Handout 2: Renewable Resources in the 2016 IRP

This handout consists of a summary table that provides the DNV GL technical and financial parameters for renewable resources considered in the 2016 IRP.

The complete DNV GL report is available in the 2016 IRP document as Appendix M.

Contact Us:
Portland General Electric
Integrated Resource Planning
121 SW Salmon Street
Portland, OR 97204
(503) 464-7312
irp@pgn.com

DNV·GL

Portland General Electric's 2016 IRP Parameters

	Metric	Units	Offshore Wind 30 aMW: Coos Bay, Oregon	Wind 116 aMW: Ione, Oregon	Wind 100 aMW: Montana East of Rockies Along Colstrip Line	Solar PV 25 aMW Fixed Tilt: Christmas Valley, Oregon	Solar PV 25 aMW Single Axis Tracking: Christmas Valley, Oregon
Technical Parameters	Capacity: MW	MW	72	338	236	115	103
	Capacity factor	%	42%	34%	42%	21.70%	24.20%
	Power curve	-	MHI Vestas V164-8.0MW	GE 2.0-116	GE 2.0-116	*N/A*	*N/A*
	Expected forced outage rate	%	2.5%	1%	1%	1%	1%
	Panel efficiency if applicable	%	*N/A*	*N/A*	*N/A*	15.5% - 16%	15.5% - 16%
	Inverter efficiency if applicable	%	*N/A*	*N/A*	*N/A*	98% - 99%	98% - 99%
	Maintenance cycle and average maintenance days	-	Once every 12 months, 4 days per turbine	Semi-annual, 60-80 hours per turbine	Semi-annual, 60-80 hours per turbine	3 days per year plus quarterly maintenance (at night)	3 days per year plus quarterly maintenance (at night)
	Approximate footprint	Acres/MW	30-40	80	80	5	7
	Construction period, once permitted	months	18-24	10	9	6-8	6-8
Financial Parameters	Total overnight capital cost, including EPC and owner's costs	$M	$504M ($7M/MW)	$558M ($1.68M/MW)	$401M ($1.70M/MW)	$206M ($1.79M/MW)	$204M ($1.98M/MW)
	Standard deviation from average total overnight capital cost	$M	Expected range: $5M-$8M/MW	Std dev: $0.350M/MW	Std dev: $0.350M/MW	Expected range: $1.7M-$ 1.9M/MW	Expected range: $1.9M-$-2.1M/MW
	Escalation rate for capital costs over next 20 years, if different from inflation		See Capex maturity tab	See Capex maturity tab	See Capex maturity tab	See Capex maturity tab	See Capex maturity tab
	Fixed O&M	$/MW/yr	$165,000	$45,000	$45,000	$9,900	$10,000
	Breakdown of fixed O&M costs including, but not limited to, service contracts and warranty costs, royalty payments, and labor	$/MW/yr	Vessels: 53,000/MW Parts: $11,000/MW Labor: $22,000/MW Onshore support: $22,000/MW BOP O&M: 3,000/MW Insurance: $16,000/MW Lease payments: $28,000/MW Other: 10,000/MW	Scheduled Turbine O&M: $17,000 /MW BOP O&M: $3,000-5,000 /MW Utilities: $1,000 /MW Project Mgmt Admin: $3,000 /MW Gen Charges: $1,500 /MW Land Lease: $5,500 /MW Insurance: $3,000 /MW Property Taxes: $5,500 /MW Professional Advisory: $3,000/MW Other G&A: $1,500/MW	Scheduled Turbine O&M: $17,000 /MW BOP O&M: $3,000-5,000 /MW Utilities: $1,000 /MW Project Mgmt Admin: $3,000 /MW Gen Charges: $1,500 /MW Land Lease: $5,500 /MW Insurance: $3,000 /MW Property Taxes: $5,500 /MW Professional Advisory: $3,000/MW Other G&A: $1,500/MW	Module cleaning: $5,000-6,500/MW; Other: $3,400-4,900/MW	Module cleaning: $5,000-6,500/MW; Other: $3,500-5,000/MW
	Non fuel variable O&M	$/MW/yr	*N/A*	N/A	N/A	N/A	N/A
	Approximate capital drawdown schedule	-	Approx. 15% down, 65% for deliveries to port, 5% for construction, 15% for commissioning (pro rata)	Approx. 20% down, 50% on Ex-works completion (pro rata), 20% on delivery to site, 5% on commissioning, 5% on final completion	Approx. 20% down, 50% on Ex-works completion (pro rata), 20% on delivery to site, 5% on commissioning, 5% on final completion	Approximately: 10% down at start, 80% in monthly progress payments, 10% at substantial completion	Approximately: 10% down at start, 80% in monthly progress payments, 10% at substantial completion
	Ongoing expected Capital Additions or maintenance accrual	$/yr	Included in Fixed O&M (above)	$16,500	$16,500	$2,400	$2,500
	Design life: years	years	25	25	25	30	30
	Decommissioning accrual	$/yr	$1,600,000	$0	$0	$0	$0

