Emissions Analyses

Koshkonong Solar Energy Center

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Dane County, WI

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Koshkonong Solar

Solar farms are designed and operated with the intention of supporting the environmental and overall health of the regional community. Solar energy is one of the most efficient sources of energy generation with respect to limiting carbon dioxide equivalent emissions, as emissions are primarily produced during the manufacture of panels and not during operation of facilities (**Table 1**)[1 2 3 4 5]. Additionally, substituting fossil fuel sources with renewable sources like solar reduces the release of other harmful emissions including sulfur oxides (SO_x), nitrogen oxides (NO_x), methane (CH_4), particulate matter (PM_{10}) and carbon monoxide (CO), while simultaneously reducing water consumption[1 2 3 4 5].

Table 1: Carbon Dioxide Equivalent Emissions by Generation Source	
Source	**Tons CO_2 Equivalent/megawatt-hour (MWh)**
Coal	0.70 – 1.80
Natural Gas	0.30 – 1.00
Hydroelectric	0.01 – 0.30
Geothermal	0.05 – 0.10
Solar Photovoltaic Mono-Crystalline Silicon*	0.04 – 0.13
Solar Photovoltaic Poly-Crystalline Silicon*	0.02 – 0.09
Concentrated Solar Power*	0.01 – 0.10
Wind*	0.01 – 0.02

*Emissions associated with manufacturing, transportation, and decommissioning[1 2 3 4 5]

According to the U.S. Energy Information Administration[6], the operation of utility and small scale solar energy farms in the U.S. in 2020 (January through December) generated 129,483 gigawatt-hours (GWh) of clean renewable energy. Using the U.S. Environmental Protection Agency's (EPA) Greenhouse Gas Equivalencies Calculator[7], utility-scale solar energy generation prevented more than 91.5 million metric tons of carbon dioxide equivalent from entering the atmosphere from January to December in 2020.

Tables 2 and **3** provide the estimated amount of air pollutant emissions that may be reduced if coal-fired and natural gas-fired generating facilities in Wisconsin were replaced by the anticipated base energy production values of the Project referenced in **Section 2.1.3.2** of the Application for a Certificate of Public Convenience and Necessity (CPCN). The resulting reduction in emissions is due to the fact that the operation of solar generation facilities produces no direct emissions of carbon dioxide or other harmful air pollutants [1 2 3 4 5]. The air

[1] IPCC, 2011: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow (eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1075 pp. (Chapter 3, 4, 5, 7 & 9).

[2] Li, X., Wagner, F., Peng, W., Yang, J., & Mauzerall, D. L. 2017. Reduction of solar photovoltaic resources due to air pollution in China. Proceedings of the National Academy of Sciences, 114(45), 11867-11872. doi: 10.1073/pnas.1711462114

[3] Sims, R. E., Rogner, H., & Gregory, K. 2003. Carbon Emission and Mitigation Cost Comparisons between Fossil Fuel, Nuclear and Renewable Energy Resources for Electricity Generation. Fuel and Energy Abstracts, vol. 45, no. 2, 2003, p. 102., doi:10.1016/s0140-6701(04)93161-x

[4] Fthenakis, V.M., Kim, H. C., & Alsema, E. 2008. Emissions from Photovoltaic Life Cycles. Environmental Science & Technology, 42(6), 2168-2174. doi:10,1021/es071763q

[5] World Nuclear Association. 2011. Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources.

[6] United States Energy Information Administration. February 24, 2021 Table 1.1.A. Net Generation from Renewable Sources: Total (All Sectors), 2010-January 2020.

[7] United States Environmental Protection Agency. Greenhouse Gas Equivalencies Calculator. Accessed March 2021.

emission metrics are based on data compiled from the U.S. Environmental Protection Agency's (EPA) Emissions and Generation Resource Integrated Database (eGRID)[8] and historical air emissions information from the Wisconsin Department of Natural Resources (WDNR)[9] for existing generation facilities in Wisconsin. Both datasets are necessary for the evaluation; individually, each dataset does not provide all emission components desired for the analyses. Emissions data included in the analyses are from 2018, as emissions data for 2019 has not been published by the WDNR at the time of these analyses.

For each emission component listed in **Tables 2** and **3**, the air emissions in tons per MWh were calculated based on recorded 2018 production values for coal and natural gas generation facilities in the Wisconsin. Then, the average production value for each emission component was calculated using the facility-specific values. The averages were then multiplied by the base energy production estimate of the Project (i.e., 600,000 MWh) as described in **Section 2.1.3.2**.

