



Memorandum

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

Date: May 1, 2020

Project #: 42518.01

From: Steven J. Kochis, PE

Re: Rockville Road
Mulnite Farms, East Windsor, CT
Carbon Debt Analysis

VHB provided services to Greenskies Clean Energy that included performing a carbon debt analysis of the proposed Mulnite Farms Solar installation, a ± 5 MW AC solar farm in East Windsor, 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 ± 32 acres from active agriculture (i.e. tobacco) 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 carbon stock in one acre of cropland after one year of growth, including soil organic carbon: 17.43 MT CO₂¹.

To estimate emissions avoided by converting agricultural land to either gravel/compacted roads or warm season grasses, this analysis used emissions estimates specific to Hartford County provided by Michigan State University's US Cropland Greenhouse Gas Calculator ("Calculator").² The Calculator accounts for emissions associated with farming activities such as soil tillage, fuel consumption, and fertilizer use. Soybean crop was used as a proxy for all agricultural production at the Project Site so as not to overestimate the benefits of avoiding such activities. Soybean crop has the lowest overall emissions per acre per year among all available inputs within the tool (i.e., corn, wheat, soybean, switchgrass, silage, and oats). For reference, estimated GHG emissions per year for soybean production is 0.15 MT CO₂eq/acre compared to 0.40 MT CO₂eq/acre for corn production. To estimate the sequestration benefits of converting 32 acres of cropland to grasslands, this analysis referred to a study from Iowa State University that quantified the average annual benefit to be 0.93 MT CO₂/acre.³

¹ U.S. EPA. (2019). *Greenhouse Gases Equivalencies Calculator - Calculations and References*. Retrieved 01 May 2020, from <https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references>

² Michigan State University. (2019). US Cropland Greenhouse Gas Calculator. Retrieved 01 May 2020, from <http://surf.kbs.msu.edu/county/CT/Hartford>

³ Iowa State University. (2011). *Incorporating Prairies into Multifunctional Landscapes*. <http://www.extension.iastate.edu/Publications/PMR1007.pdf>

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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).⁴ 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.

Findings

The carbon debt of the Project is estimated to be 9,659 MT CO₂eq over a period of 30 years. This figure includes:

- Cropland conversion (30-year emission avoidance and 30-year sequestration): 1,018 MT CO₂eq;
- Cropland conversion (one-time release of carbon stock): 558 MT CO₂; and
- Upstream activities of solar PV system: 8,083 MT CO₂eq.

The Project is expected to produce 9,622 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),⁵ the estimated annual emissions avoided by the Project is anticipated to be 4,287 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 926 passenger vehicles driven for one year or CO₂ emissions from 495 homes' energy use for one year.⁶

Anticipating a carbon debt of 9,659 MT CO₂eq and annual PV production benefits of 4,287 MT CO₂eq, it would take the Project 2.25 years (or nearly 27 months) to have a net improvement with respect to GHG emissions.

⁴ NREL. (2013). *Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics*. Retrieved 01 May 2020, from <https://www.nrel.gov/docs/fy13osti/56487.pdf>

⁵ U.S. EPA. (2016). eGrid Summary Tables 2018. Retrieved 01 May 2020, from https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018_summarytables.pdf





⁶ U.S. EPA. (2019). Greenhouse Gas Equivalencies Calculator. Retrieved 01 May 2020, 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:





4,287 Metric Tons ▼





Greenhouse gas emissions from

  926 Passenger vehicles driven for one year	-or-	  10,637,717 Miles driven by an average passenger vehicle
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CO₂ emissions from


  482,390 gallons of gasoline consumed	-or-	  421,120 gallons of diesel consumed	-or-
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  4,723,686 Pounds of coal burned	-or-	  56.8 tanker trucks' worth of gasoline	-or-
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  495 homes' energy use for one year	-or-	  726 homes' electricity use for one year	-or-
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 **23.6**


 railcars' worth of coal burned


-or-

 **9,925**

 barrels of oil consumed

-or-

 **175,251**


 propane cylinders used for home barbeques


-or-

 **0.001**

 coal-fired power plants in one year

-or-

 **546,730,636**


 number of smartphones charged


Greenhouse gas emissions avoided by

 **1,458**


 Tons of waste recycled instead of landfilled


-or-

 **208**

 Garbage trucks of waste recycled instead of landfilled

-or-

 **182,410**



 **0.926**





trash bags of waste recycled instead of landfilled

-or-



Wind turbines running for a year

-or-


162,861



Incandescent lamps switched to LEDs

Carbon sequestered by

70,886



tree seedlings grown for 10 years

-or-


5,599



acres of U.S. forests in one year

-or-

29



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