User Guide – Levelized Cost of Energy Calculator

PREDESIGN Phase

Aligns with B3 Guidelines version 3.2r02

Center for Sustainable Building Research
College of Design · University of Minnesota

LCOE Calculator User Guide – Predesign Phase

Part 1 - Using the Levelized Cost of Renewables to Meet State Energy Statutes

Statute 16B.32 Energy Use (2015)

Subd. 1a) "The predesign must include an explicit cost and price analysis of complying with the two-percent requirement compared with the present and future costs of energy supplied by a public utility from a location away from the building site and the present and future costs of controlling carbon emissions."

Levelized Cost of Energy (LCOE) Method

Under this approach, construction projects will be required to install renewable energy on site with output equal to or greater than 2% of total building energy use as stated in B3 Guideline E.2 Renewable Energy when…

wind/solar levelized cost < cost of grid electricity + cost of carbon

levelized cost = (installation cost + financing costs + fuel costs + maintenance costs)/MWh production over service life

where installation cost = an estimate based on system size and research from national installation cost studies, such as Lazard's Levelized Cost of Energy Analysis

financing cost = $0 (usually) for state projects

fuel costs = $0 (usually) for wind/solar projects

maintenance costs = an estimate based on research conducted by Energy Information Administration (EIA) or national research laboratory such as PNNL

MWh production = total electricity production over service life (from installer estimate)

service life = 20 - 25 years depending on system type

and cost of grid electricity = time-weighted average price from utility + fees and surcharges

cost of carbon = currently set at $37/metric ton (U.S. technical estimate 2013)

Example Calculation - PV Installation

Levelized Cost of Energy (LCOE) calculation for PV installation

Assume installation cost = $120/MWh (first cost/lifetime MWh)

financing cost = $0

fuel cost = $0

maintenance cost = $11.08/MWh (average from Lazard's LCOE Analysis v.14, 2020)

LCOE PV = $120 + $0 + $0 + $11.08 = $131.08/MWh = **$0.131/kWh**

Cost of grid electricity calculation

Assume bare electric rate = $0.080/kWh

Fees + surcharges = $0.030/kWh

Cost of carbon = $0.017/kWh (note: based on $37/metric ton and 1.1 x current emission rate of 0.937 lbs CO_2/kWh for MN average, EIA 2019)

Cost of grid electricity = $0.080 + $0.030 + $0.016 = **$0.126/kWh**

In this example, a PV system with output equal to or greater than 2% of the building's predicted total energy use would not be required.

Part 2 – Using the LCOE Calculator Tool

Two options must be investigated using the calculator to achieve compliance with E.2 Renewable Energy: a solar photovoltaic (PV) option, and either a solar hot water or small wind option. Each of these three technologies has its own tab in the calculator tool. Note that ground source (geothermal) heat pumps, air source heat pumps, and passive solar energy may be desirable for the project, but do not qualify to meet the requirements of E.2.

The predesign phase LCOE calculator requires a small number of inputs to perform the levelized cost of energy calculation. These inputs typically include the required yearly energy production (>/= 2% of predicted total building energy use as determined by the SB2030 Energy Standard Tool) and the yearly average fuel/electricity costs at the site (including any demand charges, delivery charges, surcharges, and fees). All other necessary inputs are generally either provided as defaults or assumptions built into the calculation cells. Input cells with default values should not be adjusted unless there is reason to adjust them. Calculation cells are locked so users cannot adjust them.

When the levelized cost of renewable energy is less than the cost of utility-delivered energy including the social cost of carbon, the calculator will indicate "yes" in the bottom-most cell, and the requirement to install renewable energy is met. In that case, project teams will be required to obtain an estimate from an installer and revisit this credit with the more accurate pricing information during the design phase.

PV Tab Guidance and References

Cell C8	Default value based on conservative estimate from NREL research, accessed 6/2016 - http://www.nrel.gov/analysis/tech_footprint.html
Cell C9	This value should be >/= 2% of the building's total annual energy use as calculated by the SB2030 Energy Standard Tool (E.1.c), **converted to kWh**, in compliance with Credit E.2a
Cell C10	Calculated result
Cell C11	Calculated result
Cell C13	Default value based on size of the PV system. The value is calculated using the lower bounds for national PV installation costs as reported in Lazard's Levelized Cost of Energy Analysis v.14, 2020.
Cell C14	If not $0, add total financing costs over life of project and divide by lifetime energy production (MWh)
Cell C15	This value should be $0 for PV projects.
Cell C16	Default value $11.08, average from Lazard's Levelized Cost of Energy Analysis v.14
Cell C18	**Renewable Energy Total Cost/kWh** - Compare this result with Total Cost/kWh of Utility-Delivered Energy
Cell C22	This cost should reflect a time-weighted average if prices vary by month
Cell C23	This cost should include all other fees and surcharges based on kWh use
Cell C24	Assuming CO2 emission rate of 0.937 lbs CO2/kWh of electricity (from EIA Minnesota Electricity Profile, 2019). $37/metric ton is the "central" social cost of carbon value calculated by the US federal government in 2015. (Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact

	Analysis, Interagency Working Group on Social Cost of Carbon, United States Government, May 2013)
Cell C26	**Utility-Delivered Energy Total Cost/kWh** - Compare this result with Total Cost/kWh of Renewable Energy
Cell C29	Final result

SHW Tab Guidance and References

Cell C8	If the conventional water heating equipment will be natural gas-fired, enter the cost of natural gas in C8 ($/therm). Only one cell from C8, C9, C10 should be entered. Natural gas costs should include all fees, delivery charges, and surcharges. They should reflect a time-weighted average if prices vary by month.
Cell C9	If the conventional water heating equipment will be propane-fired, enter the cost of propane in C9 ($/gallon). Only one cell from C6, C7, C8 should be entered. Propane costs should include all fees, delivery charges, and surcharges. They should reflect a time-weighted average if prices vary by month.
Cell C10	If the conventional water heating equipment will be electric, enter the cost of electricity for this equipment in C8 ($/kWh). Only one cell from C6, C7, C8 should be entered. Electricity costs should include all fees, delivery charges, demand charges, and surcharges. They should reflect a time-weighted average if prices vary by month.
Cell C13	Default value based on average value from NREL research, assuming regular maintenance, accessed 6/2016 - http://www.nrel.gov/analysis/tech_footprint.html
Cell C14	This value should be >/= 2% of the building's total annual energy use as calculated by the SB2030 Energy Standard Tool (E.1.c), **converted to MMBtu**, in compliance with Credit E.2a
Cell C15	Calculated result
Cell C16	Calculated result
Cell C18	Calculated result, based on review and research of solar hot water systems installed in Midwest – data from multiple sources
Cell C19	If not $0, add total financing costs over life of project and divide by lifetime energy production (MMBtu)
Cell C20	The value in this cell should not be adjusted unless using PV-powered circulation pumps, in which case enter 0. The default value assumes pump energy use averages 7% of collected energy for differential controlled systems with AC circulation pumps (7% average value from multiple sources).
Cell C21	Default value $12.30/MMBtu from EIA Annual Energy Outlook 2015
Cell C23	**Renewable Energy Total Cost/kBtu** - Compare this result with Total Cost/kBtu of Utility Delivered Energy
Cell C27	This is the combustion efficiency of the water heater. It should not be confused with the water heater's energy factor (EF). Select 80% for a standard efficiency water heater, 90% for a high efficiency (condensing) water heater, and 100% for an electric resistance water heater. (Values from "Boiler System Efficiency" ASHRAE Journal July 2006)

Cell C28	Calculated result including impact of combustion efficiency
Cell C29	Assuming emission rates of 11.79 lbs CO2/therm for natural gas, 12.55 lbs CO2/gallon of propane, 0.937 lbs CO2/kWh of electricity (from EIA Minnesota Electricity Profile, 2019). $37/metric ton is the "central" social cost of carbon value calculated by the US federal government for the year 2015. - Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis, Interagency Working Group on Social Cost of Carbon, United States Government, May 2013
Cell C31	**Utility-Delivered Energy Total Cost/kBtu** - Compare this result with Total Cost/kBtu of Renewable Energy
Cell C34	Final result