Portland General Electric's 2016 IRP Parameters

		Offshore Wind 30 aMW: Coos Bay, Oregon	Wind 116 aMW: Ione, Oregon	Wind 100 aMW: Montana East of Rockies Along Colstrip Line	Solar PV 25 aMW Fixed Tilt: Christmas Valley, Oregon	Solar PV 25 aMW Single Axis Tracking: Christmas Valley, Oregon
Technical Parameters	Capacity: MW	Based on estimated 42% NCF	Based on estimated 34% NCF	Based on estimated 42% NCF	Assumed typical dc/ac ratio of 1.20	Assumed typical dc/ac ratio of 1.20
	Capacity factor	Mean wind speed of approximately 9 m/s, which is based on preliminary mesoscale mapping	Mean wind speed of approximately 6.6 m/s, which is based on extensive wind resource analysis and experience in the region	Mean wind speed of approximately 8.2 m/s, which is based on extensive wind resource analysis and experience in the region	Result given in AC based on DC capacity factor of 18.1% with DC/AC ratio of 1.2. Assumed 30 deg tilt, due south orientation, Normalized by dc capacity, assumed Performance Ratio of 79.5%, solar resource based on experience, includes loss factor for inverter clipping.	Result given in AC based on DC capacity factor of 20.2% with DC/AC ratio of 1.2. Assumed horizontal single axis tracking oriented due south, Normalized by dc capacity, assumed Performance Ratio of 78.6%, solar resource based on regional irradiation data, includes loss factor for inverter clipping.
	Power curve	This is the turbine on which the project design is currently based. See "MHI Vestas V164-8.0MW PC" tab	The GE 2.0-116 turbine was identified as representative of the type of technology typically utilized in projects with this wind regime	The GE 2.0-116 turbine was identified as representative of the type of technology typically utilized in projects with this wind regime	*N/A*	*N/A*
	Expected forced outage rate: %	Standard assumed value; grid availability is excluded.	Standard assumed value; grid availability is excluded.	Standard assumed value; grid availability is excluded.	Standard assumed value; grid availability is excluded.	Standard assumed value; grid availability is excluded.
	Panel efficiency if applicable	*N/A*	*N/A*	*N/A*	Based upon first tier suppliers, 72 cell panels, 290 w - 310 w	Based upon first tier suppliers, 72 cell panels, 290 w - 310 w
	Inverter efficiency if applicable	*N/A*	*N/A*	*N/A*	typical aggregate loss factors. Transformers add an additional 1% loss	typical aggregate loss factors. Transformers add an additional 1% loss
	Maintenance cycle and average maintenance days	Industry standard, this does not include various inspections	Industry standard in US	Industry standard in US	maintenance occurs at night, minimal inverter maintenance	maintenance occurs at night, minimal inverter maintenance
	Approximate footprint: Acres/MW	Based on Block Island, Rampion, and Kentish Flats Extension	Typical in the US	Typical in the US	Standard industry assumption. Trackers need additional area	Standard industry assumption. Trackers need additional area
	Construction period, once permitted	Construction period only, assumes financing is also secured	Based on DNV GL expected durations for construction tasks	Based on DNV GL expected durations for construction tasks	Largely dependent upon EPC Contractor man-loading, and also weather dependent	Largely dependent upon EPC Contractor man-loading, and also weather dependent

