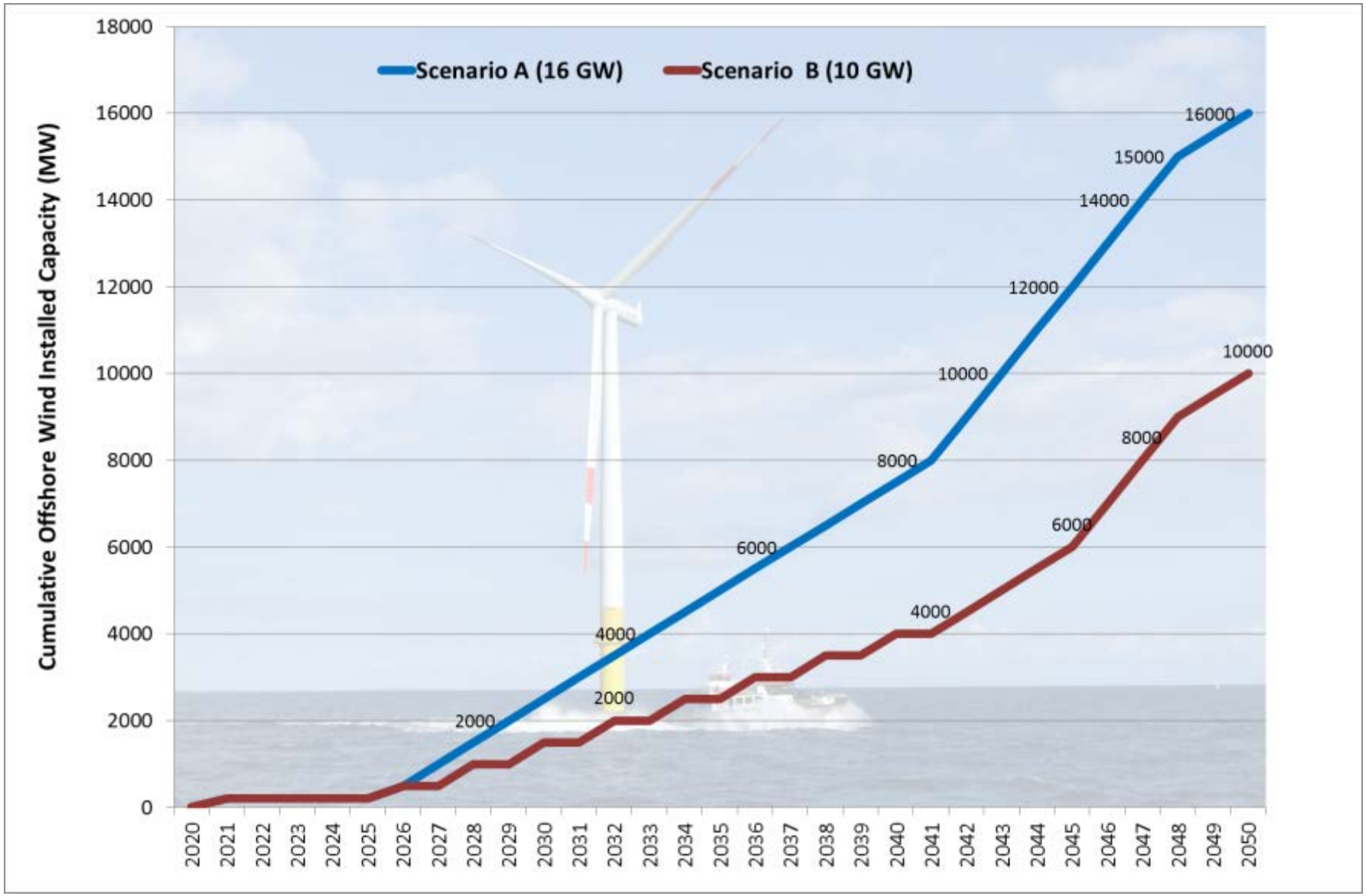
NREL Image Gallery 11598-C

# JEDI Phases

Results presented over two phases:

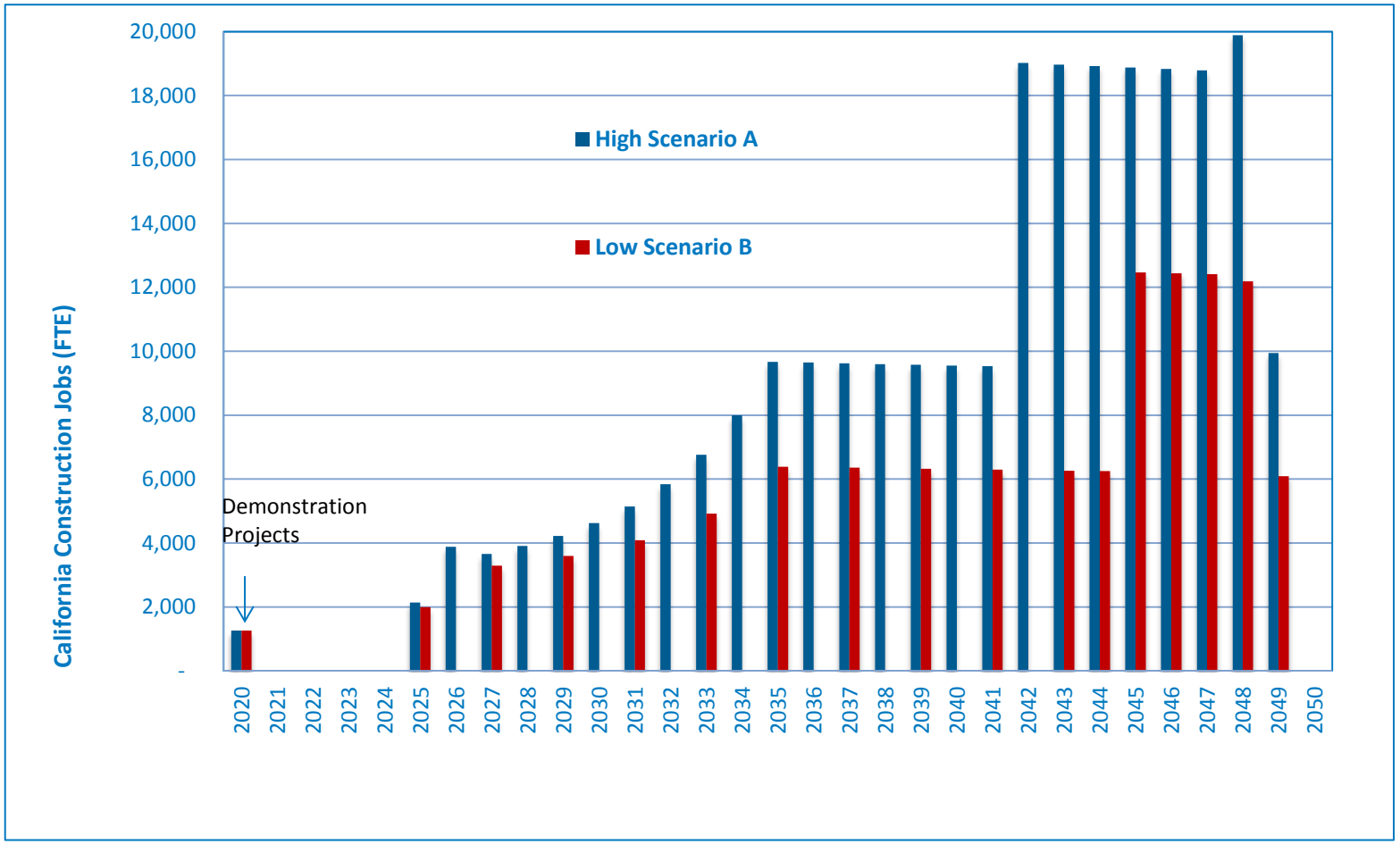
- Construction
  - Result is calculated over construction period, regardless of how long it takes to build the project
  - Example: JEDI reports an impact of 600 jobs – this is an annual average of 300 if it takes 2 years to build the project
- Operating
  - Annual, ongoing results
  - Example: JEDI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

