Memorandum

To: Christopher Thuman
Asset Manager
and
Aaron Svedlow
Development Manager
DWW Solar II, LLC

Date: June 22, 2017
Revised January 15, 2019

Project #: 42256.40

From: Susan Moberg PWS, CFM

Re: Tobacco Valley Solar Project, Simsbury CT
Carbon Debt Analysis

VHB provided services to DWW Solar II, LLC that included performing a carbon debt analysis of the proposed Tobacco Valley Solar installation, a 26.4 MW AC in Simsbury, 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 of 19.2 acres of trees and conversion of 24 acres from active agriculture (i.e., zucchini, tobacco, and corn) to either gravel/compacted roads or warm season grasses, required to construct and operate the Project. Approximately 151 acres of the 302-acre Project site is forested; proposed tree clearing represents 12.7 percent of the Project Site's forested areas and 6.4 percent of the total Project Site (see Figure B: Tree Clearing Plan). This analysis also accounted for the emissions and emissions benefits of cropland conversion, and 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) CO_2, the carbon stock in one acre of average U.S. forest: 76 MT CO_2, and the carbon stock in one acre of cropland after one year of growth, including soil organic carbon: 17.43 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").[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

[1] U.S. EPA. (2019). *Greenhouse Gases Equivalencies Calculator - Calculations and References*. Retrieved 08 January 2019, from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references
[2] Michigan State University. (2019). US Cropland Greenhouse Gas Calculator. Retrieved 08 January 2019, from http://surf.kbs.msu.edu/county/CT/Hartford

100 Great Meadow Road
Suite 200
Wethersfield, CT 06109-2377
P 860.807.4300

0.15 MT CO_2eq/acre compared to 0.40 MT CO_2eq/acre for corn production. To estimate the sequestration benefits of converting 14.0 acres of cropland to grasslands, this analysis referred to a study from Iowa State University that quantified the average annual benefit to be 0.91 MT CO_2/acre.[3]

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_2eq/kWh, and that upstream activities account for up to 70 percent of these emissions (28 g CO_2eq/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 49,076.1 MT CO_2eq over a period of 30 years. This figure includes:

- Tree removal (30-year sequestration loss): 489.6 MT CO_2;
- Tree removal (one-time release of carbon stock): 1,459.2 MT CO_2;
- Cropland conversion (30-year emission avoidance and 30-year sequestration): (489.0) MT CO_2eq;
- Cropland conversion (one-time release of carbon stock): 418.4 MT CO_2; and
- Upstream activities of solar PV system: 47,197.92 MT CO_2eq.

The Project is expected to produce 56,188.0 MWh of energy in its first year of operation.[5] Using emission factors provided by the U.S. EPA specific to the Project's eGrid region (NPCC New England),[6] the estimated annual emissions avoided by the Project is anticipated to be 14,371.8 MT CO_2eq. Attachment A provides GHG emissions equivalencies

