



Memorandum

To: Chris Ross
PV Project Developer
Greenskies Clean Energy, LLC

Date: May 1, 2020

Project #: 42517.01

From: Steven J. Kochis, PE

Re: 233 Boombridge Road
North Stonington Solar, North Stonington, CT
Carbon Debt Analysis

VHB provided services to Greenskies Clean Energy that included performing a carbon debt analysis of the proposed North Stonington Solar installation, a ± 5 MW AC solar farm in North Stonington, Connecticut (the Project). 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 ± 27 acres of forested land (pre-existing condition) to either gravel/compacted roads or warm season grasses, required to construct and operate the Project. 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: 0.77 metric tons (MT) CO₂ and the carbon stock in one acre of average U.S. forest: 85 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.

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.

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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Findings

The carbon debt of the Project is estimated to be 10,061 MT CO₂eq over a period of 30 years. This figure includes:

- Tree removal (30-year sequestration loss): 624 MT CO₂;
- Tree removal (one-time release of carbon stock): 2,295 MT CO₂; and
- Upstream activities of solar PV system: 7,142 MT CO₂eq.

The Project is expected to produce 8,502 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 3,781 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 817 passenger vehicles driven for one year or CO₂ emissions from 436 homes' energy use for one year.⁴

Anticipating a carbon debt of 10,061 MT CO₂eq and annual PV production benefits of 3,781 MT CO₂eq, it would take the Project 2.67 years (or nearly 32 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:





3,781 Metric Tons ▼





Greenhouse gas emissions from

  817 Passenger vehicles driven for one year	-or-	  9,382,134 Miles driven by an average passenger vehicle
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CO₂ emissions from


  425,453 gallons of gasoline consumed	-or-	  371,415 gallons of diesel consumed	-or-
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  4,166,143 Pounds of coal burned	-or-	  50.1 tanker trucks' worth of gasoline	-or-
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  436 homes' energy use for one year	-or-	  640 homes' electricity use for one year	-or-
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 **20.8**


 railcars' worth of coal burned


-or-

 **8,754**

 barrels of oil consumed

-or-

 **154,566**


 propane cylinders used for home barbeques


-or-

 **0.001**

 coal-fired power plants in one year

-or-

 **482,199,332**


 number of smartphones charged


Greenhouse gas emissions avoided by

 **1,286**


 Tons of waste recycled instead of landfilled

-or-

 **184**

 Garbage trucks of waste recycled instead of landfilled

-or-

 **160,880**



 **0.816**





trash bags of waste recycled instead of landfilled

-or-



Wind turbines running for a year

-or-


143,639



Incandescent lamps switched to LEDs

Carbon sequestered by

62,520



tree seedlings grown for 10 years

-or-


4,938



acres of U.S. forests in one year

-or-

25.6



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