# California JEDI Scenarios



# California Jobs Supported by Offshore Wind Scenarios

## Jobs during Construction Years

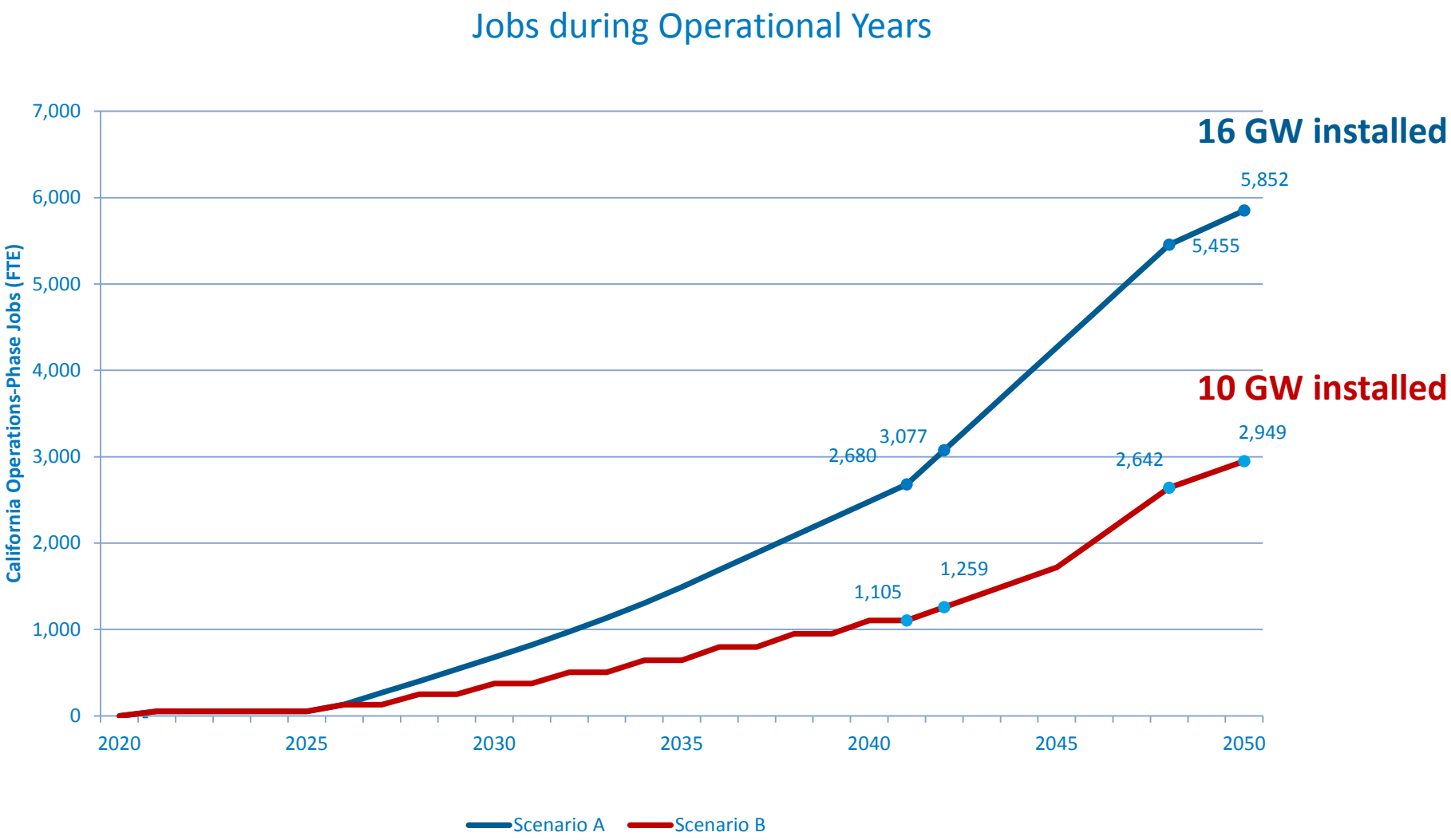


# Assumptions for In-State Equipment and Labor

## During Construction

| Construction Costs | California Share | | |
|---|---|---|---|
| **Construction Expenditure Items** | **Year 0** | **Scenario A** | **Scenario B** |
| **Turbine Equipment** | | | |
| Nacelle/Drivetrain | 0% | 50% | 25% |
| Blades | 0% | 100% | 50% |
| Towers | 0% | 100% | 100% |
| **Materials and Other Equipment** | | | |
| Basic construction (concrete, rebar, gravel, mooring lines, etc.) | 60% | 80% | 70% |
| Foundation (including anchors or alternatives for fixed-bottom types only) | 10% | 65% | 30% |
| Substructure | 0% | 55% | 25% |
| Project collection system | 0% | 0% | 0% |
| HV cable (project site to point of grid interconnection) | 5% | 30% | 15% |
| Onshore substation | 5% | 45% | 30% |
| Offshore substation | 5% | 40% | 25% |
| **Labor Installation** | | | |
| Foundation | 5% | 65% | 30% |
| Substructure | 5% | 65% | 30% |
| Erection/Installation | 5% | 65% | 30% |
| Project collection | 5% | 65% | 30% |
| Grid interconnection (including substation) | 5% | 65% | 30% |

# California Jobs Supported by Offshore Wind Scenarios



# Assumptions for In-State Equipment and Labor – O&M

| Annual Operating and Maintenance Costs | California Share | | |
|---|---|---|---|
| **Operational Costs** | **Year 0** | **Scenario A** | **Scenario B** |
| **Labor** | | | |
| Technician salaries | 50% | 100% | 100% |
| Monitoring and daily operation staff and other craft labor | 50% | 75% | 50% |
| Administrative | 100% | 100% | 100% |
| Management/Supervision | 10% | 100% | 90% |
| **Materials and Services** | | | |
| Water transport | 20% | 75% | 50% |
| Site facilities | 100% | 100% | 100% |
| Machinery and equipment | 5% | 25% | 10% |
| Subcontractors | 1% | 25% | 10% |
| Corrective maintenance parts | 5% | 25% | 10% |

*Photo by Senu Sirnivas, NREL 27853*

# Potential California Earnings from Offshore Wind

## Average Annual Earnings of Onsite, Supply Chain, and Induced Workers ($ 2014)

| | Scenario A | Scenario B |
|---|---|---|