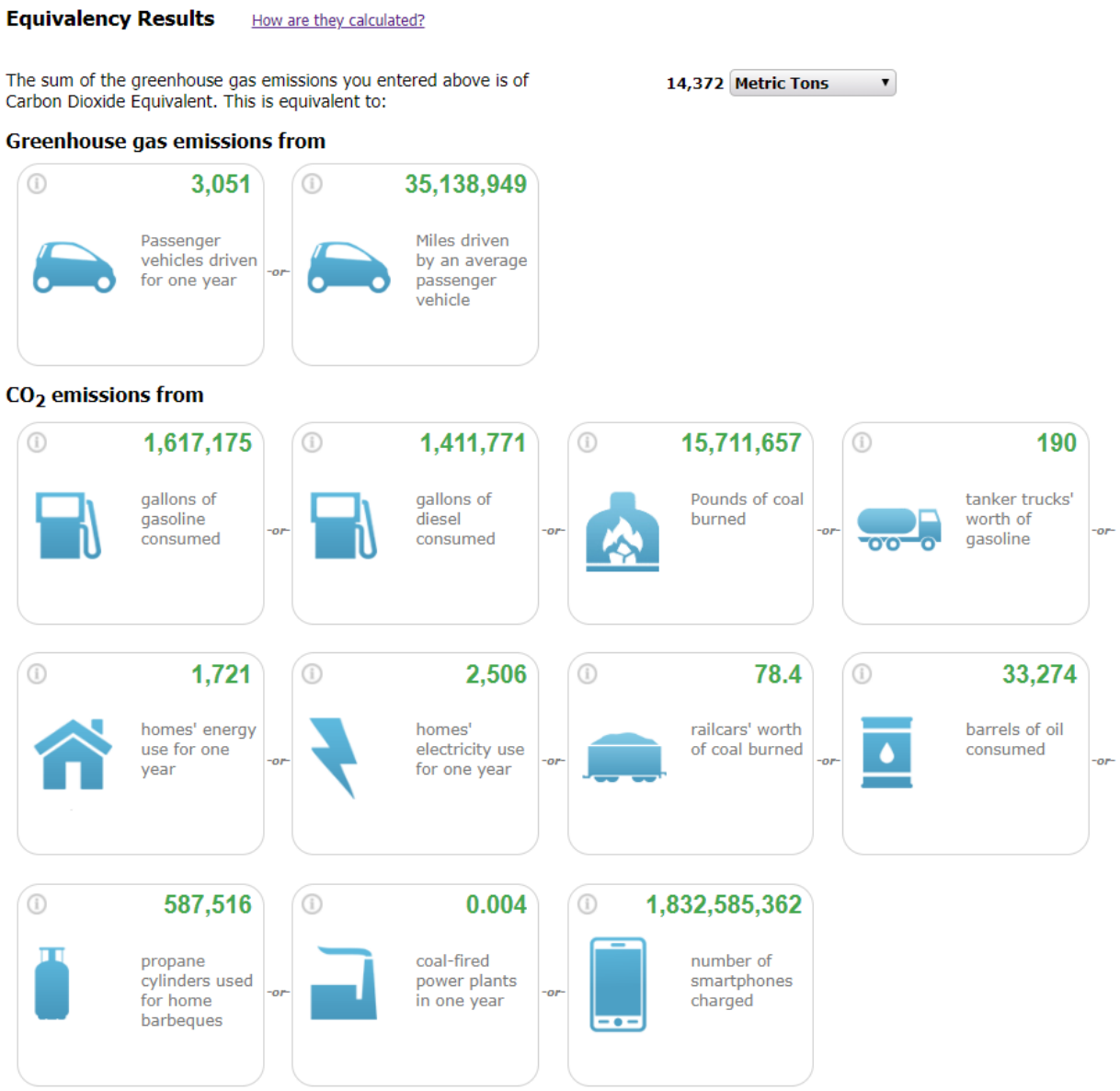
[3] Iowa State University. (2011). *Incorporating Prairies into Multifunctional Landscapes*. http://www.extension.iastate.edu/Publications/PMR1007.pdf
[4] NREL. (2013). *Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics.* Retrieved 19 October 2017, from https://www.nrel.gov/docs/fy13osti/56487.pdf
[5] Revolution Labs of Colorado (2019). Analysis performed using PVSyst 6.75 based on the current site plan, taking into account topography and shading.
[6] U.S. EPA. (2016). eGrid Summary Tables 2016. Retrieved 08 January 2019, from https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf

for this estimate. For example, the Project's estimated annual emissions avoidance is equivalent to GHG emissions from 3,051 passenger vehicles driven for one year and CO_2 emissions from 1,721 homes' energy use for one year.[7]

Anticipating a carbon debt of 49,076.1 MT CO_2eq and annual PV production benefits of 14,371.8 MT CO_2eq, it would take the Project 3.4 years (or nearly 41 months) to have a net improvement with respect to GHG emissions.

[7] U.S. EPA. (2019). Greenhouse Gas Equivalencies Calculator. Retrieved 08 January 2019, from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Attachment A: Equivalencies for the Greenhouse Gas Emissions Avoided by DESRI, Simsbury CT



Source:

U.S. EPA. (2019). *Greenhouse Gases Equivalencies Calculator - Calculations and References*. Retrieved 15 January 2019, from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references