

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

Date: May 1, 2020

Memorandum

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:  $17.43 \text{ MT CO}_2^1$ .

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").<sup>2</sup> 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 CO<sub>2</sub>eq/acre compared to 0.40 MT CO<sub>2</sub>eq/acre for corn production. To estimate the sequestration benefits of converting 32 acres of cropland to grasslands, this analysis referred to a study from lowa State University that quantified the average annual benefit to be 0.93 MT CO<sub>2</sub>/acre.<sup>3</sup>

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

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

<sup>&</sup>lt;sup>3</sup> 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 CO<sub>2</sub>eq/kWh, and that upstream activities account for up to 70 percent of these emissions (28 g CO<sub>2</sub>eq/kWh).<sup>4</sup> 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 CO<sub>2</sub>; 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),<sup>5</sup> the estimated annual emissions avoided by the Project is anticipated to be 4,287 MT CO<sub>2</sub>eq. 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 CO<sub>2</sub> emissions from 495 homes' energy use for one year.<sup>6</sup>

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.

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

<sup>&</sup>lt;sup>5</sup> U.S. EPA. (2016). eGrid Summary Tables 2018. Retrieved 01 May 2020, from <a href="https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018">https://www.epa.gov/sites/production/files/2020-01/documents/egrid2018</a> summarytables.pdf

<sup>&</sup>lt;sup>6</sup> U.S. EPA. (2019). Greenhouse Gas Equivalencies Calculator. Retrieved 01 May 2020, from <a href="https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator">https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator</a>

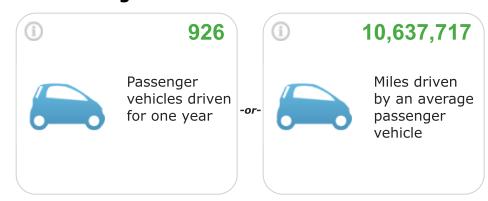
## **Equivalency Results**

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**

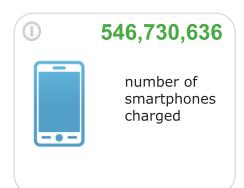


### CO<sub>2</sub> emissions from









# Greenhouse gas emissions avoided by





trash bags of waste recycled instead of landfilled



Wind turbines running for a year

-or-



## **Carbon sequestered by**

