



Memorandum

To: Jean-Paul La Marche
Development Manager
CleanFocus and Greenskies

Date: December 26, 2019

Project #: 42496.00

From: Steven J. Kochis, PE

Re: 117 Oil Mill Road
Waterford Solar Project, Waterford, CT
Carbon Debt Analysis

VHB provided services to CleanFocus and Greenskies that included performing a carbon debt analysis of the proposed Waterford Solar installation, a ± 16 MW AC solar farm in Waterford, Connecticut (the Project). This analysis was performed assuming the pre-timber harvest period of the Site. The purpose of this analysis was to determine when the Project will have a net improvement in greenhouse gas (GHG) emissions compared to the loss/conversion of ± 75 acres of trees to either gravel/compacted roads or warm season grasses, required to construct and operate the Project. Approximately 148 acres of the 152-acre Project site are forested; proposed tree clearing represents 51 percent of the Project Site's forested areas and 49 percent of the total Project Site. This analysis also accounted for the emissions associated with upstream activities of the solar photovoltaic (PV) system.

Methods

In this analysis VHB used the U.S. Environmental Protection Agency (U.S. EPA) conversion factors to identify the amount of carbon sequestered in one year by one acre of average U.S. forest: 0.85 metric tons (MT) CO₂ and the carbon stock in one acre of average U.S. forest: 76 MT CO₂.¹ There is no cropland conversion in the Project.

To calculate GHG emissions associated with upstream activities of the Project's system components, this analysis utilized a study from the National Renewable Energy Laboratory (NREL) that estimated total life cycle emissions of solar PV systems to be approximately 40 g CO₂eq/kWh, and that upstream activities account for up to 70 percent of these emissions (28 g CO₂eq/kWh).² Upstream activities of solar PV systems include:

- Raw materials extraction;
- Materials production;
- Module manufacture;
- System/plant component manufacture; and
- Installation/plant construction.

¹ U.S. EPA. (2019). *Greenhouse Gases Equivalencies Calculator - Calculations and References*. Retrieved 19 November 2019, from <https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references>

² NREL. (2013). *Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics*. Retrieved 19 November 2019, from <https://www.nrel.gov/docs/fy13osti/56487.pdf>

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Estimated emissions generated, avoided, or sequestered were extended over a 30-year period – the assumed lifetime of the Project. This period is consistent with the NREL study on the life-cycle of solar PV systems.

Findings

The carbon debt of the Project is estimated to be 37,066.3 MT CO₂eq over a period of 30 years. This figure includes:

- Tree removal (30-year sequestration loss): 1,912.5 MT CO₂;
- Tree removal (one-time release of carbon stock): 5,700.0 MT CO₂; and
- Upstream activities of solar PV system: 29,453.8 MT CO₂eq.

The Project is expected to produce 28,726.7 MWh of energy in its first year of operation. Using emission factors provided by the U.S. EPA specific to the Project's eGrid region (NPCC New England),³ the estimated annual emissions avoided by the Project is anticipated to be 12,776.1 MT CO₂eq. The attachment provides GHG emissions equivalencies for this estimate. For example, the Project's estimated annual emissions avoidance is equivalent to GHG emissions from 2,713 passenger vehicles driven for one year and CO₂ emissions from 1,474 homes' energy use for one year.⁴

Anticipating a carbon debt of 37,066.3 MT CO₂eq and annual PV production benefits of 12,776.1 MT CO₂eq, it would take the Project 2.9 years (or nearly 35 months) to have a net improvement with respect to GHG emissions.

³ U.S. EPA. (2016). eGrid Summary Tables 2016. Retrieved 19 November 2019, from https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

⁴ U.S. EPA. (2019). Greenhouse Gas Equivalencies Calculator. Retrieved 19 November 2019, from <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

Equivalency Results [How are they calculated?](#)

The sum of the greenhouse gas emissions you entered above is of Carbon Dioxide Equivalent. This is equivalent to:

12,776 Metric Tons ▼

Greenhouse gas emissions from

  2,713 Passenger vehicles driven for one year	-or-	  31,702,481 Miles driven by an average passenger vehicle
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CO₂ emissions from

  1,437,617 gallons of gasoline consumed	-or-	  1,255,020 gallons of diesel consumed	-or-
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  14,077,509 Pounds of coal burned	-or-	  169 tanker trucks' worth of gasoline	-or-
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  1,474 homes' energy use for one year	-or-	  2,163 homes' electricity use for one year	-or-
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70.3



railcars' worth of coal burned

-or-

29,579



barrels of oil consumed

-or-

522,283



propane cylinders used for home barbeques

-or-

0.003



coal-fired power plants in one year

-or-

1,629,364,423



number of smartphones charged

Greenhouse gas emissions avoided by

4,346



Tons of waste recycled instead of landfilled

-or-

621



Garbage trucks of waste recycled instead of landfilled

-or-

543,618



2.8





trash bags of waste recycled instead of landfilled

-or-



Wind turbines running for a year

-or-

485,359



Incandescent lamps switched to LEDs

Carbon sequestered by

211,256



tree seedlings grown for 10 years

-or-

16,685



acres of U.S. forests in one year

-or-

86.4



acres of U.S. forests preserved from conversion to cropland in one year