Table 2: Potential Wisconsin Coal-Fired Generation Emissions Reductions[8 9]

Emission Component	Tons per Year	Tons per 30-Year Operation
CO_2	680,844.6	20,425,339.5
NO_x	329.3	9,878.7
SO_2	334.5	10,035.3
$PM_{2.5}$	54.2	1,625.2
ROG (Reactive Organic Gases)	11.9	356.1
CO	201.5	6,044.6
CH_4	73.8	2,215.5
N_2O	10.7	321.6

Table 3: Potential Wisconsin Natural Gas-Fired Generation Emissions Reductions[8 9]

Emission Component	Tons per Year	Tons per 30-Year Operation
CO_2	513,048.4	15,391,452.2
NO_x	1,548.5	46,455.1
SO_2	128.3	3,849.1
$PM_{2.5}$	84.9	2,546.6
ROG (Reactive Organic Gases)	145.1	4,353.4
CO	247.4	7,423.5
CH_4	41.1	1,234.1
N_2O	0.9	27.8

[8] United States Environmental Protection Agency. March 9, 2020. Emissions and Generation Resource Integrated Database (eGRID2018) [xlsx]
[9] Wisconsin Department of Natural Resources. Historical air emission information, 2018 facility emissions by facility [xlsx]. Accessed March 2021.

The EPA's AVoided Emissions and geneRation Tool (AVERT)[10] evaluates how energy policies and programs such as energy efficiency and renewable energy lead to changes in emissions of particulate matter ($PM_{2.5}$), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and carbon dioxide (CO_2) from electric power plants at a county, state, or regional level. AVERT uses 2019 emissions and generation data. The AVERT Tool was used to verify conclusions from the analyses of 2018 EPA and 2018 WDNR emissions data. **Table 4** provides the results of AVERT in the central region using an annual production estimate of 600,000 MWh for Koshkonong Solar. Emissions reductions are estimated at the regional level. Results of the AVERT correspond with estimated emissions reductions discovered during the analyses of 2018 EPA and WDNR emissions data.

Table 4: AVERT Emissions Reductions Results		
Emission Component	**Tons per Year**	**Tons per 30-Year Operation**
CO_2	560,140.0	16,804,200.0
NO_x	426.6	12,799.0
SO_2	400.0	12,000.0
$PM_{2.5}$	26.8	804.9

The EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool[11] was used to quantify potential mortality reductions due to reduced harmful air pollutants in the State of Wisconsin. COBRA, in conjunction with AVERT results, estimates 1 fewer case of premature mortality due to Project emissions reductions compared to the baseline emissions scenario in Wisconsin over the following 20 years. Total health benefits from the Project emissions reductions in the State are estimated between $3,627,690 and $8,182,678, per COBRA data. In addition to the COBRA Tool, the EPA estimates monetized health benefits from clean energy deployment using the Benefits Per-Kilowatt-Hour calculator[12]. The EPA indicated that the Project could yield annual health savings from $15,480,000 to $39,180,000 million.

Replacing fossil fuel energy generation with renewable energy sources has a positive impact on health and wellness in addition to reduced healthcare costs. Studies conducted by the Union of Concerned Scientists[13] determined that the decrease in pollutant emissions from fossil fuels is linked to increased longevity, reduced loss of workdays, and reduced overall healthcare costs. A 2013 study estimated that healthcare costs in the United States related to impacts from fossil fuels ranged between $361 and $886 billion annually[14]. By providing reductions in harmful emissions, utility-scale solar energy development can provide tangible benefits to the region in which it is located.

[10] United States Environmental Protection Agency. Avoided Emissions and geneRation Tool (AVERT). Accessed March 2021.
[11] United States Environmental Protection Agency. June 2020. CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.
[12] United States Environmental Protection Agency. Estimating the Health Benefits per-Kilowatt Hour of Energy Efficiency and Renewable Energy. Accessed March 2021.
[13] Union of Concerned Scientists. 2016. The Hidden Costs of Fossil Fuels.
[14] Machol, B., & Rizk, S. 2013. Economic value of U.S. fossil fuel electricity health impacts. Environment International, 52, 75-80. doi: 10.1016/j.envint.2012.03.003