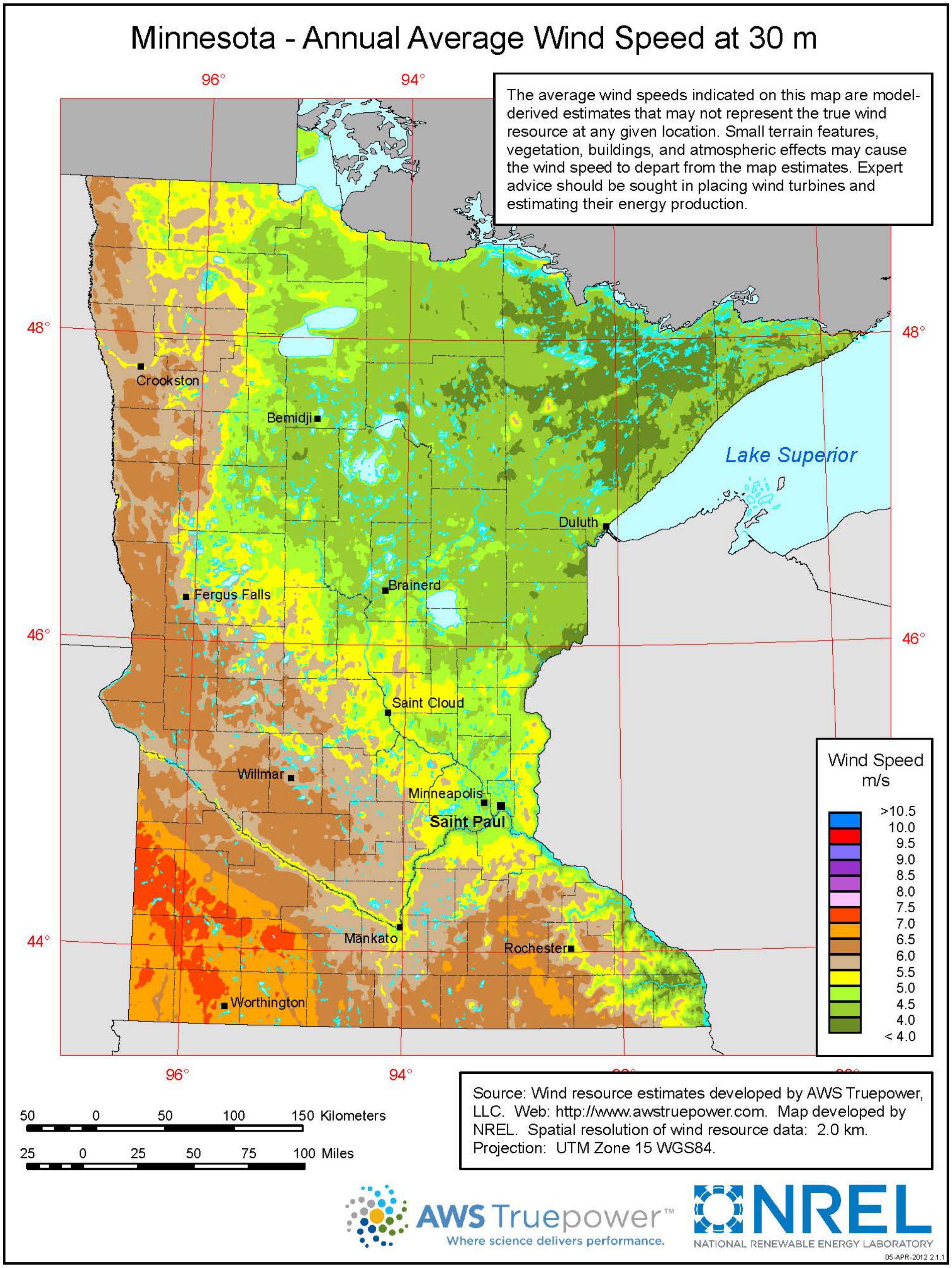
Wind Tab Guidance and References

Please note that this calculator tab is limited to turbines with peak power </= 100kW (ie, “small wind”). Results will not be valid for utility-scale turbines.

Cell C9	Default value based on NREL research for small wind systems, accessed 6/2016 - http://www.nrel.gov/analysis/tech_footprint.html
Cell C10	This value should be >/= 2% of the building's total annual energy use as calculated by the SB2030 Energy Standard Tool (E.1.c), **converted to kWh**, in compliance with Credit E.2a
Cell C11	Calculated result
Cell C12	Locate the project site on the NREL MN wind speed map showing wind speed **on clear sites** at 30m hub height (included on last tab of calculator tool). All wind speed ranges taken from the wind speed map should be rounded down to the nearest bin value (e.g. 6.0 to 6.5 m/s = 6 m/s) for a conservative estimate. Care should be taken to ensure that the selected building site will offer a clear site with minimal obstructions to the wind as well as the space required for the turbine tower and any required setbacks. Consult the turbine siting guidelines and diagrams discussed briefly on the second-to-last tab of the calculator tool.
Cell C13	Selecting 1 turbine will yield the lowest costs. Increasing the number of turbines will increase installation and maintenance costs, but may be necessary in some cases to meet energy production requirements.
Cell C14	Calculated result, note that peak power is not always equal to nameplate capacity of turbine
Cell C15	Calculated result, based on installation costs for distributed wind in "Distributed Wind Market Report, 8/2014, PNNL
Cell C17	Calculated result
Cell C18	If not $0, add total financing costs over life of project and divide by lifetime energy production (MWh)
Cell C19	This value should be $0 for wind projects.
Cell C20	Calculated result, based on O&M costs for distributed wind in "Distributed Wind Market Report, 8/2014, PNNL
Cell C22	**Renewable Energy Total Cost/kWh** - Compare this result with Total Cost/kWh of Utility-Delivered Energy
Cell C26	This cost should reflect a time-weighted average if prices vary by month