| **Onsite** | $130,422 | $139,725 |
| **Supply Chain** | $81,593 | $79,452 |
| **Induced** | $55,389 | $55,209 |

*Photo from Zachary Finucane, NREL 27999*


*Photo from Zachary Finucane, NREL 16718*

# Learning from Block Island

- Engage with local stakeholders early in the process
  - SeaPlan Report (http://www.seaplan.org/wp-content/uploads/Addressing-Interactions-between-Fisheries-and-Offshore-Wind-Development-BIWF-May-2016.pdf)

- Hire local workers

## Good Jobs

All told, more than 300 local workers were involved with building the Block Island Wind Farm. Deepwater Wind used four Rhode Island ports – at Block Island, Galilee, Quonset Point and ProvPort – to complete construction and staging.

*Photo by Dennis Schroeder, NREL 40398*

From http://dwwind.com/project/block-island-wind-farm/

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For more than 35 years, NREL has delivered innovation impact enabling the emergence of the U.S. clean energy industry.

Deepwater Wind Farm 3 miles off Block Island as seen from shore
*Photo by Dennis Schroeder, NREL 40475*

Thank you

Suzanne Tegen, NREL

Suzanne.Tegen@nrel.gov

Block Island, Rhode Island. *Photo from Dennis Schroeder, NREL 40389*

# Technology Assumptions for Present and Future Offshore Wind Turbines (Musial, NREL)

| | 2015 Technology | 2020 Technology | 2025 Technology |
|---|---|---|---|
| Turbine Rated Power (MW) | 6 | 8 | 10 |
| Turbine Rotor Diameter (m) | 155 | 180 | 205 |
| Turbine Hub Height (m) | 100 | 112 | 125 |
| Turbine Specific Power ($W/m^2$) | 318 | 314 | 303 |
| Substructure Technology | Floating | Floating | Floating |

- Turbine size is expected to increase – trend shows lower cost with size
- Impact of technology innovation based on DELPHOS tool assumptions for fixed bottom systems out to 2025
- NREL floating model estimated impact of innovations out to 2030.

Beiter, P., W. Musial, A. Smith, L. Kilcher, R. Damiani, M. Maness, S. Sirnivas, T. Stehly, V. Gevorgian, M. Mooney, G. Scott. 2016. A Spatial-Economic Cost-Reduction Pathway Analysis for U.S. Offshore Wind Energy Development from 2015-2030. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-66579 http://www.nrel.gov/docs/fy16osti/66579.pdf