Portland General Electric's 2016 IRP Parameters

Financial Parameters	Total overnight capital cost, including EPC and owner's costs	Based on industry expectations for floating offshore wind projects	$1,000/kW turbine, $450/kW EPC, $230/kW development/contingency/etc	$1,000/kW turbine, $470/kW EPC, $230/kW development/contingency/etc	$2.15 per Wp, which includes construction costs and reflects fixed-tilt technologies and the larger utility-scale PV projects that require financing	$2.38 per Wp, which includes construction costs and reflects single axis tracking technologies and the larger utility-scale PV projects that require financing
	Standard deviation from average total overnight capital cost	floating offshore wind assumed to be at the high end of the range	Standard deviation is high due to limited availability of recent data of similar projects in this region	Standard deviation is high due to limited availability of recent data of similar projects in this region	A cost range of $2.00 - $ 2.30 per Wp is expected for fixed-tilt projects. This is considered to represent the range of typical projects in the Pacific Northwest; it does not capture the extremes of the possible range.	A cost range of $2.25 - $ 2.50 per Wp is expected for single-axis tracking projects. This is considered to represent the range of typical projects in the Pacific Northwest; it does not capture the extremes of the possible range.
	Escalation rate for capital costs over next 20 years, if different from inflation	Informed by the IEA's Annual Energy Outlook (2013) and by DNV GL's experience with utility-scale project cost trends	Informed by the IEA's Annual Energy Outlook (2013) and by DNV GL's experience with utility-scale project cost trends	Informed by the IEA's Annual Energy Outlook (2013) and by DNV GL's experience with utility-scale project cost trends	Informed by the IEA's Annual Energy Outlook (2013) and by DNV GL's experience with utility-scale project cost trends	Informed by the IEA's Annual Energy Outlook (2013) and by DNV GL's experience with utility-scale project cost trends
	Fixed O&M: $/MW-month	See below, averaged over economic lifetime	See below, averaged over economic lifetime	See below, averaged over economic lifetime	See below, averaged over economic lifetime	See below, averaged over economic lifetime
	Breakdown of fixed O&M costs including, but not limited to, service contracts and warranty costs, royalty payments, and labor.	Based on European experience, adjusted for floating project	Based on DNV GL database	Based on DNV GL database	Cleaning: $1500-$2000/MWp; Budget includes: System monitoring, regular visual inspections, preventative maintenance, periodic electrical testing, inventory management, occasional medium voltage and inverter work; on-site staff is typically present for these services on projects larger than 25 MWp.	Cleaning: $1500-$2000/MWp; Budget includes: System monitoring, regular visual inspections, preventative maintenance, periodic electrical testing, inventory management, occasional medium voltage and inverter work; on-site staff is typically present for these services on projects larger than 25 MWp.
	Non fuel variable O&M: $/MWh	No non-fuel variable O&M costs	No non-fuel variable O&M costs	No non-fuel variable O&M costs	No non-fuel variable O&M costs	No non-fuel variable O&M costs
	Approximate capital drawdown schedule	Based on known projects, will depend on contractual responsibilities	Typical for US industry	Typical for US industry	Typical for US industry	Typical for US industry
	Ongoing expected Capital Additions or maintenance accrual: $/yr.	Small project, with likely shared vessel resources, so can not separate scheduled and unscheduled maintenance costs	Based on DNV GL database, 25-year average value, does not include unscheduled BOP maintenance	Based on DNV GL database, 25-year average value, does not include unscheduled BOP maintenance	$2.90 per kWp / yr This is driven by inverter repair/replacement	$3.00 per kWp / yr This is driven by inverter repair/replacement
	Design life: years	project life, Industry standard (design life is 25 years)	project life, Industry standard (design life is 20-25 years)	project life, Industry standard (design life is 20-25 years)	project life, Industry standard (design life is 30 years)	project life, Industry standard (design life is 30 years)
	Decommissioning accrual: $/yr.	7-10% of the capital cost. A bond will be required to accumulate funds.	Decommissioning cost is widely assumed to be offset by salvage value of used components. A bond may be required to accumulate funds, although this is uncommon for onshore wind projects.	Decommissioning cost is widely assumed to be offset by salvage value of used components. A bond may be required to accumulate funds, although this is uncommon for onshore wind projects.	Decommissioning cost is widely assumed to be offset by salvage value of used components. A bond may be required to accumulate funds.	Decommissioning cost is widely assumed to be offset by salvage value of used components. A bond may be required to accumulate funds.