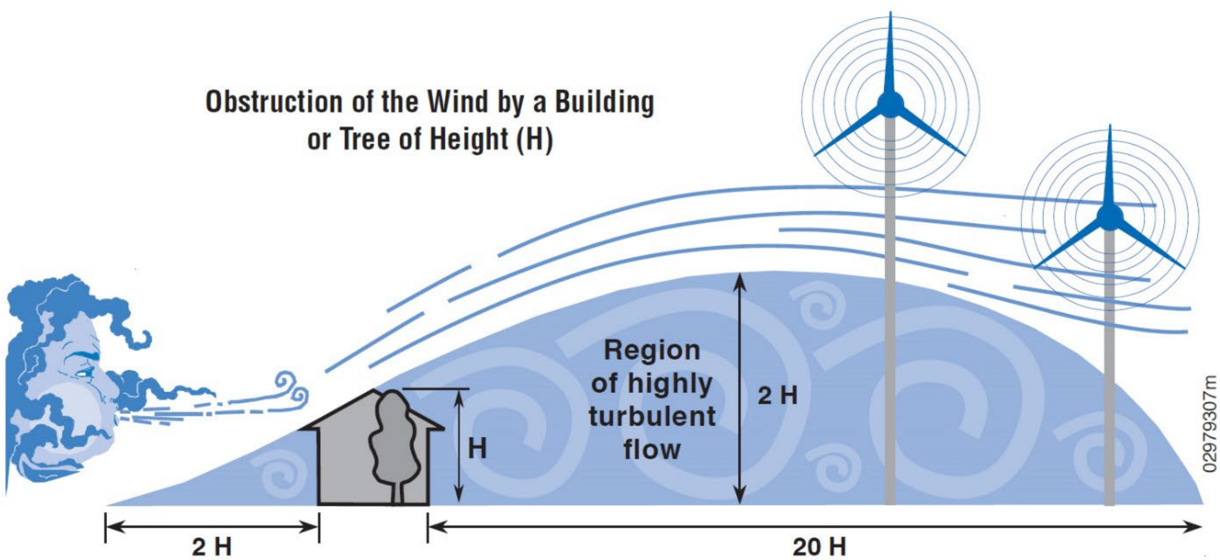
Cell C27	This cost should include all other fees and surcharges based on kWh use
Cell C28	Assuming CO_2 emission rate of 0.937lbs CO_2/kWh of electricity (from EIA Minnesota Electricity Profile, 2019). $37/metric ton is the "central" social cost of carbon value calculated by the US federal government for the year 2015. - Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis, Interagency Working Group on Social Cost of Carbon, United States Government, May 2013
Cell C30	**Utility-Delivered Energy Total Cost/kWh** - Compare this result with Total Cost/kWh of Renewable Energy
Cell C33	Final result

Part 3 – Wind Turbines: Wind speed Map and Site Impacts on Energy Production



The NREL wind speed map provides an estimate of average yearly wind speed at 30 meters off the ground (essentially the tower height) for clear sites. A particular building site may not provide enough open space to install a turbine or may not offer enough clearance from neighboring buildings to meet local turbine setback requirements. In these cases, it may be infeasible to install a wind turbine and a different renewable energy technology should be pursued. Alternatively, a site may have tall obstructions that interrupt prevailing wind flow through the site. In this case, the wind speed estimated on the wind speed map may need to be adjusted downward.

If a turbine cannot be installed outside of the blue zone of turbulence shown in the diagram below for the prevailing wind direction, estimated wind speed should be adjusted downward or another renewable energy technology should be investigated. Installing a turbine in the region of turbulence can impact the life expectancy of a turbine by increasing stress on its components.



Some final guidance on wind turbine siting from NREL "Small Wind Electric Systems, A U.S. Consumer's Guide", 2004.

How Do I Choose the Best Site for My Wind Turbine?

You can have varied wind resources within the same property. In addition to measuring or finding out about the annual wind speeds, you need to know about the prevailing directions of the wind at your site. If you live in complex terrain, take care in selecting the installation site. If you site your wind turbine on the top of or on the windy side of a hill, for example, you will have more access to prevailing winds than in a gully or on the leeward (sheltered) side of a hill on the same property. In addition to geologic formations, you need to consider existing obstacles such as trees, houses, and sheds, and you need to plan for future obstructions such as new buildings or trees that have not reached their full height. You also need enough room to raise and lower the tower for maintenance, and if your tower is guyed, you must allow room for the guy wires.